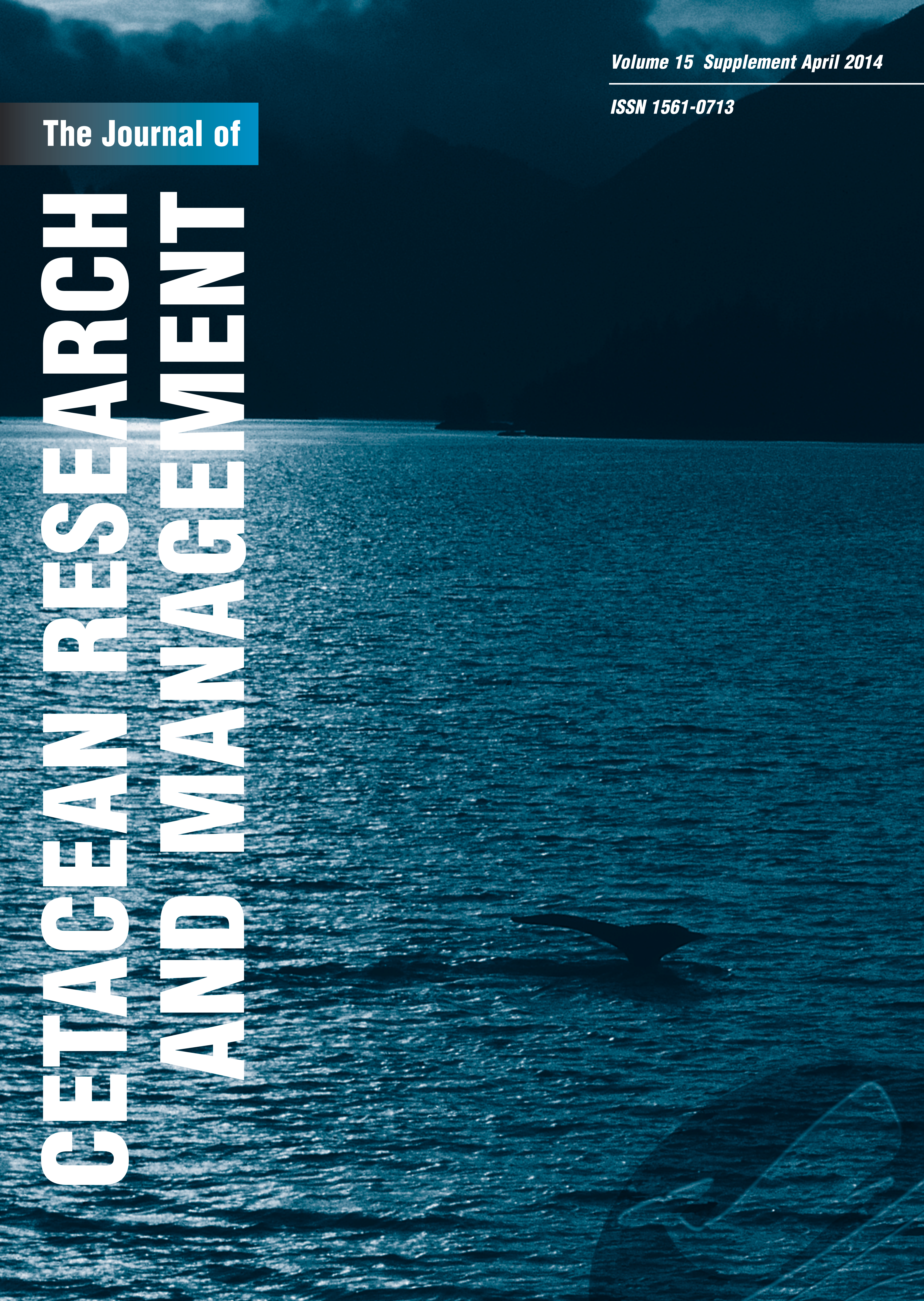

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The Journal of CETACEAN RESEARCH AND MANAGEMENT

Editorial

Welcome to this the supplement to the fifteenth volume of the *Journal of Cetacean Research and Management*.

This supplement to the Journal contains the Report of the Scientific Committee from its Annual Meeting held from 3-15 June 2013 in Jeju Island, Republic of Korea. The meeting was attended by some 147 participants (including over 45 invited participants); 27 member nations were represented. It also contains the reports of six intersessional meetings:

(1) the Report of the Planning Meeting for the 2013 IWC-POWER Cruise held in October 2012 in Tokyo, Japan;
(2) the Report of the Fourth AWMP Workshop on the Development of *SLA*s for the Greenlandic Hunts held in December 2012 in Copenhagen, Denmark;
(3) the Report of the Expert Workshop to Review the Icelandic Special Permit Research Programme held in February 2013 in Reykjavik, Iceland;
(4) the Report of the 'Second' Intersessional Workshop on the *Implementation Review* for Western North Pacific Common Minke Whales held in March 2013 in La Jolla, California, USA;
(5) the Report of the Fourth Intersessional Workshop on the Review of Maximum Sustainable Yield Rates (MSYR) in Baleen Whales held in March 2013 in La Jolla, California, USA; and
(6) the Report of the Workshop on Marine Debris held in May 2013 in Woods Hole, USA.

There was no accompanying Commission meeting this year following the decision made by the Commission in Panama in 2012 to meet Biennially rather than Annually from now on. The next meeting of the Commission will be held in Slovenia in September 2014.

Several topics were discussed in Jeju. A brief summary of the work of the Scientific Committee in Jeju is given below. Full details of the large amount of work undertaken can be found in the report of the Scientific Committee and its many sub-groups in this supplement.

The Committee continued its work on matters related to the Revised Management Procedure (RMP). The RMP was developed to establish a conservative way to evaluate anthropogenic removals in the light of potential future commercial catches (there is a moratorium on commercial catching of whales in force). The objectives for commercial catches were established by the Commission with the highest priority being to ensure that no catches would be allowed if there was a possibility that the populations subject to exploitation were below 10% of the level at which maximum sustainable yield might be obtained (i.e. 54% of the unexploited population size). There is a focus on fully taking into account scientific uncertainty when providing advice. The major work in 2013 was on the completion of the *Implementation Review* for western North Pacific common minke whales, which has been achieved after several years of hard work.

'Aboriginal subsistence whaling' is regulated by the IWC in several parts of the world. This year, work continued on the development of advice on safe catch limits and *SLA*s for the hunts off Greenland. Completing this work is a high priority for the Scientific Committee and work continued on this topic in 2013. The Committee as usual provided advice on whether proposed strike limits for subsistence hunts by subsistence whaling countries were sustainable.

The issues of bycatches of whales in fishing gear and collisions with ships are important at a number of levels including animal welfare and may have conservation implications for certain populations. The Scientific Committee has been working on this issue for several years. In 2013, discussions focussed on criteria for determining the cause of death for ship struck whales, as well as further progress on the IWC ship strike database and entanglement responses.

The Committee has now agreed abundance estimates for Antarctic minke whales for the final two sets of circumpolar international cruises undertaken by the IWC. Work on explaining the differences between the two estimates is ongoing. Work is also progressing on a special volume of papers reviewing the results of the IDCR/SOWER Antarctic cruises. The new international 'POWER' series of cruises, in the North Pacific, was also discussed.

The Committee continued work on assessments of other Southern Hemisphere species including blue whales, humpback whales and right whales. Humpback whale Breeding Stocks D, E and F are being assessed, as is the small Arabian Sea population of humpbacks. IWC is working with the Southern Ocean Research Partnership (SORP) as part of the Southern Ocean assessments.

Understanding North Pacific gray whale stock structure is essential for determining the status of animals on the western and eastern feeding grounds and assessing human impacts including subsistence hunting and oil and gas operations. The Committee is undertaking a major review of information from telemetry, genetic and photo-identification studies. Work continued on this issue this year.

The Icelandic Special Permit programme was reviewed this year, including the holding of a special workshop as part of the Committee's guidelines for the review of such permits.

The Committee examined a number of topics related to the environment and cetaceans. These included: progress on Phase II of the POLLUTION 2000+ research programme and the impacts of oil and dispersants on cetaceans, as well as cetacean disease and unexplained mortality events. The effects of anthropogenic sound on cetaceans is beginning to be investigated, and a workshop on this topic is planned. Marine debris is another important area, and the Committee reviewed the report of the first of two workshops addressing this issue. More work is planned in all of these areas.

In response to a request by the Commission, the Scientific Committee developed a list of candidate cetacean populations for 'Conservation Management Plans' (CMPs). Issues such as pollution, entanglements and ships strikes were identified as being of major importance to the development of these plans.

The focus for discussions this year on whalewatching were the impacts of whalewatching on cetaceans, and this included an investigation into whaewatching in Korea, where the meeting was held. The scientific aspects of the Commission's Five-Year Strategic Plan for Whalewatching were also reviewed.

The Committee's main focus for small cetaceans was a review of populations in East Asian waters (China including Taiwan, Korea, Japan and Russian belugas). Progress on previous recommendations on endangered populations of vaquita, Hector's dolphins, Irrawaddy river dolphins and others were discussed, along with an update on an Indo-Pacific bottlenose dolphin drive fishery in the Solomon Islands. On a positive note the Committee was pleased to receive progress reports on the nine projects funded under the IWC's voluntary fund for small cetaceans.

The IWC has a new website, and also a new web address: *http://www.iwc.int*. The website will be used increasingly in the future to distribute documents and reports. Papers for the Journal are now submitted, reviewed and, if accepted, published online. This year all Scientific Committee meeting documents were distributed online, making a substantial saving on paper and printing costs.

An electronic archive of all past Scientific Committee and Commission documents and publications is underway. Many of the earlier papers have been scanned and will be uploaded to the website in due course. This major undertaking is progressing well. All past Journal papers and Supplements are now available online, as are the Annual Reports and the older Reports of the IWC.

Greg Donovan
Editor
Cambridge, 17 March 2014

Supplement Contents

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*Detailed contents for the Plenary Section (pp.1-75) are given on the next page.

PLENARY SECTION: CONTENTS

Report of the Scientific Committee

The meeting was held at the Shilla Jeju Hotel, Republic of Korea from 3-15 June 2013 and was chaired by Toshihide Kitakado. This meeting is SC/65a. The next meeting of the Scientific Committee in May or June 2014 will be SC/65b, and the next meeting of the Commission (IWC/65) will take place during September or October 2014. A list of participants is given as Annex A.

1. INTRODUCTORY ITEMS

1.1 Chair's welcome and opening remarks

Kitakado, the Committee Chair for the first time, welcomed the participants to the 2013 Annual Scientific Committee meeting. He thanked the Government of Korea for hosting the meeting and for providing the excellent facilities and an opening reception. He also expressed his thanks to the IWC Commissioner for Korea, Mr Bok-Chul Chung, for his assistance. The Committee then paused for a moment of silence, with great sorrow, for those who had passed away since the last meeting.

Graham Chittleborough died in October 2012. He gained an international reputation for his work on humpback whales based on the commercial catches off Australia and in the Antarctic following World War II. Graham contributed his knowledge of humpback whales to the work of the 'Committee of Three Scientists on the Special Scientific Investigation of the Antarctic Whale Stocks', attending meetings to review its progress and findings in Rome (1961) and Seattle (1963). He was also the first scientist to recognise the extent of illegal hunting of humpback whales taking place in the Antarctic in the late 1950s-early 1960s.

Malcolm Clarke died in May 2013. He was recognised internationally for his work on oceanic squid, and was well known to and respected by many members of the Scientific Committee for his investigations of squid as the food of sperm whales, in particular his *Discovery Report* based on stomach contents of sperm whales in Southern Hemisphere catches. He also undertook ground-breaking research on sperm whale anatomy, including the use of the spermaceti organ in diving.

Rebecca Leaper died unexpectedly just before the meeting, well before her time. She was a dedicated and passionate marine conservation scientist and spent two years on the Australian delegation as an ecosystem modeller. She had been a key member of science teams at the Australian Antarctic Division, the Tasmanian Aquaculture and Fisheries Institute, CSIRO and most recently at the University of Tasmania's Institute of Marine and Antarctic Science, working on issues ranging from the role of whales in their marine ecosystems through to conservation mechanisms for marine biodiversity. Her passion for her work was matched only by her generosity of spirit.

Captain Leif Petersen, who died in March 2013, never attended the Scientific Committee. However, his dedication, skill and courage as a pilot for pioneering aerial surveys beginning in Greenland and Iceland in the 1980s and eventually for many parts of northern Europe including the more recent SCANS and NASS programmes meant that he contributed as much to conservation and management as any of the scientists who participated. It is important that scientists never underestimate the contribution of pilots, skippers and crews to their work. Leif became an indispensable colleague and lasting friend to many scientists attending the Scientific Committee meeting; several of us are still alive because of him.

Vyacheslav Alekseevich Zemsky died at the age of 93 after a distinguished career in the Soviet Union and the Russian Federation. In the 1970s, he was very active in IWC related issues and the new Russia-US marine mammal working group. Between 1993-2000, Zemsky, with a number of members of the Soviet whaling expeditions, collated all the materials and documents preserved in departmental archives to create a corrected catch history of the whales hunted in the Southern Hemisphere.

1.2 Appointment of rapporteurs

Donovan was appointed rapporteur with assistance from various members of the Committee as appropriate. Chairs of sub-committees and Working Groups appointed rapporteurs for their individual meetings.

1.3 Meeting procedures and time schedule

The Committee agreed to the meeting procedures and time schedule outlined by the Chair.

1.4 Establishment of sub-committees and working groups

As agreed last year (IWC, 2013c, p.59) and included in the draft agenda, a pre-meeting of the sub-committee on the Revised Management Procedure (RMP) met in Jeju on 1-2 June 2013 to begin the *Implementation Review* for North Atlantic fin whales. The report of the pre-meeting is given as Annex D, Appendix 2.

A number of sub-committees and Working Groups were established. Their reports were either made Annexes to this report (see below) or subsumed into the main text of this report.

Annex D – Sub-Committee on the Revised Management Procedure;
Annex D1 – Working Group on the *Implementation Review* for Western North Pacific Common Minke Whales;
Annex E – Standing Working Group on Aboriginal Subsistence Whaling Management Procedures;
Annex F – Sub-Committee on Bowhead, Right and Gray Whales;
Annex G – Sub-Committee on In-Depth Assessments;
Annex H – Sub-Committee on Other Southern Hemisphere Whale Stocks;
Annex I – Working Group on Stock Definition;
Annex J – Working Group on Non-deliberate Human-Induced Mortality of Large Whales;
Annex K – Standing Working Group on Environmental Concerns;
Annex K1– Working Group to Address Multi-species and Ecosystem Modelling Approaches;
Annex L – Sub-Committee on Small Cetaceans;
Annex M – Sub-Committee on Whalewatching;
Annex N – Working Group on DNA;
Annex O – *Ad hoc* Working Group on National Progress Reports;
Annex P – Working Group on Special Permits; and
Annex Q – *Ad hoc* Working Group on Abundance Estimates.

Table 1

List of data received by the IWC Secretariat since the 2012 meeting.

Date	From	IWC ref.	Details
Catch data from the previous season:			
25/04/13	Norway: N. Øien	E108 Cat2012	Individual minke records from the Norwegian 2012 commercial catch.
01/06/13	Japan: T. Sakamoto	E108 Cat2012	Individual data for Japan special permit catch 2012 North Pacific (JARPN II) and 2012/13 Antarctic (JARPA II).
02/06/13	Russia: V. Ilyashenko	E108 Cat2012	Individual catch records from the aboriginal harvest in the Russian Federation in 2012.
03/06/13	Iceland: G. Víkingsson	E108 Cat2012	Individual catch records from the Icelandic 2012 commercial catch.
Sightings data:			
17/04/13	Japan: K. Matsuoka	E106	POWER North Pacific cruise sightings data 2012.
17/04/13	Japan: K. Matsuoka	E107	Data from dedicated sightings surveys in 2012 in the North Pacific under JARPN II.

1.5 Computing arrangements
Allison outlined the computing and printing facilities available for delegate use**.**

2. ADOPTION OF AGENDA
The adopted agenda is given as Annex B.

3. REVIEW OF AVAILABLE DATA, DOCUMENTS AND REPORTS

3.1 Documents submitted
The documents available are listed in Annex C. As agreed last year, for the first time, primary papers were only available at the meeting in electronic format (IWC, 2013c, pp.78-9).

3.2 National Progress Reports on research
As agreed last year, all National Progress Report information usually submitted in paper form was submitted electronically through the IWC National Progress Reports data portal (IWC, 2013c, p.1). Developing such a portal and then expanding it to allow multiple data entry users for each country (the latter had not originally been envisaged two years ago when the portal was agreed) was a major undertaking. The Committee thanked Miller of the Secretariat for the considerable amount of work he had undertaken during the year to make this possible. Inevitably, a number of issues to be addressed and potential improvements to be made arose during the year as the portal began to be used. These were referred to an *ad hoc* Working Group and the Committee **endorses** the report of that Group (Annex O) and its recommendations. It again **recommends** that all member states submit National Progress Reports through the IWC portal (*http://portal.iwc.int*).

3.3 Data collection, storage and manipulation
3.1.1 Catch data and other statistical material

Table 1 lists data received by the Secretariat since the 2012 meeting.

3.1.2 Progress of data coding projects and computing tasks

Allison reported that Version 5.5 of the catch databases was released in February 2013. Work has continued on the entry of catch data into both the IWC individual and summary catch databases, including data received from the 2011 season and some additional information for records from Durban in the 1960s and 1970s. Sightings data from the 2011 POWER cruise (see Annex G, Appendix 2) are being validated.

Programming work during the past year has focused on completing the North Pacific common minke whale *Implementation* trials including amending the control program and conditioning and running trials. Further details are given under Item 6.1.

4. COOPERATION WITH OTHER ORGANISATIONS
The Committee noted the great value of co-operation with other international organisations to its work. The observers' reports below briefly summarise relevant meetings of other organisations. The contributions of several collaborative efforts are dealt with in the relevant sub-committees.

4.1 Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)
The report of the IWC observer at the 31st Meeting of the CCAMLR Scientific Committee (CCAMLR-SC), held in Hobart, Australia from 22-26 October 2012 is given as IWC/65/4(2013)A. The main items considered at the CCAMLR meeting of relevance to the IWC included: (1) fishery status and trends of Antarctic fish stocks, krill, squid and stone crabs; (2) incidental mortality of seabirds and marine mammals in fisheries in the CCAMLR Convention Area; (3) harvested species; (4) ecosystem monitoring and management; (5) management under conditions of uncertainty about stock size and sustainable yield; (6) scientific research exemption; (7) CCAMLR Scheme of International Scientific Observation; (8) new and exploratory fisheries; and (9) joint CCAMLR-IWC Workshop with respect to ecosystem modelling in the Southern Ocean.

Reports of the Scientific Committee (SC-CCAMLR) and its Working Groups on Ecosystem Monitoring and Management (WG-EMM) and Fish Stock Assessment (WG-FSA) and their various subgroups are available through the CCAMLR secretariat and on the CCAMLR website[1].

The CCAMLR Working Group on Incidental Mortality in Fisheries (WG-IMAF) did not meet in 2012 and no new information on cetacean-fisheries interactions in the Southern Ocean became available to CCAMLR. The next meeting of the Working Group is likely to take place prior to the annual meeting of CCAMLR in 2013.

The Committee thanked Kock for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next CCAMLR-SC meeting.

4.2 Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)[2]
The Committee did not receive a report from an observer at the 2013 meeting of the Conference of the Parties (3-14 March 2013).

4.3 Convention on the Conservation of Migratory Species (CMS)[3]
4.3.1 Scientific Council

There was no meeting of the Scientific Council during the intersessional period.

[1]*http://www.ccamlr.org/.*
[2]*http://www.cites.org.*
[3]*http://www.cms.int.*

4.3.2 Conference of Parties (COP)
There was no Meeting of the Parties during the intersessional period.

4.3.3 Agreement on Small Cetaceans of the Baltic and North Seas (ASCOBANS)[4]
The report of the IWC observer at the 7th Meeting of the Parties (MoP) to ASCOBANS, held in Brighton, UK from 22-24 October 2012 is given as IWC/65/4(2013)G. The main results from the meeting are summarised below.

(1) The Conservation Plan for the Harbour Porpoise Population in the Western Baltic, the Inner Danish Waters and the Kattegat was adopted. The main aim of the plan is to intensify research and conservation efforts for harbour porpoises in this area.
(2) Work on the Baltic Sea Recovery Plan (Jastarnia Plan) and the North Sea Conservation Plan were reviewed. The implementation of these will continue to be of importance over the next three years.
(3) Bycatch and underwater noise were identified as future priorities. The impact of marine debris on cetaceans will also be considered.
(4) A better understanding of how new and often lesser-studied contaminants affect individuals and populations is needed. Limiting the introduction of chemical substances into the marine environment should be considered.
(5) The western part of the ASCOBANS area has a large diversity of whale and dolphin species, but knowledge of their abundance and distribution as well as the magnitude of different threats remains scarce. Collaboration for research and conservation action in this area is needed.
(6) In general, cooperation and interaction with the European Commission, other international organisations, fishery and other economic sectors, NGOs and non-Party Range States should be strengthened.
(7) The 4th ASCOBANS Outreach and Education Award 2012 was given to Mats Amundin of Kolmården Djurpark in Sweden for his work in promoting the conservation of harbour porpoises.

No observer for the IWC attended the 20th meeting of the Advisory Committee to ASCOBANS.

The Committee thanked Scheidat for her report and **agrees** that she should represent the Committee as an observer at the next ASCOBANS Meeting of Parties and Advisory Committee meeting.

4.3.4 Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)[5]
Donovan attended the 2012 meeting of the ACCOBAMS Scientific Committee (ASC) held in Monaco from 13-15 November 2012 and his report is given as IWC/65/4(2013) L. The full report of the meeting can be found on the ACCOBAMS website.

A number of recommendations were made. The first concerned the long-standing (nine-year) recommendation, also endorsed by the IWC Scientific Committee, for an ACCOBAMS Survey Initiative. The ASC strongly endorsed an updated basinwide survey plan, agreed on the need for synergies with other efforts in the North Atlantic and on the need to hire a co-ordinator. It noted news of a survey funded by DG-Mare that will cover about 25% of the Black Sea in summer 2013. However, it strongly recommended that the whole of the Black Sea be covered synoptically and urged ACCOBAMS to do all it could to ensure this and not miss a unique opportunity.

A second recommendation addressed the continued live removals of bottlenose dolphins in the Black Sea. The ACCOBAMS Secretariat was asked to send a letter of concern to the Georgian and Ukrainian governments (copied to the Bern Convention Secretariat, the Black Sea Commission and the CITES Secretariat) recalling the illegality of live removals of cetaceans from the Black Sea and asking them to carry out an inventory and thorough assessment of individual identity of all bottlenose dolphins kept in captivity by means of genetic, morphological and photo-id methods and to provide appropriate administrative measures in order to prevent substitution of dolphins that die in captivity by animals taken from the wild. The ASC noted that the IWC Scientific Committee has guidelines on the practical aspects of the use of DNA registers for cetaceans.

The ASC also agreed to work towards a Conservation Plan for fin whales of the Mediterranean. It noted: (1) the importance of continuing work to elucidate the stock structure and movements of fin whales in the ACCOBAMS area; (2) the importance of the ACCOBAMS Survey initiative to provide a summer snapshot of distribution throughout the whole region as well as a reliable estimate of total abundance; (3) that all of the groups working in the area be asked to update available information on fin whales, including those related to potential threats (e.g. see the work of Fossi on micro-plastics, Fossi *et al.*, 2012) and to consult on priorities for future work with a focus on conservation; and (4) that an outline draft Conservation Plan be developed for consideration at the next ASC, with a view to reviewing whether the time is ripe to engage with stakeholders to develop a full plan.

The ASC also developed a statement of concern over the ongoing seismic survey work in the area of the Hellenic Trench. In particular, it requested all involved in the planned surveys to provide information to the ASC and take urgent precautionary action to protect the local cetaceans. The ASC offered to provide advice and drew attention to the ACCOBAMS guidelines for seismic surveys, and urged that: duplicate surveys should be avoided across the same area, alternative approaches to seismic airgun survey should be sought and deployed and efforts should be made to avoid ensonifying adjacent areas simultaneously.

ACCOBAMS and the IWC have been working together on ship strikes for some time. ACCOBAMS agreed that the work should continue, welcomed the appointment of the ship strikes co-ordinators (one of whom is the Chair of the ASC ship strikes working group) and reiterated its support for the global database and existing monitoring and mitigation efforts. The ASC ship strikes working group will continue to work on these issues and foster collaboration with IWC, ASCOBANS, CMS and IMO and develop priority actions and studies, including the consideration of a project to develop a standard training module.

Finally, the ASC developed a recommendation on scientific aspects of whalewatching. It noted that an 'ACCOBAMS certificate of accreditation for whale watching' will be developed and agreed that this should take into account the ACCOBAMS Whale Watching Guidelines. It also supported the continuation and expansion of national or regional training courses (based on the PELAGOS expertise) for operators covering the biology of animals,

[4]*http://www.ascobans.org.*
[5]*http://www.accobams.org.*

risks, boat behaviour around the animals, how to achieve ACCOBAMS accreditation, involvement in scientific research, etc. The ASC will continue to consider potential adverse effects on cetaceans and means to mitigate these. It also urged monitoring the activity of whale-watching operators in each country in order to obtain information on growth and development to try to identify potential problems before they become too difficult to manage. Finally it agreed to assist in the development of methods to better inform the general public about responsible boat behaviour around cetaceans. The ASC noted the importance of continued co-operation with IWC and others on this issue.

The Committee thanked Donovan for his report and **agrees** that he should represent the IWC at the next ACCOBAMS meeting.

4.4 Food and Agriculture Organisation of the United Nations (FAO)

No observer for the IWC attended the 2012 meeting of FAO.

4.5 Inter-American Tropical Tuna Commission (IATTC)

The reports of the IWC observer at the 83rd and 84th meetings of the IATTC held in La Jolla, USA 25-29 June 2012 and 24 October 2012 respectively are given as IWC/65/4(2013)E. The Antigua Convention came into force on 27 August 2010 and under this the IATTC is expected to give greater consideration to non-target and associated species, including cetaceans, in taking management decisions. A summary was given of ongoing work describing what is known about the direct impact of the fisheries on other species in the ecosystem and the environment. This ongoing work will shape future directions of AIDCP (see Item 4.6) and IATTC measures aimed at managing fisheries and conserving dolphins.

The Committee thanked Rusin for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next AIDCP meeting.

4.6 Agreement on the International Dolphin Conservation Program (AIDCP)

The report of the IWC observer at the 25th and 26th Meetings of the Parties to the AIDCP held in La Jolla, USA on 19 June 2012 and 23 October 2012 respectively is given as IWC/65/4(2013)F. The AIDCP mandates 100% coverage by observers of fishing trips by purse seiners of carrying capacity greater than 363t in the agreement area and in 2012 all trips (746) by such vessels were sampled by independent observers.

The overall dolphin mortality limit (DML) for the international fleet in 2012 was 5,000 animals and the unreserved portion of 4,900 was allocated to 84 qualified vessels that requested DMLs. In 2012, no vessel exceeded its DML. The number of sets on dolphin associated schools of tuna made by vessels over 363t has been increasing in recent years, from 9,246 in 2008 to 10,910 in 2009 to 11,645 in 2010, however fewer were made in 2011 (9,604) and 2012 (9,220). While fewer dolphin sets were made in 2011 and 2012, this remains a frequent practice and the predominant method for catching yellowfin tuna by purse-seine in the ETP. There have been insufficient resources to conduct dolphin and ecosystem assessment surveys since 2006 so it is unclear when updated abundance estimates for cetaceans in the ETP will be available.

In 2011 and 2012, the AIDCP focused significant discussion on consideration of reducing observer coverage and developing an 'Ecosystem Friendly' certification scheme for tuna caught in association with dolphins. Due to the increasing sentiment among some Parties that the dolphin problem has been solved and that dolphin-fishing methods are better economically and environmentally than dolphin-safe methods, in 2013 the AIDCP Parties are expected to continue consideration of these proposals and others that have the potential to increase fishing effort on dolphins and the magnitude of associated direct and indirect effects of this practice.

The Committee thanked Rusin for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next AIDCP meeting.

4.7 International Committee on Marine Protected Areas (ICMMPA) and IUCN Marine Mammal Protected Areas Task Force

The International Committee for Marine Mammal Protected Areas was formed as an international committee of experts in 2006 to address common issues and challenges faced by scientists and managers using spatial management tools to manage and conserve important cetacean habitats or populations. In 2008, the IWC endorsed and supported a proposal by ICMMPA to host the first international conference on marine mammal protected areas, in 2009. Since that time, the ICMMPA has undertaken several initiatives and has co-hosted, with France, a second conference in Martinique, in 2011[6]. In October 2012 the ICMMPA met in La Rochelle, France, hosted by l'Université de La Rochelle. The primary agenda for the meeting was to develop the mission statement, terms of reference and structural organisation of the newly approved IUCN arm of ICMMPA. This partner organisation is a Task Force on Marine Mammal Protected Areas. These documents were developed and will be available from the new Task Force co-chairs Erich Hoyt and Giuseppe Notarbartolo di Sciara, once the Task Force is officially announced. The IUCN MMPA Task Force membership includes all of the ICMMPA members, with several IUCN member additions. The ICMMPA remains a non-governmental partner for the Task Force and, amongst other tasks, will convene conferences and other initiatives that may not fit the IUCN Task Force terms of reference. The IUCN MMPA Task Force will be officially announced at IMPAC3 in October 2013.

ICMMPA is currently working with the Government of Australia, who will host the third International Conference on Marine Mammal Protected Areas, at a venue in Adelaide in November 2014.

4.8 International Council for the Exploration of the Sea (ICES)[7]

The report of the IWC observer documenting the 2012 activities of ICES is given as IWC/65/4(2013)B. The ICES Working Group on Marine Mammal Ecology (WGMME) met 5-8 March 2012.

The WGMME built on the work of the ASCOBANS/HELCOM small cetacean population structure workshop to determine Management Units (MUs) for the more common species as such information is relevant to the development of biodiversity indicators. Based on the available information, there were single MUs in the European North Atlantic for common dolphins, white-beaked dolphins, white-sided dolphins and common minke whale. For bottlenose dolphins there are ten separate units closely associated with the mainly

[6] *http://second.icmmpa.org.*
[7] *http://www.ices.dk.*

resident inshore populations in the European North Atlantic and a separate MU for the wider ranging mainly offshore animals. For harbour porpoises, MUs are proposed for the Iberian Peninsula, Bay of Biscay, Celtic Sea and northwest Ireland/west Scotland and the North Sea. The MUs for harbour porpoises will need to be revisited as indicators for the Marine Strategy Framework Directive (MSFD) become better defined.

The WGMME considered biodiversity indicators and bycatch was the only indicator suggested that had a clear link with a particular human activity. The indicator metric proposed by ICG-COBAM was very clearly linked to OSPAR's EcoQO on harbour porpoise bycatch in the North Sea. With pressure for the rapid development of biodiversity indicators for good environmental status through the Marine Strategy Framework Directive (MSFD), it is essential that they are based on sound science and take a pragmatic approach to the incorporation of fisheries data. As such, it was proposed that a management framework approach is adopted (rather than the EcoQO approach) and further developed in 2013 for relevant species.

WGMME conducted a review of the effects of wave energy converters on marine mammals and provided recommendations on research, monitoring and mitigation schemes. These are at a relatively early stage of development when compared to other renewable energy technologies and this is reflected in the lack of knowledge of their effects on the marine environment. It is essential that full advantage is taken of test deployments and early arrays to gather information on the actual interactions between devices and wildlife. A review of such work is being undertaken during 2013.

The ICES Working Group on Bycatch of Protected Species (WGBYC) met on 7-10 February 2012. It reviewed the status of information on recent bycatch estimates and assessed the extent of the implementation of bycatch mitigation measures. Reports from 17 member states indicated extrapolated estimates of bycatch for 2010 of about 870 cetaceans. The species involved were striped dolphins, common dolphins, harbour porpoises and bottlenose dolphins. Estimates are patchy and monitoring obligations not being met by several member states. Implementation of bycatch mitigation measures was also found to be poor, with few countries able to confirm that obligations for pinger deployment were being met.

The 2012 ICES Annual Science Conference (ASC) was held in Bergen, Norway 17-21 September 2011. Some sessions were designed with marine mammals included as an integral part. A number of sessions were of relevance to the Committee, including those describing:

(1) bycatch and discards;
(2) consequences of improved survey performance on assessments and management advice; and
(3) how does renewable energy production affect aquatic life?

The Committee thanked Haug for the report and **agrees** that he should represent the Committee as an observer at the next ICES meeting.

4.9 International Maritime Organization (IMO)[8]

The report of the IWC observer to the IMO is given as IWC/65/4(2013)J. The IWC has contributed to IMO discussions on addressing ship strikes and the impacts of underwater noise from shipping. In December 2012, IMO adopted changes to the shipping lanes in the Santa Barbara Channel, and off San Francisco, California, USA in order to reduce ship strike risk to blue whales (COLREG.2/Circ.64).

The IMO has been developing non-mandatory technical guidelines to minimise underwater noise from commercial ships. These include available options for ship-quieting technologies and operational practices. In April 2013, the IMO correspondence group working on the issue (including participation by the IWC Secretariat) presented draft guidelines to the IMO sub-committee on ship design and equipment (DE57/17). The guidelines help establish a consistent approach to assist designers, ship owners and ship operators in evaluating how much noise reduction is possible for new and existing ships when compared to existing ships of similar type, size and propulsion system. The IMO Marine Environment Protection Committee (MEPC) is expected to approve the guidelines in early 2014 and make them available as an MEPC circular.

The IMO also continued to develop a mandatory Polar Code. This is intended to augment existing measures to reduce the environmental impacts of shipping in polar waters, taking into account their greater environmental sensitivity. This work will continue through 2013.

The Committee thanked Leaper for his report and **agrees** that he (or the Secretariat) should represent the Committee at the next IMO meeting.

4.10 International Union for the Conservation of Nature (IUCN)[9]

Cooke and Reeves, the IWC observers, reported on the considerable cooperation with IUCN that had occurred during the past year and this is given as IWC/65/4(2013)I.

World Conservation Congress

The World Conservation Congress was held on Jeju Island, Korea in September 2012. There were three cetacean-related events at the Congress: a workshop on lessons learned from the IUCN western gray whale conservation initiative; a poster presentation on the local population of Indo-Pacific bottlenose dolphins found around Jeju; and a workshop on cetacean conservation and whalewatching in Africa. IUCN issued a number of statements on Korean environmental issues, including on the possible resumption of whaling in Korean waters.

Western gray whales

Two further meetings of the IUCN Western Gray Whale Advisory Panel have been held in the past year, in November 2012 in Korea and in May 2013 in Japan. At the time of writing, the report of the May meeting is not yet available but a summary of results can be found in Annex F, Appendix 5. An updated population assessment was received by the Panel but the data from the two independently collected series of photo-id data yielded apparently discrepant results, one indicating an increasing population and the other indicating a stable or declining population. An assessment based on one of these data sets is available as SC/65a/BRG27.

Red List updates

Updates since the last Annual Meeting include listing of the Mediterranean 'subpopulations' of the following species: sperm whale (Endangered), fin whale (Vulnerable), striped dolphin (Vulnerable), common bottlenose dolphin (Vulnerable), Cuvier's beaked whale (Data Deficient), long-finned pilot whale (Data Deficient) and Risso's dolphin (also Data Deficient).

[8]*http://www.imo.org.*

[9]*http://www.iucn.org/.*

A current list of all cetacean species and populations that have been assessed for the Red List, and their current Red List classification, is maintained on the Cetacean Specialist Group site[10] with links to the assessments which are held on the Red List website[11].

Cetacean Specialist Group
IUCN Cetacean Specialist Group members have continued to actively assist with cetacean conservation and research projects around the world. Of particular current interest is the ongoing project on study of the status and management options for the Critically Endangered Mekong river population of Irrawaddy dolphins run by WWF Cambodia in co-operation with relevant public authorities. The website of the IUCN Cetacean Specialist Group[12] contains regular updates on IUCN's cetacean-related activities and other work in which group members are involved.

The Committee thanked Cooke and Reeves for their report and **agrees** that Cooke should continue to act as observer to IUCN for the IWC.

4.11 North Atlantic Marine Mammal Commission (NAMMCO)[13]

4.11.1 Scientific Committee
The report of the IWC observer at the 19th meeting of the NAMMCO Scientific Committee (NAMMCO SC) held in Tasiilaq, East Greenland from 19-22 April 2012 is given as IWC/65/4(2013)K.

A joint Norwegian-Russian Ecosystem Survey examined habitat use and prey associations of white-beaked dolphins in late summer. Dolphins used the southern Atlantic waters and the Polar Front area farther north, with a general overlap with most prey species and positive association with blue whiting in the southern habitat.

Catch and bycatch data from 2006-08 from a monitored segment of the Norwegian fleet of coastal gillnetters were used to estimate bycatch rates of harbour porpoises in Norway. Landings statistics were used to extrapolate to the entire fishery, estimating a total annual bycatch of 6,900 porpoises by the two fisheries. The bycatch numbers of harbour porpoises could also be high in Iceland, based on preliminary information presented to the NAMMCO-ICES workshop in 2010. The NAMMCO-SC recommended that total bycatch estimates be attempted and that assessments of sustainability proceed through the relevant Working Groups.

NARWHALS-WEST GREENLAND/CANADA
The NAMMCO-SC agreed on the metapopulation structure for narwhals in Baffin Bay, Hudson Bay and adjacent waters as a useful approach for identifying summer aggregations as management units in narwhals. Satellite tracking of whales that return to summering grounds the following year suggest interannual site fidelity, with summer aggregations to some extent being demographically-independent sub-populations with minimal or no exchange of animals. Narwhals in Canada constitute five separate stocks with some limited exchange between three of the stocks.

There had been an overall increase in West Greenland narwhal catches during the 20th century which was especially pronounced after 1950. However since 1993, a significant decline in overall catches has been observed. Aerial surveys conducted in the North Water in May resulted in fully corrected abundance estimates of 10,677 (95% CI: 6,120-18,620) narwhals in 2009 and 4,775 (95% CI: 2,417-9,430) in 2010.

Age estimation by racemization was used to estimate biological parameters of narwhals, including a maximal lifespan expectancy of ~100 years of age.

NARWHALS IN EAST GREENLAND
Satellite tracking showed that narwhals in East Greenland have a yearly migration where they leave the fjords and move off the coast in winter. Whales from the Scoresby Sound area seem to belong to a stock separate from other narwhal aggregations in East Greenland. Age-structure data from Ittoqqortormiit was applied to assessments of both East Greenland areas, and the harvest was found to select for older animals. The current annual growth rate in the absence of harvest was estimated between 1.2% (95% CI:0-3.5) and 3.7% (95% CI:1.6-5.9), depending upon model and area.

It was noted that there is little information on the predicted response of marine mammals to changing Arctic conditions including changes in sea ice, climate and prey species as well as increased human development activity such as seismic, shipping, and drilling. The NAMMCO-SC recommended holding an international symposium on the effect of seismic and other development activities on Arctic marine mammals with a focus on white whales and narwhals.

WHITE WHALES
Aerial surveys conducted in the North Water in May resulted in fully corrected abundance estimates of 2,008 (95% CI 1,050-3,850) white whales in 2009 and 2,482 (95% CI 1,439-4,282) in 2010.

The assessment of West Greenland white whales was updated with age-structured data, recent abundance estimates and catches. Results from different scenarios provided annual growth rate estimates from 3.2% to 5%, in the absence of harvest. The depletion ratio for 2012 was estimated as 44% (95% CI: 16%-88%), with a yearly replacement of 510 (95% CI:170-780) individuals. The NAMMCO-SC agreed that the revised assessment confirmed that the current removals based on the 2009 advice are sustainable. Based on a 70% probability of population increase, it concluded that a total annual removal of 310 white whales in West Greenland is sustainable (excluding Qaanaaq).

No specific advice was given on the North Water (Qaanaaq), since the current removals remain at a low level relative to the population size. No advice was given for the harvest in Canada.

AGE DETERMINATION WORKSHOPS
Recognising that there are a number of problems with age determination for white whales and narwhals, three age determination workshops were organised. The first in Tampa (FL, USA) examined the state of the art of general ageing techniques; the second in Beaufort (NC, USA) focused on age estimation of belugas using teeth; and the third in Copenhagen (Denmark) focused on the use of tusks for age estimation in narwhals.

The NAMMCO-SC agreed that an annual deposition rate of tooth GLG was to be the accepted standard in white whales, and it recommends that aspartic acid racemisation is applied to white whales, including fore known history/age animals in the analyses in order to calibrate the technique and provide an alternative ageing method.

PILOT WHALES
The NAMMCO-SC agreed that it was unlikely that a full pilot whale assessment could be attempted in the near future.

[10]*http://www.iucn-csg.org/index.php/status-of-the-worlds-cetaceans.*
[11]*http://www.redlist.org.*
[12]*http://www.iucn-csg.org/.*
[13]*http://www.nammco.no/.*

It was noted that both an adapted 'AWMP' procedure as well as the PBR approach could be used for an inverse advice calculation of the minimum abundance required to sustain the average take by the Faroese.

With the average annual catch by the Faroese since 1997 being 678, and the CV of the latest abundance estimate being 0.27, the AWMP procedure estimates that an abundance estimate around 50,000 pilot whales and a similar precision is required to sustain the catch. In comparison, the PBR approach calculates an abundance estimate around 80,000 whales. These calculations reflect precautionary estimates of the minimum abundance estimates required to sustain the Faroese hunt. However, the geographical range of the stock(s) that supply the Faroese hunt is unknown, and it is unresolved how the calculated estimates compare with the accepted estimate of 128,000 (95% CI: 75,700-217,000) pilot whales from the Icelandic and Faroe Islands area of T-NASS.

The average annual catch of long-finned pilot whales in West Greenland during 1993-2007 was 126 whales and an aerial survey estimated 7,440 (95% CI 3,014-18,367) animals in 2007. Applying a PBR approach, the sustainable harvest level of pilot whales would be around 50 whales per year. An estimate based on the AWMP procedure suggests that an annual take of 70 whales is sustainable. However, the survey did not cover the entire range of pilot whales in West Greenland and the summer aggregation cannot be considered an isolated stock. Instead, it is likely connected to pilot whales along Labrador and at Newfoundland.

The NAMMCO-SC noted that humpback whales are present in previously unsurveyed areas off East Greenland, in agreement with information provided by observers on seismic surveys.

The average annual catch of white-beaked dolphins in West Greenland during 1993-2007 was 30 dolphins. An aerial survey estimated 11,801 (95% CI 7,562-18,416) animals in 2007. Applying a PBR approach suggests that the sustainable harvest level would be around 125 whales per year.

A bowhead whale male tagged in Disko Bay in May 2010 moved into the Northwest Passage where it spent about two weeks in September 2010 in close proximity to a bowhead whale tagged in Alaska in spring the same year. Both returned to their normal seasonal range, but the excursions suggest that bowhead whales from the Pacific and the Atlantic occasionally may be connected in years with little sea ice in the Northwest Passage.

Based on an increase in sightings, the NAMMCO-SC recommended monitoring of trends and abundance of the Spitsbergen population of bowhead whales. Norway will continue passive acoustic monitoring with two extra devices in the northern Fram Strait and north of Svalbard.

SURVEY PLANNING

A new large-scale T-NASS survey of cetaceans in the North Atlantic is desirable within the near future, and the NAMMCO-SC discussed how best to approach such a large-scale survey effort. The most optimal year for a large scale coordinated survey is 2015. The survey plans for the different countries are generally similar to those of the last T-NASS survey.

4.11.2 Council

The report of the IWC observer at the 21st Annual Council Meeting of NAMMCO held in Svolvær, Norway from 11-13 September 2012 is given as IWC/65/4(2013)C. In 2010, the Council approved the go-ahead for a manual on hunting. It will be the first comprehensive manual for hunters that details weaponry and ballistics information with a focus on safety.

An international expert group on killing methods for small cetaceans met in November 2011. Significant reductions in killing times have been recorded in recent years in the Faroe Islands, Greenland, Japan and Nunavut Canada, due to development of new equipment and practices. Several recommendations were made regarding further improvement in killing methods, safety and training of hunters.

The Council has concluded that an abundance of pilot whales in the range of 50,000-80,000 animals will sustain the annual Faroese drive hunt. The most recent abundance estimate for the pilot whale stock is 128,000 in the Iceland-Faroese survey area. This means that the annual Faroese catch of pilot whales is well within sustainable limits.

Based on a NAMMCO initiative, a project has been designed to test different modelling approaches of interactions between marine mammals and fisheries. The project, which includes scientists both from NAMMCO and other relevant countries, will start as soon as funding is obtained.

The Committee thanked Sakamoto for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next NAMMCO Council Meeting.

4.12 North Pacific Marine Science Organisation (PICES)[14]

The report of the IWC observer at the 21st annual meeting of PICES held from 12-21 October 2012 in Hiroshima, Japan is given as IWC/65/(2013)H. The Marine Birds and Mammals Advisory Group (AP-MBM) requested that a seabird observer be included in the IWC-POWER cruise and it also revised its terms of reference as follows:

(1) provide information and scientific expertise to BIO and the FUTURE Program, and, when necessary, to other scientific and technical committees with regard to the biology and ecological roles of marine mammals and seabirds in the PICES region;
(2) identify important problems, scientific questions, and knowledge gaps for understanding the impacts of climate change and anthropogenic factors on MBMs in ecosystems of the PICES region through Workshops, Theme Sessions and Science Reports;
(3) assemble information on the status and key demographic parameters of marine mammals and seabirds and contribute to the Status Reports; and
(4) improve collaborative, interdisciplinary research with marine mammal and seabird researchers and the PICES scientific community.

Two sessions at the 2012 AP-MBM workshop were of relevance to the IWC, these were:

(1) the feasibility of updating prey consumption by marine birds, marine mammals, and large predatory fish in PICES regions; and
(2) environmental contaminants in marine ecosystems: seabirds and marine mammals as sentinels of ecosystem health.

The Committee thanked Kato for attending on its behalf and **agrees** that he should represent the Committee as an observer at the next PICES meeting.

[14]*http://www.pices.int/.*

4.13 Protocol on Specially Protected Areas and Wildlife of the Cartagena Convention for the Wider Caribbean (SPAW)[15]

The report of the IWC observer to SPAW is given as IWC/65/4(2013)D. At its 5th meeting of the Scientific and Technical Advisory Committee, held 22nd October 2012, SPAW recommended that collaboration with the IWC should be strengthened through the possible conclusion of a Memorandum of Cooperation.

The three-year Spain-UNEP LifeWeb Project comes to an end in December 2013. Under this, a number of activities have been completed including:

(1) broad-scale regional mapping of migration routes, critical habitats and human threats after compilation of available information and datasets; and
(2) a regional workshop on integration, mapping, GIS analysis of marine mammal migration routes, critical habitats and human threats in the wider Caribbean Region (WCR) held in Miami, Florida, 9-11 May 2011.

As a result of this work, regional maps and factsheets have been produced on the following issues:

(1) distribution of the 25 marine mammals species that occur regularly in the WCR (24 cetaceans and the West Indies manatee);
(2) species' richness;
(3) main threats and human impacts faced by marine mammals: pollutions, interactions with fisheries, maritime traffic, etc.; and
(4) existing policies, marine protected areas and governance for the conservation of marine mammals.

SPAW has developed a management plan for the Marine Mammal Sanctuary of the Dominican Republic and a learning exchange on the economic benefits of whalewatching was organised in March 2013 in Samaná, Dominican Republic.

A workshop on broadscale marine spatial planning and transboundary marine mammal management was held in Panama in May 2012. Participants were trained in marine spatial planning applied to marine mammals. As a result of this workshop, two sub-regional areas have been approved for the future scenario work in the WCR, due to their importance as habitats for marine mammals and to existing work and ongoing cooperation dynamics on marine mammals. The first sub-region proposed ranges from the Dominican Republic down to Trinidad and Tobago through the Lesser Antilles, with a focus on strengthening the links between existing or projected marine mammal sanctuaries and on developing other cooperation activities with the neighbouring islands.

The second sub-region encompasses the continental coast of Latin America from Venezuela to the border between Brazil and French Guiana, together with the Dutch Caribbean islands of Aruba, Bonaire and Curacão being included in the area. The scenario work in this second area will foster support to the already started cooperation between these countries and territories, particularly through a technical workshop held in Suriname in March 2013.

The IWC and Caribbean Environmental Programme (CEP) Secretariats have partnered in order to convene three workshops on the topics of entanglement and ship strike for the wider Caribbean countries. It was recognised that the IWC has the international technical expertise in understanding and responding to these human impacts and as such can provide the countries of the WCR access to this expertise through capacity building training and workshops. The first of two capacity building trainings on determining human impact and entanglement response training was conducted in English and Spanish in Mexico in November 2012.

The Committee thanked Carlson for attending on its behalf and **agrees** that she should represent the Committee as an observer at the next SPAW meeting.

4.14 Commission of the South Pacific (CPPS, Comisión Permanente del Pacífico Sur)

The report of the observers at the Meeting of the Parties to CPPS, held in Guayaquil, Ecuador from 10-12 April 2013 is given as IWC/65/4(2013)F. Mattila presented an overview of the global scope of the large whale entanglement issue and described the training currently offered through the IWC by the technical adviser and other members of the IWC expert advisory panel on this topic. Subsequently, the national representatives of the CPPS countries consulted with the Government of Ecuador, which had made an earlier formal request of the IWC Secretariat for National training for Ecuador. As a result of these consultations, Ecuador has agreed to host an IWC entanglement response training that will include participation by up to three participants from the other CPPS countries. Ecuador, CPPS and NGOs will provide the logistical and financial support for the training, and the IWC will provide the trainers and curriculum. The training will be held in Salinas, Ecuador, 27-28 June 2013.

It is anticipated that this training may stimulate requests for full national training from some other CPPS member countries. It may also represent a model or mechanism by which the two Conventions can conduct cooperative work in order to advance common goals to reduce human impact to cetaceans.

The Committee thanked Mattila and Félix for their joint report and also Mattila for attending on its behalf and **agrees** that he should represent the Committee at the next CPPS meeting.

5. REVISED MANAGEMENT PROCEDURE (RMP) – GENERAL ISSUES

5.1 Complete the MSY rates review

Since 2007, the Committee has been discussing maximum sustainable yield rates (MSYR) in the context of a general reconsideration of the plausible range to be used in population models used for testing the *Catch Limit Algorithm* (*CLA*) of the RMP (IWC, 2008b; 2009a; 2009c; 2010b; 2010c; 2010e; 2011d; 2011g; 2012b). The current range is 1% to 7%, in terms of the mature component of the population. Last year, the Committee agreed that no more than one further year should be allowed to complete the review, and that if it could not be completed this year, the current range (MSYR 1-7% in terms of the mature component of the population) would be retained.

5.1.1 Report of the intersessional Workshop

As part of the work plan agreed last year to complete the review, an intersessional Workshop was held in La Jolla, USA in March 2013 and a detailed summary and review of its report (SC/65a/Rep5) is given in Annex D, item 2.1.1. While the Workshop made considerable progress, it was not able to develop recommendations on the appropriate range of MSYR rates. Rather, it identified four areas of work that would assist discussions at this meeting. It also identified three main issues requiring discussion at the Annual Meeting:

[15] *http://www.cep.unep.org/cartagena-convention.*

(1) limitations of the modelling approach itself;
(2) limitations within the approach (e.g. paucity of data); and
(3) interpretation of the results in the context of the RMP.

The Committee thanked Donovan for chairing the intersessional Workshop and the participants for their work during it and subsequently, without which it would not have been possible to conclude the MSYR review at this meeting (see below).

5.1.2 Discussion including work completed since the Workshop

SC/65a/RMP09 presented results from an energetic model presented to the MSYR Workshop. The model was used to predict variability in the realised rate of increase (r_0) in a generic depleted whale population given estimates of the variability and autocorrelation in birth-rates. The Committee thanked de la Mare for conducting the analyses. The individual-based population dynamics model was reviewed by the EM group (see Annex K1).

None of the model runs conducted in SC/65a/RMP09 led to estimates of MSYL that were 0.6 or larger. In addition, Cooke (2007) had shown that MSYL was closer to 0.5 than to 0.6 based on simulations in the context of a model with environmental effects for a wide range of parameter values. The Workshop had identified two scenarios for consideration with respect to the relationship between $MSYR_{1+}$ and r_0: $MSYR_{1+}=r_0/2$ and $MSYR_{1+}=r_0/1.619$. The latter scenario corresponds to $MSYL_{1+}=0.6$. Given the results in SC/65a/RMP09 and in Cooke (2007), the Committee **agrees** that $MSYR_{1+}=r_0/2$ was more appropriate for drawing inferences regarding the range of MSY rates for use in trials.

A key component of the work over the period of the review had been directed at a meta-analysis of observed rates of increase at low population size. SC/65a/RMP08 provided the results of a final sensitivity test for the Bayesian hierarchical meta-analysis using the data for rates of increase for the 13 baleen whale stocks selected in SC/65a/Rep05. The extent of environmental variation in r_0 as a function of r_0/r_{max} in SC/65a/RMP08 was determined from Equation 2 in SC/65a/RMP09. The lower 5% and 10% points of the posterior predictive distribution for r_0/r_{max} for an unknown stock for this sensitivity test were 0.419 and 0.512 respectively. SC/65a/RMP02 constructed a posterior predictive distribution for an unknown stock for r_0 rather than r_0/r_{max}. The lower 5% and 10% points of this posterior predictive distribution were 0.029 and 0.037 respectively. The Committee thanked Punt for his work in undertaking these analyses.

The Committee recognised the considerable additional work that had been undertaken since the current range for (1% to 7% in terms of the mature component of the population) was selected in 1993 (IWC, 1994c, p.57). In particular, since 2007, the Committee had *inter alia:*

(1) assembled and evaluated information on rates of increase for stocks at low population size;
(2) explored some of the impacts of environmental effects on r_0 relative to r_{max} and the shape of the yield curve for exploited baleen whales; and
(3) developed a meta-analysis framework to integrate this information, along with information on demographics, to derive a probability distribution for r_0 and r_0/r_{max}.

Given the available information and knowledge, the Workshop had explored the sensitivity of the distribution for r_0/r_{max} to a number of factors, including choices of stocks from amongst those for which suitable data were available and to the potential effects of environmental variation on rates of increase (see Annex D, table 4). The Committee recognised that while the meta-analysis was an important advance, it was inevitably limited for a number of unavoidable reasons including uncertainty over a number of factors, as described in Annex D, item 2.1.3.

In conclusion, despite these uncertainties, the Committee **agrees** that it has a better basis to select the range for MSYR for use in trials than when the 1% to 7% choice had been made in 1993. In completing the review this year it recognised that this did not mean that additional work should not continue and be periodically reviewed by the Committee, both in a general sense and as part of *Implementations* and *Implementation Reviews.*

Given its importance in terms of meeting conservation objectives, discussion focused on the lower bound for MSYR for use in trials, based on the assumption MSYR $\sim r_0/2$. A number of options were considered when examining the results of the meta-analysis relating to choice of percentile (5% or 10%), the value for r_{max}, and whether the meta-analysis should be based on r_0 or r_0/r_{max}. A broad consideration of the full set of sensitivity tests in SC/65a/Rep05, SC/65a/RMP02 and SC/65a/RMP08, suggests a range of 1% to 2.5% for the lower bound for MSY rate expressed in terms of the age 1+ component of the population (during the RMP development process and to date, MSYR has been expressed in terms of the mature component of the population; the AWMP development process by contrast expresses MSYR in terms of the 1+ component).

Recognising the uncertainties in the meta-analysis and the need for precaution, the Committee **recommends** that $MSYR_{1+}=1\%$ be adopted as a pragmatic and precautionary lower bound for use in trials. The value corresponds to the lower of the two percentiles in table 5 of SC/65a/Rep05, and the lowest of the r_{max} values; all of the point estimates of r_0 used in the meta-analysis correspond to $MSYR_{1+}$ values larger than 1% under $MSYR_{1+}\sim r_0/2$. In essence, $MSYR_{1+}=1\%$ is roughly the equivalent of 1.5% $MSYR_{mat}$. The Committee also **recommends** that the current upper bound of $MSYR_{mat}=7\%$ be changed to the roughly equivalent $MSYR_{1+}=4\%$. These recommendations have the additional practical advantage of unifying the MSYR 'currencies' of the RMP and AWMP processes.

In making this practical recommendation, the Committee **recognises** that much remains to be learnt regarding MSYR for baleen whales and that the issue of the appropriate range for MSYR should continue to be reviewed as new information becomes available. In particular, should data become available for more species and populations, the meta-analysis should be revisited with a view to making it more representative. The Committee **emphasises** in particular the need for information relating to stocks of species of interest for the RMP, including fin, sei, Bryde's and minke whales (although of course information on MSYR is important in assessing the status of all species within the Committee's work). Work should also continue to better understand the impact of environmental variation on MSYR and the biological and ecological processes leading to density-dependence, together with the shape of yield curves and hence the relationship between r_0 and $MSYR_{1+}$. As is already the case, consideration of MSYR for particular species and stocks should also occur during *Implementations* and *Implementation Reviews,* particularly where other information for the stock or species concerned suggests alternative plausible values to those discussed above.

The Committee also **recommends** that the '*Requirements and Guidelines for Implementations under the RMP*' (IWC, 2012h) be updated as given in Annex D, item 2.1.3.

The Committee thanked Brandon, Butterworth, Cooke, de la Mare, Donovan, Kitakado and Punt, as well as the other participants of the many intersessional meetings without whom it would not have been possible to complete the MSYR review. Above all, it acknowledged the contribution and dedication of the field researchers, whose data, particularly on bowhead, blue, right and humpback whales, collected over periods of up to 40 years, formed the backbone of the meta-analysis and the MSYR review.

5.2 Finalise the approach for evaluating proposed amendments to the *CLA*

In 2006, the Committee agreed that two steps needed to be completed in order to finalise the approach for evaluating proposed amendments to the *CLA*: the review of MSY rates, completed this year (see Item 5.1 above), and specification of additional trials for testing the *CLA* and amendments to it. Last year, the Committee re-established a working group under Allison to develop and run such trials for consideration at this year's meeting. However, Allison reported that there had been insufficient time during the intersessional period to conduct the work.

The Committee noted that the Working Group on Ecosystem Modelling had identified a set of possible issues to be addressed using individual-based simulation and other models (see Annex K1, item 3). These issues could form the basis for additional trials to further explore the behaviour of the RMP. The Committee **agrees** to re-establish the working group under Allison (see Annex R) to formulate and run trials related to environmental degradation, taking account of the discussions in Annex K1, and to report the results to the next Annual Meeting.

5.3 Evaluate the Norwegian proposal for amending the *CLA*

In 2004, Norway had indicated that it might submit a proposal for the revision of the *CLA* and the base-case and *Robustness Trials* (IWC, 2006a, pp.79-80). In 2007, the Committee received a paper (Aldrin and Huseby, 2007) documenting the results for all single stock trials for a proposed alternative *CLA*, as required for consideration of a proposed revision of this nature (IWC, 2007a, p.89).

The Committee noted in the past that evaluation of this proposal required: (a) completion of the MSYR review, (b) review of the trials conducted in Aldrin and Huseby (2007); and (c) review of additional trials which explore the performance of the RMP given environmental degradation. This year, the Committee has completed the MSYR review (see Item 5.1), but it was not able to complete the trial specifications related to environmental degradation (see Item 5.2) and it did not have time to review Aldrin and Huseby (2007).

The Committee **agrees** that: (a) Aldrin and Huseby (2007) should be a primary document for SC/65b; and (b) it would not be necessary to have all of the trials related to environmental degradation completed before a decision on amending the *CLA* could be made, given the time required to parameterise trials based on individual-based models. It also **agrees** that the *Implementation Review* for the North Atlantic common minke whales could take place even though a decision had yet to be made regarding the Norwegian proposal to amend the *CLA*.

5.4 Modify the 'Catch Limit' program to allow variance-covariance matrices

Last year, it was noted that the Norwegian 'CatchLimit' code for the current *CLA* allows variance-covariance matrices for the abundance estimates to be specified, and Allison was tasked to work intersessionally with the Norwegian Computing Center to develop a final version of the program. She reported that the Norwegian version of the current *CLA* version was used in the trials for western North Pacific minke whales, although some coding issues remain. The Committee **recommends** that Allison contact the Norwegian Computing Center to resolve any final coding issues.

5.5 Update the 'Requirements and Guidelines for Conducting Surveys'

Last year, the Committee recommended that a review covering model-based abundance estimation in theory and practice, and its relation to the design-based approach, be conducted. The review was to provide draft text for inclusion in the 'Requirements and Guidelines for Conducting Surveys' (IWC, 2012g). Hedley was contracted to conduct the review, but was unable to complete it on time. The Committee looks forward to receiving the review at the 2014 Annual Meeting.

5.6 Update the list of accepted abundance estimates to include western North Pacific common minke whales

The Committee noted that last year it had developed a list of accepted abundance estimates related to RMP stocks (IWC, 2013d, p.105). It **agrees** that the list of accepted abundance estimates for the RMP be updated using the values provided by the Working Group on western North Pacific minke whale (see Annex D1, item 9). The broader question of accepted abundance estimates is addressed under Item 22.

5.7 Other business

A number of issues arose during the 'second' western North Pacific common minke whale *Implementation Review* Workshop (SC/65a/Rep04) that were of general relevance to the RMP process and required the Committee's attention. The issues, and the rationale for the sub-committee's recommendations, are given in Annex D, item 2.7. The recommendations arising are as follows.

(1) Imbalanced sex ratio in incidental catches: the Committee **agrees** to consider this matter at the 2014 Annual Meeting and encourages papers on this topic.
(2) Review of abundance estimates in an RMP context: the Committee **endorses** the recommendation that the specified set of associated information be provided along with abundance estimates in its 'Requirements and Guidelines for *Implementations* and *Implementation Reviews*'.
(3) Changing survey coverage in time-series of abundance estimates: the Committee **agrees** to consider the matter at the 2014 Annual Meeting and encourages papers on the topic. It will at that time re-examine the set of core robustness trials which relate to this issue.
(4) Use of surveys carried out in different months in both the *Implementation* process and in actual implementation of the RMP: the Committee **agrees** to consider the matter at the 2014 Annual Meeting and encourages papers on the topic.

5.8 Work plan

The Committee's views on the work plan developed by the RMP sub-committee are given in Item 24, and the financial implications in Item 26.

6. RMP – *IMPLEMENTATION*-RELATED MATTERS

6.1 North Pacific common minke whales

Since 2010, the Committee has been following the process of an *Implementation Review* for western North Pacific common minke whales according to its 'Requirements and Guidelines for *Implementations* under the RMP' (IWC, 2012b). The scheduled period for an *Implementation* or *Implementation Review* is normally two years but, given the complexities of this particular *Implementation Review*, it has not been possible to keep to this schedule. This year's Annual Meeting was thus the third of the *Implementation Review*, but its objectives were those of the 'Second Annual Meeting' as described in the Requirements and Guidelines for *Implementations*, which are to complete the *Implementation Review* by examining the results of the final *Implementation Simulation Trials* and agreeing recommendations for implementation of the RMP.

6.1.1 Review report of intersessional Workshop

The Committee reviewed the report of the intersessional Workshop held in La Jolla, California in March 2013 and chaired by Donovan (SC/65a/Rep04). The Workshop is referred to as the '2nd Intersessional Workshop', although it is actually the third such Workshop because of the extended schedule of this *Implementation Review*.

The Workshop was primarily a technical Workshop, the objectives of which were to review the results of work agreed at the 2012 Annual Meeting of the Scientific Committee (IWC, 2013c) and to consider the results of the final trials using the agreed approach that forms part of the *Implementation* process (IWC, 2012h). The ultimate objectives were to develop recommendations for consideration by the Committee on: management areas; RMP variants (e.g. catch-cascading, catch-capping); suggestions for future research to narrow the range of plausible hypotheses or eliminate some hypotheses; and 'less conservative' variants(s) with their associated required research programmes and duration.

A detailed summary of the Workshop report is given in Annex D1, item 2. A map defining the sub-areas used for the *Implementation Review* is given as Fig. 1.

The Workshop made considerable progress but it had not been possible to consider final trial results because decisions necessary for finalising the trials were only able to be taken at the Workshop. However, some preliminary results for some trials were available and review of these led to refinement and reduction of the total number of management variants (see Item 6.1.3.1) to be considered at this Annual Meeting.

The Workshop had developed a work plan for the remainder of the intersessional period aimed at completing the final trials and providing results well in advance of this Annual Meeting. Considerable progress was made but because of the complexities of this *Implementation Review* it had not been possible to complete this work prior to the Annual Meeting. The Workshop had also identified a number of generic issues related to conducting trials which were referred to the RMP sub-committee (see Annex D, item 2.7).

The Committee **endorses** the conclusions and recommendations from the Workshop report (SC/65a/Rep04) and expressed its thanks to Donovan and all participants for their hard work and progress.

6.1.2 Progress since intersessional Workshop

6.1.2.1 UPDATE TO TRIAL SPECIFICATIONS

Changes to the trial specifications and the code implementing these specifications since the 2nd Intersessional Workshop are described in Annex D1, item 3.1. The Committee **endorses** these changes to the trial specifications; the final trial specifications are given in Annex D1, Appendix 2.

6.1.2.2 REVIEW OF FINAL CONDITIONING RESULTS

Regarding conditioning the *Implementation Simulation Trials*, the Committee had reviewed the fit diagnostics for the base-case trials and those for many of the sensitivity tests implemented in other trials at the 2012 Annual Meeting (IWC, 2013c). Work on conditioning trials continued during the intersessional period and the conditioning diagnostics for all trials conducted during this period had been reviewed by Punt. The Committee had agreed that the *ad hoc* Working Group established under the Working Group on the *Implementation Review* for Western North Pacific common minke whales to review trial results should check the conditioning of any trials that may be influential in the final decisions regarding the selection of RMP variants. The

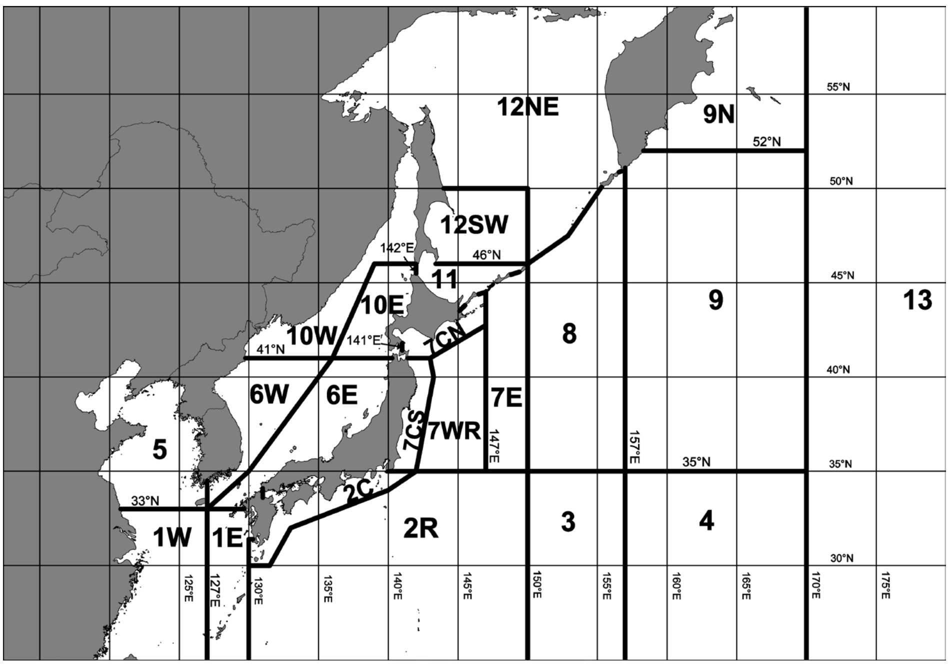

Fig.1. The 22 sub-areas used for the *Implementation Simulation Trials* for North Pacific minke whales.

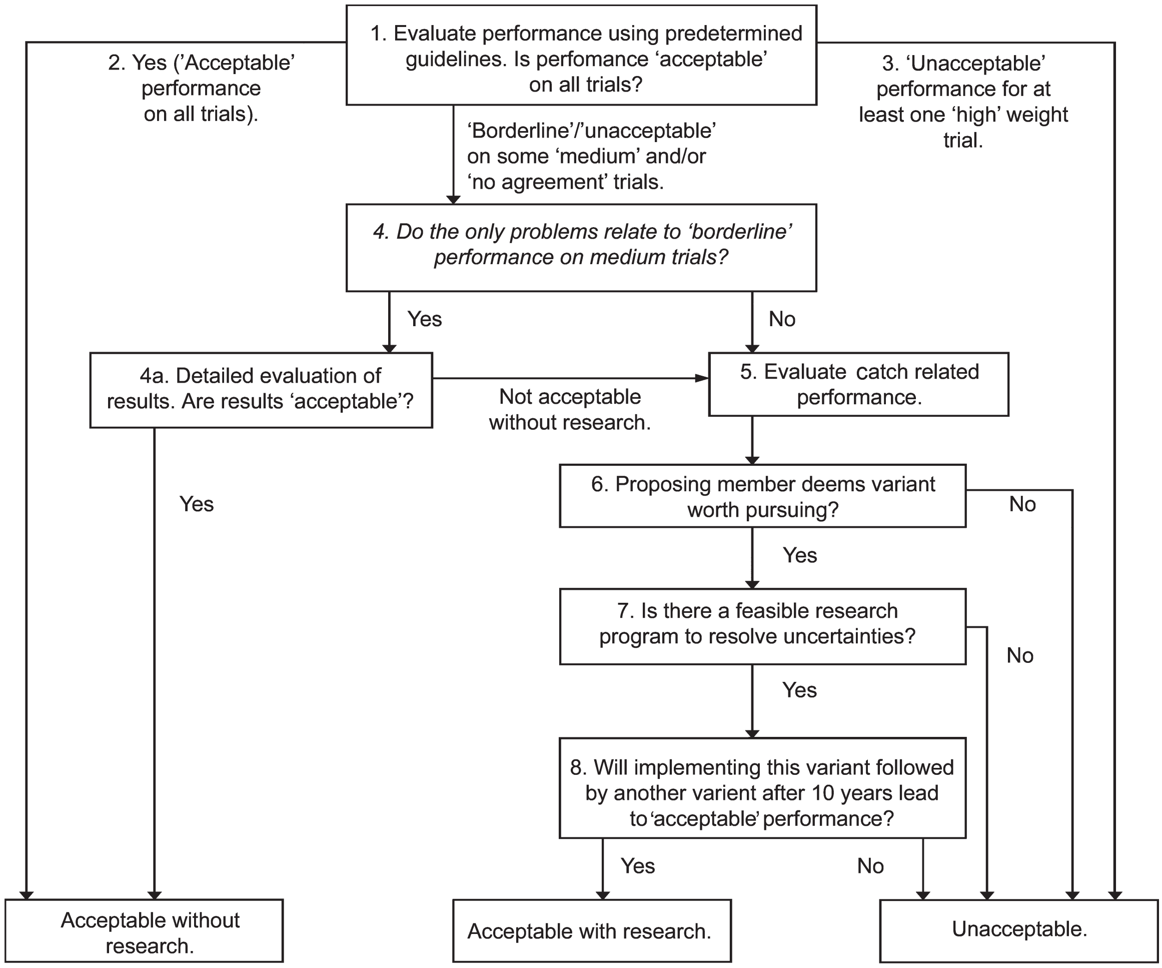

Fig.2. Flowchart summarising the procedure for review of *IST*s (from IWC, 2005a, pp.91-92).

Committee confirms that conditioning had been successfully achieved for all influential trials (Annex D1, item 3.2).

6.1.3 Complete Implementation Review

According to the Requirements and Guidelines for *Implementations,* completing the *Implementation Review* involves reviewing the results of the final *Implementation Simulation Trials* and making recommendations on: Management Areas; RMP variants; and inputs to the *CLA* for use in actual applications of the RMP.

6.1.3.1 REVIEW RESULTS OF FINAL *IMPLEMENTATION SIMULATION TRIALS*

The procedure for reviewing results of the final trials is given in the Committee's Requirements and Guidelines for *Implementations* (IWC, 2012h). A very brief summary is given below.

Fig. 2 shows a flow chart of the decision process to be followed.

The procedure first involves consideration of specified diagnostics to evaluate conservation performance generated from trial results, and determining from them whether the performance of each trial is 'acceptable', 'borderline' or 'unacceptable' under each of the defined RMP variants (see Annex D1, item 4.1). The style in which these results should be presented is detailed in Annex D1, item 4.2. RMP variants are defined by the *Management Areas* to be used (*Small Areas*, etc.) and how any catches are to be taken from them (see Annex D1, item 5). This part of the procedure is a technical exercise that follows directly from the results and requires no judgement.

The second stage is to evaluate each RMP variant by considering the results of all trials together in order to decide whether each variant is 'acceptable without research', 'acceptable with research' or 'unacceptable' (see Annex D1, item 5). This part of the procedure does require judgement because consideration is needed of the overall balance of the trials and the characteristics of any specific trials for which performance is questionable. The process for evaluating each variant can be summarised as follows:

(1) if the performance is close to 'acceptable' for a small number of 'borderline' trials then the Committee may agree that the variant is 'acceptable without research';
(2) if the performance is close to 'unacceptable' or is 'unacceptable' for a number of trials based on a specific hypothesis, then the Committee may agree that this is a candidate for the 'acceptable with research'; and
(3) if the performance is close to 'unacceptable' or is 'unacceptable' for a number of trials under several hypotheses, then the Committee may agree that the variant is 'unacceptable' and thus eliminated from further consideration.

Ten RMP variants to be evaluated had arisen from the 2nd Intersessional Workshop.

(1) *Small Areas* equal sub-areas. For this option, the *Small Areas* for which catch limits are set are 5, 6W, 7CS, 7CN, 7WR, 7E, 8, 9*, and 11.
(2) Sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CN, 9 and 11.
(3) Sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 9 and 11.

(4) Sub-areas 5, 6W, 7CS, 7CN, 7WR+7E+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 7CN, 7WR, 9 and 11.
(5) Sub-areas 5 and 6W are *Small Areas* and catches are taken from sub-areas 5 and 6W. Sub-areas 7+8+9*+11+12 form a combination area and catches are cascaded to the sub-areas within the combination area. The catch limits for sub-areas 12SW and 12NE are not taken.
(6) Sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* except that the catches from the 7+8 *Small Area* are taken from sub-areas 7CS and 7CN using the same method as for catch cascading to allocate the catch across the two sub-areas.
(7) Sub-areas 5+6W+6E+10W+10E and 7+8+9*+11 are *Small Areas*; catches from the 5+6W+6E+10W+10E *Small Area* are taken from subareas 5 and 6W using the same method as for catch cascading to allocate the catch across those five sub-areas, and catches from the 7+8+9+11 *Small Area* are taken in sub-area 7CN.
(8) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 8 and 9 using the same method as for catch cascading to allocate the catch across the two sub-areas.
(9) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across these sub-areas.
(10) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8, 9 and 11 using the same method as for catch cascading to allocate the catch across these sub-areas. Catches from sub-area 11 occur in May and June only.

After reviewing the initial results at the meeting, Japan requested that an 11th variant be evaluated.

(11) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across these sub-areas, except the catches from sub-areas 7CS, 7CN, 7WR and 7E are reduced by 50% after first subtracting the bycatches in these sub-areas.

The Committee's Requirements and Guidelines for *Implementations* allow for additional variants to be proposed for evaluation during the 2nd Intersessional Workshop as part of the *Implementation* process. However, due to the complexities of this *Implementation Review*, the results of only a few trials had been available during the 2nd Intersessional Workshop rather than the complete set as envisioned in the Requirements and Guidelines. Recognising these exceptional circumstances, the Committee **decided** to evaluate this additional variant noting that it was in accord with the RMP in that catches from all *Small Areas* cannot exceed the RMP catch limit (except when the bycatch exceeds the RMP catch limit when the commercial catch is set to zero).

In doing so, the Committee **reiterates** that, under normal circumstances, proposal and evaluation of additional variants should not take place at the 2nd Annual Meeting.

Annex D1, table 2 lists the factors considered in the trials and the plausibility assigned to each. Some of the factors were assigned 'medium' plausibility because the Committee had not been able to reach agreement on whether they should be 'low', 'medium' or 'high' (IWC, 2013c, p.11). A list of all the trials is given in Annex D1, table 1. In all there were 66 trials of which none were given 'high' weight. More details are given in Annex D1, item 5.

Annex D1, tables 3 and 4 summarise the application of the procedure for evaluating conservation performance. Results are shown in Annex D1, table 3 by stock-structure hypothesis and in Annex D1, table 4 by RMP variant. Annex D1, table 5 lists the average catches by sub-area for each RMP variant for the six base-case trials, reported for years 1-10 and for the entire 100-year projection period. The results in this table are illustrative only; the actual catches will depend on the application of the *CLA* to the abundance estimates and catches selected by the Committee (see Items 6.1.4.2 and 6.1.4.3).

The full set of trial results is available from the Secretariat upon request. Results for each variant are given in Annex D1, item 5 and are summarised below.

Variants 1, 2, 3, 4 and 6
These variants did not have 'unacceptable' performance for any trials, but had 'borderline' performance for one trial (B04) as shown in Annex D1, fig. 3. Given that the 'borderline' performance was close to 'acceptable', and that 'borderline' performance occurred only once out of 66 trials, these variants can be considered as candidates which are 'acceptable without research' (step 4a in Fig. 2).

Variant 5
Variant 5 had 'unacceptable' performance for trial B04 (Annex D1, fig. 3). It had 'borderline' performance for trials A04 (Annex D1, fig. 4), B03 (Annex D1, fig. 5), C03 (Annex D1, fig. 6), and C04 (Annex D1, fig. 7). Given that this variant fails for only one trial (B04) and is 'borderline' on four trials in which it is close to 'acceptable' for trial A04, this variant can be considered 'acceptable with research' because it fails only for stock structure hypothesis B (step 4a in Fig. 2).

Variant 7
Variant 7 performed 'unacceptably' on 22 out of 27 trials for stock-structure hypothesis C and 'borderline' on two (C14, C17). It also had 'borderline' performance for two trials based on stock-structure hypotheses A and B (A04, B04). This variant was close to 'acceptable' for these two trials (Annex D1, figs 3 and 4). This variant can thus be considered as a candidate for 'acceptable with research' because it was 'borderline' for only two out of 39 trials for hypotheses A and B, while its performance was 'unacceptable' for hypothesis C; that is, this variant fails for only one stock structure hypothesis (step 4a in Fig. 2).

Variant 8
Variant 8 was acceptable for all 'medium' weight trials. Therefore this variant can be considered to be 'acceptable without research' (steps 1 and 2 in Fig. 2).

Variant 9
Variant 9 performed 'unacceptably' on 20 out of 27 trials for stock-structure hypothesis C, and had 'borderline' performance for four trials (C11, C14, C17 and C30). It had 'borderline' performance on only two out of 39 trials based on stock-structure hypotheses A and B (A04, B04). This variant can thus be considered as a candidate for 'acceptable with research' because it fails only for stock structure hypothesis C (step 4a in Fig. 2).

Variant 10
Variant 10 performed ‘unacceptably’ on 23 out of 27 trials for stock-structure hypothesis C and had ‘borderline’ performance for two trials (C17 and C27). It also performed ‘unacceptably’ for one trial for stock structure hypothesis B (B04) and ‘borderline’ for 8 trials (B03, B05, B06, B09, B18, B20, B22, B28). ‘Borderline’ performance was also observed for three trials for stock structure hypothesis A (A03, A04, A28). This variant is therefore ‘unacceptable’.

Variant 11
Variant 11 performed ‘unacceptably’ on three out of 27 trials for stock-structure hypothesis C (C13, C20, C23) and had ‘borderline’ performance for 16 stock structure hypothesis C trials. The conservation performance of this variant is between that of variants 5 and 9, which were both considered to be candidates for variants with research. Therefore, this variant can be considered as a candidate for ‘acceptable with research’.

Variants with research
With respect to variants that are candidates for ‘acceptable with research’, it is the responsibility of relevant government(s) to inform the Committee whether it wishes additional trials to be run to determine the conservation performance of proposed ‘hybrid variants’. A ‘hybrid variant’ is one for which catches for the first 12 years are set using the candidate ‘acceptable with research’ variant followed by a 6-year phase down/phase out period and then catches set by an ‘acceptable without research’ variant. The conservation performance of the ‘hybrid variant’ must be ‘acceptable’ under the criteria described above.

If the ‘hybrid variant’ performs acceptably then, before it can be recommended, the Committee must agree a research programme that it believes has a realistic chance of determining whether the trial(s) for which this variant performed poorly should be accorded low weight. The Committee will review progress with the research programme annually and may recommend early reversion to the ‘acceptable’ variant if progress is not sufficient.

The Committee noted that any research proposal submitted would be reviewed at next years’ meeting.

6.1.4 Recommendations

6.1.4.1 RMP VARIANTS

Under the management options recommended (see below), the *Management Area* designations for each RMP variant are as follows.

(1) Variant 1: sub-areas 5, 6W, 7CS, 7CN, 7WR, 7E, 8, 9* and 11 are *Small Areas*.
(2) Variant 2: sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* (all of the catch from the 7+8 *Small Area* is taken from sub-area 7CN).
(3) Variant 3: sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* (all of the catch from the 7+8 *Small Area* is taken from sub-area 7CS).
(4) Variant 4: sub-areas 5, 6W, 7CS, 7CN, 7WR+7E+8, 9* and 11 are *Small Areas* (all of the catch from the 7WR+7E+8 *Small Area* is taken from sub-area 7WR).
(5) If Variant 5 proves to be acceptable with research: sub-areas 5 and 6W are *Small Areas* and catches are taken from sub-areas 5 and 6W. Sub-areas 7+8+9*+11+12 form a Combination Area (catch limits for sub-areas 12SW and 12NE are not taken).
(6) Variant 6: sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* (catches from the 7+8 *Small Area* are taken from sub-areas 7CS and 7CN using the same method as for catch cascading).
(7) If Variant 7 proves to be acceptable with research: sub-areas 5+6W+6E+10W+10E and 7+8+9*+11 are *Small Areas*; (catches from the 5+6W+6E+10W+10E *Small Area* are taken from sub-areas 5 and 6W using the same method as for catch cascading; catches from the 7+8+9+11 *Small Area* are taken in sub-area 7CN).
(8) Variant 8: sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* (catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 8 and 9 using the same method as for catch cascading).
(9) If Variant 9 proves to be acceptable with research: sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* (catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading).
(10) If Variant 11 proves to be acceptable with research: sub-areas 5, 6W, and 7+8+9*+11+12 are *Small Areas* (catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading).

The Committee **agrees** that, according to the Committee’s Requirements and Guidelines for *Implementations* (IWC, 2012h):

(1) variants 1, 2, 3, 4, 6 and 8 are ‘acceptable without research’;
(2) variants 5, 7, 9 and 11 are candidates for ‘acceptable with research’; and
(3) variant 10 is ‘unacceptable’.

Some members stated that with only two exceptions, all of the ‘unacceptable’ trials were under stock structure hypothesis C. Under the Committee’s current Requirements and Guidelines for *Implementations* under the RMP, when there is no agreement on plausibility of the hypotheses, the plausibility is automatically assigned as ‘medium’. In the case of stock structure hypothesis C, there was no agreement and therefore the plausibility became ‘medium’ as for the other stock structure hypotheses. However these members reiterated their view that the plausibility of stock structure hypothesis C is ‘low’ (IWC, 2011c, p.138). Whilst agreeing that the review of trials had appropriately followed the Committee’s current Requirements and Guidelines for *Implementations*, under these circumstances they could not accept the recommendations on management based on the conservation performance of the *Implementation Simulation Trials* using hypothesis C reviewed at this meeting. They pointed out that the problem of assigning plausibility has been an ongoing problem and suggested that it is necessary to review the method of determining plausibility.

6.1.4.2 ESTIMATES OF ABUNDANCE

The Committee did not have sufficient time to finalise the estimates of abundance for use in actual applications of the RMP. Annex D1, table 6 summarises the current status of abundance estimates for use in the trials and in actual applications of the RMP. Work to determine whether the abundance estimates that need further consideration can be accepted for use in actual applications of the RMP is included in the work plan. Final decisions regarding which abundance estimates can be used in actual applications of the RMP will be made at next year’s meeting, taking into account any revision to the Requirements and Guidelines for Conducting Surveys (see Item 5.5, Annex D, item 2.5).

6.1.4.3 HISTORICAL AND FUTURE REMOVALS
The Committee has previously agreed that the best estimates of the direct catches and the average predicted bycatch from the six baseline trials would be used in actual applications of the RMP (IWC, 2013c). The calculated average predicted bycatch from the six baseline trials are given in Annex D1, Appendix 2.

6.1.4.4 CONSIDERATION OF DATA/ANALYSES TO REDUCE HYPOTHESES IN FUTURE
The Committee did not have sufficient time to discuss this item fully. It **encourages** those Contracting Governments which are contemplating application of the RMP to review previous discussions on this matter in the Committee.

The Committee highlighted that the *Implementation Simulation Trials* structure provided a way to identify the value of information to resolve uncertainties. In particular, analyses could be undertaken to assess where data on mixing proportions and abundance would be most informative in terms of resolving the plausibility of various hypotheses. The Committee recognised that becoming familiar with how to use the *Implementation Simulation Trials* structure to evaluate the value of information could be complicated, and **encourages** members of the Committee to work with the Secretariat to develop the ability to condition and run trials.

6.1.5 Surveys and estimates of abundance
6.1.5.1 RESULTS FROM RECENT SURVEYS
SC/65a/NPM01 presented the results of satellite tracking of common minke whales in the Sea of Japan in autumn 2012. Little information on migration behaviour was obtained because of the short transmission duration (14 days). More details are given in Annex D1, item 8.1. The Committee welcomes this information and **recommends** that researchers conducting tagging studies on North Pacific minke whales work together with those conducting similar work in other areas, particularly in relation to tag technology and deployment.

SC/65a/NPM04 provided a cruise report on a sighting survey in the East Sea in spring 2012. More details are given in Annex D1, item 8.1.

6.1.5.2 PLANS FOR FUTURE SURVEYS
SC/65a/NPM02 presented the research plan for a sighting survey for common minke whales in the Sea of Okhotsk, including the Russian EEZ, in summer 2014. The primary objective of the survey is to obtain a new estimate of abundance for sub-areas 11 and 12. The secondary objective of the survey will be biopsy sampling and satellite tagging for common minke whales, if permission is obtained from the Government of the Russian Federation. This latter objective is important given the need to obtain information on the mixing rate of J- and O-stocks, and the distribution of J-stock in the Okhotsk Sea. Further details are given in Annex D1, item 8.2.

SC/65a/NPM05 reported that a sighting survey for common minke whale will be conducted in the Yellow Sea in spring 2014. This survey is part of a four-year programme to survey the waters of sub-areas 5 and 6W and increase survey coverage from 13% to 35%. Further details are given in Annex D1, item 8.2.

The Committee welcomes these plans and noted that there have been no surveys in sub-area 12 in recent years. It appointed Miyashita and An to provide oversight of these surveys on behalf of the Committee. The Committee **strongly recommends** that the Government of the Russian Federation give permission for the survey to take place in its EEZ in the Sea of Okhotsk throughout sub-area 12, given the importance of abundance estimates for sub-area 12 to the understanding of the status of common minke whales in the western North Pacific.

6.1.5.3 UPDATED LIST OF ACCEPTED ABUNDANCE ESTIMATES
Annex D1, Appendices 3 and 4 summarise information on primary effort, primary sighting position, survey blocks, sub-areas and area definitions for surveys for western North Pacific minke whales. The Committee thanked Miyashita, Hakamada and An for providing this information, which had been requested by the 2nd Intersessional Workshop.

Annex D1, table 7 lists these estimates of abundance in a format consistent for collation with estimates from other species and areas.

6.1.6 Conclusions
The Committee re-established the Intersessional Steering Group (see Annex D1, item 11 for membership) to co-ordinate intersessional work and prepare for the 2014 Annual Meeting.

The Committee recognised that this *Implementation Review* had been the most complicated to date and thanked all those who had contributed over the last three years to its completion, especially Hammond and Donovan who chaired the Working Group and intersessional Workshops, respectively. In particular, the Committee expressed its appreciation for the large amount of work done by Allison and De Moor without which it would not have been possible to complete the *Implementation Review*. The Committee noted that the need to take three years to complete this complicated *Implementation Review* may have implications for conducting other *Implementations* and *Implementation Reviews*. The Committee **agrees** to review its Requirements and Guidelines for *Implementations* under the RMP in this context at next year's meeting.

6.2 North Atlantic fin whales
6.2.1 Implementation Review
The Committee reviewed the report of the pre-meeting to initiate the *Implementation Review* (see Annex D, Appendix 2) and **endorses** its conclusions, recommendations and work plan. It established an intersessional group (see Annex R) under Elvarsson to develop revised specifications for the trials. It **recommends** that a two-day Workshop is held back-to-back with an AWMP intersessional Workshop in early 2014 to reduce travel costs.

6.3 North Atlantic common minke whales
6.3.1 Review new information
The Committee received five papers which had either been presented to the Special Permit Review Workshop held in Iceland (SC/65a/Rep03), or were revised versions of papers presented then. Details are given in Annex D, item 3.2.1.

The Committee **welcomes** the information in SC/F13/SP17 and SC/F13/SP20rev. It should be useful for the upcoming *Implementation Review,* and, in particular, the work of the joint AWMP/RMP Working Group on stock structure.

The Committee recognised the value of the satellite tracking of minke whales, reported in SC/F13/SP18, for the development of *Implementation Simulation Trials*. It **reiterates** the recommendations of the Special Permit Review that such tagging should continue, as much information as possible should be collected from each tagged individual, and that the results from the various stock definition approaches should be integrated.

The Committee **agrees** that data from satellite tracking could be used in *Implementation Simulation Trials* both qualitatively and quantitatively. There would be benefits in identifying the analysis methods to apply to data from satellite-tagged animals to determine the minimum number of animals needed for meaningful quantitative estimates and the point at which tagging additional animals leads to minimal additional information. If such analysis methods are developed, they should be reviewed by the Working Group on Stock Definition.

The Committee noted that SC/F13/SP06 stated the main objective of the aerial survey component of the research programme is to obtain a seasonal profile of relative abundance in coastal Icelandic waters in the off-season. This is discussed in Annex D, item 3.2.1.

6.3.1.1 NEW SURVEYS

SC/65a/RMP10 presented Norway's plans to conduct a new series of annual partial surveys over the period 2014-19 to collect data for a new estimate of minke whale abundance in the Northeast Atlantic in accordance with the requirements of the RMP. The survey and analytical methods will follow the procedures used in the previous survey cycles.

The Committee noted that the upcoming *Implementation Review* could lead to changes to the definitions of the *Small Areas*. It recognised that there are some advantages in agreement between survey and *Small Area* boundaries, but **agrees** that an approach has been developed which can address changes in *Small Area* boundaries.

6.3.2 Prepare for 2014 Implementation Review

The Committee was informed that the joint AWMP/RMP group is coordinating discussions and analyses on using genetics to examine stock structure for North Atlantic minke whales. It reviewed the report of the group (Annex D, Appendix 3) and **endorses** its recommendations. It **reiterates** its recommendation from last year that the work plan for the group (IWC, 2013d) be completed, and **recommends** the holding of a joint AWMP/RMP intersessional Workshop to consider stock structure hypotheses for common North Atlantic minke whales. It **recommends** a research proposal to conduct simulation analyses to support the deliberations of the intersessional Workshop (Annex D, Appendix 4) and future considerations of stock structure for other populations (see Item 26).

6.3.3 Recommendations

The Committee **recommends** that a Steering Group under Walløe be established to co-ordinate planning for the 2014 *Implementation Review* (see Annex R). It **recommends** that a three day pre-meeting be held prior to the 2014 Annual Meeting to ensure that sufficient progress is made on the *Implementation Review*, noting that this *Implementation Review* could be more complicated than previous ones because the original *Implementation* was not conducted under the current Requirements and Guidelines for *Implementation.*

6.4 North Atlantic sei whales

Last year, the Committee established an intersessional group to review the available data for North Atlantic sei whales in the context of a possible *pre-Implementation assessment* and provide a report to the 2013 Annual Meeting. Unfortunately, insufficient progress was made during the intersessional period to warrant starting the *pre-Implementation assessment* at this year's meeting. The Committee therefore **recommends** that the intersessional group be re-established and progress evaluated at the 2014 Annual Meeting. The decision whether to initiate an *Implementation* after a *pre-Implementation assessment* is made by the Commission. The Committee noted that this procedure might lead to delays now that the Commission will meet biennially; it may consider possible recommendations to the Commission at next year's meeting.

6.5 Western North Pacific Bryde's whales

6.5.1 Prepare for 2016 Implementation Review

The Committee received an update on progress and plans for the 2016 *Implementation Review* (Annex D, item 3.4). A sighting survey will be conducted in western North Pacific minke whales sub-areas 7 and 8 in 2013. IWC-POWER cruises will also take place in 2013 and 2014. Sightings data will be collected and attempts will be made to biopsy Bryde's whales. Bryde's whale genetic samples were collected during JARPN II cruises in 2012 and additional samples will be collected during the 2013 JARPN II cruises.

6.6 Work plan

The Committee's views on the work plan for the sub-committee on the RMP are given in Item 24, and the financial implications in Item 26.

7. NON-DELIBERATE HUMAN-INDUCED MORTALITY OF LARGE WHALES

The report of the Working Group on Non-deliberate Human-induced Mortality of Large Whales is given as Annex J.

7.1 Criteria for determining cause of death

The objective of this Item is to assist the Committee in its general attempts to assess human caused mortality and in particular to agree to specific criteria by which the Ship Strike Data Review Group can assess ship strikes reported to the ship strike database. If standardised criteria became internationally accepted, this will also assist countries as they report ship strikes through their National Progress Reports.

Moore reported via videolink on a workshop held in the USA (1-2 February 2012) that defined criteria for degrees of confidence in the diagnosis of sharp or blunt vessel trauma, and peracute or chronic fishery trauma in cetaceans. The amount of data needed to make an adequate diagnosis depends on the scenario as is discussed in Moore *et al.* (2013b) and summarised in Annex J, item 6. Their criteria are for 'Confirmed', 'Probable' and 'Suspect' outcomes and this approach had been used to examine large whale mortalities in the northwest Atlantic in the context of management strategies designed to mitigate these impacts (Van der Hoop *et al.*, 2012). They found that trends in numbers (and location) of reports of vessel strikes and entanglements did not differ significantly before or after 2003, when a number of management mitigation initiatives were begun along the Atlantic coast of the USA.

A handbook was presented for recognising, evaluating and documenting human interactions in stranded cetaceans and pinnipeds was presented (Moore and Barco, 2013). The Committee **recognises** the value of standardising approaches to enable more consistent data collection which in turn can assist in obtaining information on the likely extent of causes of death and necessary priorities for mitigation. Details are provided in Annex J, item 6.

The above two papers describe complementary actions and criteria and represent important tools for stranding networks globally. While a full forensic necropsy is often very difficult this should nevertheless be the goal to aim for. The two papers provided a progression of data collection options, and the visual options in the handbook should be feasible almost anywhere. Data collected using these protocols are being archived with the ultimate intent of making some images available for consultations and training. The Committee **encourages** this work and broader use of the handbook.

One hundred and eight ship strike reports from Alaskan waters between 1978-2011 are described in Neilson *et al.* (2012). In order to assess the reliability of these reports, which ranged from well documented reports with full necropsies to secondhand reports with sparse documentation, the authors developed 'confidence criteria' for categorising the reports. The Committee **welcomes** this summary and noted that this information will provide valuable input into the IWC's ship strikes database.

The criteria developed in these papers have been used to develop the criteria and definitions in Annex J, Appendix 2. The Committee **recommends** that these be adopted for the IWC ship strike database.

7.2 Reporting to National Progress Reports

This matter is discussed under Item 3.2.

7.3 Entanglement of large whales

7.3.1 Estimation of rates of entanglement, risks of entanglement and mortality

SC/65a/HIM02 describes a recent incidental catch of a baleen whale in a long-line fishery off the Brazilian coast. The incident demonstrates the need for more investigation of such interactions in the southwest Atlantic Ocean. A large long-line fleet operates out of ports along Brazil's southern coast in the path of migratory whales. The fleets are not monitored and they are unlikely to report whales entangled in their gear since, while it is forbidden to entangle a whale and there are regulations requiring that they are reported, these measures are not effective. In September 2012, just south of this area, a meeting was held to develop an action plan to mitigate bycatch and entanglement in similar Argentine fisheries. It is hoped that a report of the action plan developed will be available at next year's meeting. The Committee looks forward to receiving a report of the plan.

7.3.2 Methods to estimate time-series of bycatch

This item was not discussed by the Working Group this year but will be considered next year in light of discussions in e.g. Annexes D1 and E.

7.3.3 Collaboration with FAO and FIRMS

The IWC is currently an observer to the FIRMS partnership (Fisheries Resources Management System). It had been hoped that FIRMS may hold data on fishing effort that could be useful in estimating bycatch but FIRMS appears to have changed its focus somewhat since initial discussions with the IWC. Leaper will follow up on any new developments intersessionally to see if there is progress to discuss next year.

7.3.4 Collaboration with Commission initiatives on entanglement, including consideration of mitigation measures

Much of the work of the Secretariat's technical advisor, Mattila (generously seconded by the USA since 2012) has been devoted to capacity building on the issue of large whale entanglement. The strategy has provided an overview for over 500 scientists and government managers from 20 countries, followed by detailed training and assistance with setting up entanglement response networks. Over the remainder of 2013, training is scheduled for Ecuador (with participants from the Permanent Commission for the South Pacific (CPPS) countries), Panama, and a joint IWC-UNEP-SPAW session for the French and English Caribbean. The Committee **commends** this work, noting that besides assisting countries to establish relatively safe entanglement response capabilities which have already released a number of individual whales, it has stimulated other local and national initiatives on the issue of entanglement, including actions intended to both understand and mitigate them. The Committee **reiterates** that prevention rather than disentanglement is the ultimate solution. It **encourages** members to submit information and papers on prevention studies to next year's meeting.

7.4 Ship strikes

7.4.1 Progress on the global database

Last year, in response to a Committee recommendation (IWC, 2013h), Ritter and Panigada had been contracted jointly as co-ordinators for the ship strikes database. The primary objective was to raise awareness about the ship strike database and to stimulate its use. Outreach activities have resulted in a large number of new data entries compared to previous years. Data from around 100 incidents have been entered in the last year and the data from around a further 200 incidents are expected to be incorporated during the rest of 2013. These data cover some areas not previously covered including the Gulf of St Lawrence (Canada) and Alaskan waters. Contact was also made with researchers and authorities in Sri Lanka. A total of 111 entries of collisions between sailing vessels and cetaceans are expected to be entered by the end of 2013. A new edition of the multi-lingual IWC ship strike leaflet, supported by Belgium, has been distributed to a range of stakeholders. A self-standing banner display has been developed and two copies were produced; one was displayed at the recent European Cetacean Society conference in Portugal.

The Committee **commends** this work, noting that a modest financial investment by the IWC has produced good results. It noted the value of the leaflet to highlight the issue and create an ongoing dialog on whale avoidance in the maritime industry; for example, Neilson *et al.* (2012) had recommended its wide distribution. The Committee **recommends** that this work continues and is funded (see Item 26). The Committee also **agrees** that the co-ordinators should give priority to populations identified for CMPs for proactive data gathering outreach efforts.

The Committee noted that Australia and the USA have ship strike databases and have worked to ensure that these are compatible with the IWC database, and that data fields can be accurately mapped between them to facilitate data exchange. The Committee **reiterates** previous recommendations that member nations should submit data to the IWC's global database as soon as possible.

7.4.2 Estimating rates of ship strikes, risk of ship strikes and mortality

SC/65a/HIM01 provided information from the Canary Islands. A large fleet of commercial ferries operates on a year-round basis in the area and ship strikes are a known problem. Different ferry types exhibit distinct noise spectra. Based on certain assumptions, especially on hearing thresholds, the authors concluded that whales may be capable of hearing approaching vessels at distances that should enable them to react fast enough to avoid a collision. However, numerous factors need to be considered in evaluating the actual collision risk. Jet-driven ferries travelling at high speed, combined with comparably low intensity bow-radiated noise, result in an especially high risk of collision. These results confirm the role of vessel speed and the need to reduce vessel speed so as to minimise the risk of collision.

SC/65a/HIM03 reported that two pygmy blue whales were struck and killed in Sri Lankan waters in early 2012. The southern coast of Sri Lanka is one of the busiest shipping routes in the world and overlaps with an area of high whale sightings. The reported deaths can only be considered minimum values. These deaths and the unknown population size highlight an urgent need for long-term monitoring of the blue whale population in Sri Lankan waters and elsewhere in the northern Indian Ocean.

Vaes and Druon (2013) presented a novel approach to considering the seasonal ship strike risk to fin whales in the western Mediterranean Sea using satellite-derived data (surface temperature and chlorophyll-a content) as a proxy for fin whale habitat in addition to using AIS data for vessel traffic. The Committee agreed that further comparisons using this approach with contemporary whale sighting data are required to assess its value.

Neilson *et al.* (2012) reported data on collisions in Alaska between 1978 and 2011; these have been made available to the IWC database as noted above. There were 108 reports classified as definite, probable or possible ship strikes, mostly from collisions witnessed at sea. It was noted that even in this relatively large data set there were only a few cases in which the circumstances of the collision and outcome could be related to the size, speed and type of the vessel involved. This highlights the need for a central global database, which will increase the likelihood of obtaining a sample size sufficiently robust for meaningful analyses of factors related to risk.

7.4.3 Collaboration with the Commission's ship strikes working group including consideration of mitigation measures

An IWC-endorsed Ship Strike Mitigation Workshop was held in Tenerife in October 2012 (Tejedor *et al.*, 2013). This was primarily aimed at management and mitigation. There was broad recognition and acceptance that currently the best way to avoid collisions with whales is to avoid areas of high density, but if this is not possible then ships should maintain a vigilant watch and slow down as appropriate. Several participants from the industry agreed that they would prefer to know of a whale 'hot spot' well in advance, and be able to plan their routes accordingly, rather than getting a message upon arrival in an area that they need to re-route.

The apparent willingness of key stakeholders at this Workshop to investigate the feasibility and utility of voyage planning to avoid high density areas represents an opportunity for the Committee to play an important role in this effort. The Committee **agrees** that this is a productive way forward on this issue and **recommends** that the topic of defining and identifying critical whale 'hot spots' and engaging the shipping industry in the process should be an agenda item for the Commission's next Ship Strike Workshop. The Committee recognised that the Tenerife Workshop was primarily concerned with management and mitigation, and as such, **recommends** that the Commission's next Ship Strike Workshop reviews the report in full, and considers endorsing it and seeking partnerships with stakeholders to carry out appropriate recommended actions.

Bryde's whales in the Hauraki Gulf, New Zealand were also discussed. The population is believed to be less than 200 individuals and there have been 16 confirmed ship strike mortalities between 1996 and 2013. A proposal for funding an aerial survey to provide an abundance estimate for Bryde's whales throughout their primary range in New Zealand and to use this and data on distribution to inform mitigation measures to reduce ship-strike mortality was received (also see Item 26).

7.5 Marine debris

7.5.1 Report of the intersessional Workshop

A summary of the first IWC Marine Debris Workshop (SC/65a/Rep06), held from 13-17 May 2013 at Woods Hole Oceanographic Institution, was presented. The original objectives are outlined in IWC (2013j, pp.261-62).

Thirty-eight participants representing eight countries attended the Workshop. The first day of the Workshop included a public seminar consisting of keynote presentations which illustrated the ways in which debris and cetaceans interact, including the long lingering deaths that can result from entanglement, and a growing realisation that ingestion of plastics, including microplastics, may be a significant problem. In 2012, 280 million tonnes of plastic were produced globally, less than half of which was consigned to landfill or recycled. If current rates of consumption continue, the planet will hold another 33 billion tonnes of plastic by 2050 (Rochman, 2013). The keynote presentations also highlighted the need for improved international cooperation.

The participants recognised the potential significant impact that marine debris has on both cetacean habitat and cetaceans through both macrodebris (such as fishing gear, plastic bags and sheeting) entanglement and ingestion and through microplastics and their associated chemical exposures through ingestion or inhalation. The Workshop encouraged debris sampling when conducting observational cetacean research at sea (i.e. water sampling and visual observations during cetacean sightings surveys) and recommended that industry partners be involved in marine debris prevention, research and response to ensure success in reducing marine debris impacts on cetaceans.

Finally, the Workshop agreed that ingestion and inhalation of marine debris may sometimes be lethal, that sub-lethal impacts may also occur with long term negative consequences and that intake of debris is a problem, both as an individual welfare concern and potentially for some populations and species. More research was encouraged. The Workshop recommended that the IWC Scientific Committee should evaluate the risks of ingestion and inhalation based upon: (1) the spatial distribution of microplastics and macro debris; and (2) the feeding strategies and location of feeding areas of cetaceans. It also recommended that the Scientific Committee prioritise studies of those cetaceans that are likely at greatest risk of ingesting or inhaling macro- and micro-debris and associated pollutants (e.g. see Fossi *et al.*, 2012). The Workshop thus recommended that the initial focus of research be on three species of baleen whale: the North Atlantic right whale, the fin whale in the Mediterranean Sea and the gray whale in the eastern North Pacific. The Workshop noted that none of its recommendations required the lethal collection of cetaceans.

7.5.2 Committee discussion

A full discussion of the Workshop report can be found in Annex K, item 11.2. For a full list of scientific recommendations see SC/65a/Rep06. Information was also presented on marine debris found in the stomach contents of common minke whales, sei whales, Bryde's whales and sperm whales sampled by JARPN II (SC/65a/O03, SC/65a/O06, SC/65a/O07). No marine debris was observed in the stomachs of Antarctic minke whales (SC/65a/O09). After review of the Workshop report and other papers, the Committee **endorses** the recommendations of the Workshop (see SC65a/Rep06 for full details), including its recommended pathology protocol and **agrees** that:

(1) legacy and contemporary marine debris have the potential to be persistent, bioaccumulative and lethal to cetaceans and represent a global management challenge; and
(2) entanglement in and intake of active and derelict fishing gear and other marine debris have lethal and sub-lethal effects on cetaceans.

Therefore the Committee **strongly agrees** that marine debris and its contribution to entanglement, exposures including ingestion or inhalation, and associated impacts, including toxicity, are welfare and conservation issues for cetaceans on a global scale and a growing concern. The Committee **recommends** that the Commission and the Secretariat take prompt action to help better understand and address this growing problem, including:

(1) providing data on rates of marine debris interactions with cetaceans into the national progress reports and supporting the second marine debris Workshop (which will have mitigation and management as its focus);
(2) strengthening capacity building in the IWC entanglement response curriculum and adding information on marine debris;
(3) building international partnerships with other relevant organisations and stakeholders including an effective transfer of information about on-going research and debris-reduction and removal programmes and the international and national marine debris communities;
(4) developing programmes to remove derelict gear and schemes to reduce the introduction of new debris; and
(5) incorporating consideration of marine debris into IWC conservation management plans where appropriate and to consider making it the focus of a plan in its own right.

The Committee thanked the Workshop Convenor, the Woods Hole Oceanographic Institution for hosting the Workshop and the tremendous work done by the Workshop organisers and participants. The Committee also appreciates the funds provided by the various organisations in support of this Workshop.

The Committee **agrees** to establish an intersessional correspondence group (see Annex R) to review and prioritise the research-related recommendations from the Workshop. It was noted that this review should give consideration to: (1) the evaluation of the efficacy of fishing practices that pose a lower risk of entanglement or loss of gear, given that active and derelict fishing gear are a major cause of injury and mortality in cetaceans; and (2) further investigations into microplastics, their associated chemical pollutants and microbes, and macrodebris ingestion. Further work on microplastics has been taken up by the POLLUTION 2020 work plan (see Annex K, Appendix 2). The intersessional correspondence group will also liaise with the steering group for the second Marine Debris Workshop.

7.6 Work plan

The Committee's views on the work plan developed by the Working Group are given in Item 24, and the financial implications in Item 26.

8. ABORIGINAL SUBSISTENCE WHALING MANAGEMENT PROCEDURE (AWMP)

This item continues to be discussed as a result of Resolution 1994-4 of the Commission (IWC, 1995a). The report of the SWG on the development of an Aboriginal Whaling Management Procedure (AWMP) is given as Annex E. The Committee's deliberations, as reported below, are largely a summary of that Annex, and the interested reader is referred to it for a more detailed discussion. The primary issues at this year's meeting comprised: (1) finalising work on the PCFG (the Pacific Coast Feeding Group) of gray whales; (2) developing *SLAs* and providing management advice for Greenlandic hunts; and (3) reviewing management advice for the humpback whale fishery of St Vincent and The Grenadines. Considerable progress on items (1) and (2) was made as a result of an intersessional Workshop (see SC/65a/Rep02).

8.1 Matters arising out of the *Implementation Review* for eastern North Pacific gray whales

8.1.1 SLAs for the potential Makah hunt

In 2010, the Committee agreed that PCFG (Pacific Coast Feeding Group) whales should be treated as a separate management unit. The Makah Tribe would like to take gray whales in the Makah Usual and Accustomed fishing grounds (U&A) in the future and the objective of the *SLA*s tested during the *Implementation Review* process was to minimise the risk to the PCFG whales and meet the Commission's conservation objectives.

Last year, the Committee had agreed that two *SLA* variants met the conservation objectives of the Commission (IWC, 2013e):

(1) *SLA* variant 1: struck-and-lost whales do not count towards the APL (the 'allowable PCFG limit' – a protection level) i.e. there is no management response to PCFG whales struck but not landed; and
(2) *SLA* variant 2: all struck-and-lost whales count towards the APL irrespective of hunting month i.e. the number of whales counted towards the APL may exceed the actual number of PCFG whales struck.

SLA variant 2 was only acceptable if it was accompanied by a research programme (i.e. a photo-id programme to monitor the relative probability of harvesting PCFG whales, the results of which are presented to the Scientific Committee for evaluation each year).

However, the Committee also noted that the two variants did not exactly mimic the proposed hunt and expressed concern that the actual conservation outcome of the proposed hunt had not been fully tested. The reason for this relates to how strikes in May are treated in *SLA* calculations. No hunting is allowed after May since that is when the proportion of PCFG whales to migrating whales is highest (PCFG whales are defined as those photographed in multiple years from 1 June to 30 November within the PCFG area).

After discussions at the intersessional Workshop (SC/65a/Rep02), results were received for six new variants to cover the full range of possible strikes occurring in May or prior to May, i.e. variants allowing x strikes prior to May where $x = 1,\ldots,6$ (SC/65a/AWMP06). In summary, the performance of all the new variants was no worse than for Variant 1 and no better than for Variant 2.

In conclusion, the Committee **agrees** that the conservation performance of the proposed Makah whaling management plan has now been fully examined within the *SLA* evaluation framework. It **confirms** that the proposed management plan meets the conservation objectives of the Commission provided that if struck and lost animals are not proposed to be counted toward the APL, then a photo-identification research programme to monitor the relative probability of harvesting PCFG whales in the Makah U&A is undertaken each year and the results presented to the Scientific Committee for evaluation. In other words, only Variant 2 above meets the Commission's conservation objectives without the research requirement.

The Committee noted that the intersessional Workshop (SC/65a/Rep02) had recommended that the photo-id catalogue for the eastern North Pacific gray whales that will be used to assess whether landed whales are from the PCFG be made publicly available as it is a key component of the management approach. Weller reported that NOAA still has funds available to digitise the catalogue of PCFG whales. Scordino noted that work is underway to compile photographs from a few key contributors for a photo catalogue of PCFG whales to be held at NOAA's National Marine Mammal Laboratory; this catalogue, at least initially, will not be publicly available.

SC/65a/AWMP03 presented an update on the availability of PCFG whales in the Makah U&A based on photo-identification surveys. The results: (1) supported the proposed prohibition of hunting in the Strait of Juan de Fuca; and (2) confirmed that the availability of PCFG gray whales in Pacific Ocean waters of the Makah U&A was not appreciably different to the 30% availability used in the 2012 *Implementation Review*. An updated paper next year will also include an examination of possible trends.

8.1.2 Potential for western gray whales to be taken during aboriginal hunts

Given ongoing concern about the status of the gray whales that summer in the Western North Pacific (WNP), in 2011 the Scientific Committee emphasised the need to estimate the probability of a western gray whale being killed during aboriginal gray whale hunts (IWC, 2012a). The Committee noted that the work described in SC/65a/AWMP3 above can assist in this. This year, Moore and Weller (2013) updated the analysis of mortality risk to WNP whales from the proposed Makah hunt by incorporating Committee feedback last year (IWC, 2013c, p.20). Based on their preferred model, depending on assumptions, the probability of striking at least one WNP gray whale during a five-year period ranges from 0.036 to 0.170. The authors concluded that this represents a conservative initial step in assessing the potential risk.

The Committee welcomed this paper, recognising that it represents an initial approach. As detailed under Annex F, item 2.2.2, it also received information on an ongoing telemetry study of PCFG whales and considered the report of a US scientific task force that assessed gray whale stock structure in the light of US domestic legislation.

The Committee **agrees** that all of this information will make a valuable contribution to the recommended rangewide Workshop (Annex F, Appendix 2) described under Item 26.

Finally, in regard to questions on whether it should consider conducting an *Implementation Review* to evaluate the potential impacts of the Makah hunt on whales identified in the western North Pacific, the Committee **agrees** that ideally before an *Implementation Review* is conducted, the recommended rangewide Workshop be held (see Item 26).

8.2 Guidelines for *SLA* development and evaluation

Considerable effort was put into general consideration of the development of *SLA*s at the beginning of the AWMP process (IWC, 2000b; 2001b; 2001c; 2002b). This year, the Committee briefly outlined some guiding principles for *SLA*s to assist developers of candidate *SLA*s for the Greenland hunts. These are summarised below.

(1) The primary objective of any *SLA* is to meet the objectives set by the Commission with respect to need satisfaction and conservation performance, with priority given to the latter.
(2) *SLA*s must incorporate a feedback mechanism.
(3) Once need has been met for the 'high' need envelope while giving acceptable conservation performance, then there is no need to try to improve the performance of an SLA further.
(4) Simple *SLA*s are to be preferred, providing this simplicity does not compromise achieving the Commission's objectives.
(5) With respect to (4), empirical procedures may prove preferable to population model based procedures because: (a) they are more easily understood by stakeholders; and (b) there is little chance for significant updating of population model parameters (e.g. MSYR) over time as the extent of additional data will probably be limited for populations subject to aboriginal whaling only. Nevertheless, the choice of the form for any candidate *SLA* lies entirely in the hands of its developer, with selection amongst candidates to be based on performance in trials.
(6) If in developing *SLA*s, a situation arises where relatively simple *SLA*s fail on one or a few trials where the circumstances which might lead to the failure occur only many years in the future, rather than attempt to develop more complex *SLA*s to overcome this problem, a simpler *SLA* could be proposed despite this failure, and the difficulties dealt with by means of an *Implementation Review* should there be indications in the future that the circumstances concerned are arising. This principle applies only to:
    (a) circumstances in a scenario that are external and independent of the hunting/quota feedback loop, such as very high values of the future need envelope; and
    (b) are judged to be very unlikely to occur in the next few decades.

    Failure of an *SLA* to perform acceptably in some circumstances is not in itself a reason to apply this principle.

The Committee also reviewed and discussed the performance statistics, tables and plots that are required to evaluate conditioning and trial results. This discussion can be found under item 3.2.3 of Annex E. The Committee **endorses** this approach.

8.3 Progress on *SLA* development for the Greenlandic hunts

In Greenland, a multispecies hunt occurs and the expressed need for Greenland is for 670 tonnes of edible products from large whales for West Greenland; this involves catches of common minke, fin, humpback and bowhead whales. The flexibility among species is important to the hunters and satisfying subsistence need to the extent possible is an important component of management. For a number of reasons, primarily related to stock structure issues, development of *SLA*s for some Greenland aboriginal hunts (especially for common minke and fin whales) is more complex than previous *Implementations* for stocks subject to aboriginal subsistence whaling. The Committee has endorsed an interim safe approach to setting catch limits for the Greenland hunts in 2008 (IWC, 2009b), noting that this should be considered valid for two blocks, i.e. the target will be for agreed and validated *SLA*s, at least by species, for the 2018 Annual Meeting.

8.3.1 Common minke whales and fin whales off West Greenland

The Committee's discussions were informed by the work of the intersessional Workshop (SC/65a/Rep02) as well as those in Annex E. There is potential overlap between RMP and AWMP management with respect to common minke whales and fin whales in the North Atlantic. The process of developing *SLAs* and RMP *Implementations* for stocks in regions where both commercial and aboriginal catches occur should include the following steps: (a) development of a common trials structure which adequately captures uncertainties (regarding stock structure, mixing, MSYR, etc.); (b) identification of an *SLA* which performs as adequately as possible if there are no commercial catches; and (c) evaluation of the performance of RMP variants given the *SLA* selected at step (b).

With respect to common minke whales, the Workshop **reiterates its support** for a joint AWMP/RMP stock structure Workshop which will be essential to the *SLA* development process and the simulation framework (see Annex D, Appendix 2).

With respect to fin whales, in addition to working closely with intersessional work being undertaken within an RMP context (see Annex D), the Committee also noted that it may be possible to base the *SLA* for fin whales off West Greenland on operating models which considered West Greenland only. This will be investigated further (including at the intersessional RMP Workshop on fin whales) as it requires careful evaluation as to whether there may be more than one stock mixing off West Greenland.

In order to progress development work, the Committee last year funded a new computer program called RMP/AWMP-lite. It uses an age-aggregated rather than an age-structured model to considerably speed up calculations; this will allow developers to explore more easily the properties of candidate *SLA*s before they are submitted to rigorous full testing. It allows for multiple stocks of whales being exploited by a combination of commercial and aboriginal whaling operations. This was first reviewed at the intersessional Workshop (SC/65a/Rep02) and SC/65a/RMP05 implements the improvements suggested there.

The current approach to evaluating *SLA*s for the Greenlandic hunts treats each species independently even though need is expressed as a total amount of edible products over multiple species. The Committee **reiterates** that work on single-species *SLA*s should be completed before multi-species considerations are examined.

8.3.2 Humpback whales

The Committee's discussions were informed by the work of the intersessional Workshop (SC/65a/Rep02) as well as those in Annex E. Development of an *SLA* for humpback whales had been identified as one of the priorities for the Workshop and considerable progress was made.

8.3.2.1 STOCK STRUCTURE AND MOVEMENTS

The Committee has already agreed that the West Greenland feeding aggregation was the appropriate management unit to consider when formulating management advice. Whales from this aggregation mix with individuals from other similar feeding aggregations on the breeding grounds in the West Indies (IWC, 2008a, p.21).

In order to investigate whether West Greenland humpback whales are subject to mortality in other parts of the range then it is important to examine the available information from telemetry and photo-identification data. Considerable telemetry work has been undertaken off West Greenland (Heide-Jørgensen, 2012) and similarly there has been extensive photo-identification work. This has been used to inform how ship strike and bycatch data will be incorporated into the trials. This work is ongoing and Greenlandic scientists will work with the College of the Atlantic to present a review of the photo-identification data in time for an intersessional Workshop (see Item 26).

8.3.2.2 ABUNDANCE

The Committee has relative abundance data available from aerial surveys (see SC/65a/Rep02 and Annex E). It **agrees** to use the estimates of relative abundance from aerial surveys to condition the trials. The mark-recapture studies cover a shorter period and are heavily correlated so they will only be used in a *Robustness Trial*. However, given that mark-recapture abundance estimates may become common in the future for both humpback and bowhead whales, the Committee **agrees** that efforts should be made to develop ways to better integrate them into the operating models for the *SLA* trials.

With respect to absolute abundance, SC/65a/AWMP01 used information from 31 satellite-linked time-depth recorders to address the question of availability bias for the 2007 aerial survey. Fully corrected abundance estimates of 4,090 (CV=0.50) for mark-recapture distance sampling analysis and 2,704 (CV=0.34) for a strip census abundance estimate were developed. The estimated annual rate of increase is 9.4% per year (SE 0.01), unchanged from Heide-Jørgensen *et al.* (2012).

The Committee noted that the methods behind the new estimates had been discussed fully at previous meetings when considering the 2007 survey. The revised estimate was based on updated and improved information on the diving behaviour of whales from additional satellite tag data. It therefore **accepts** the new strip census abundance estimate as the best estimate. This information is also included in the trial specifications (see Annex E, Appendix 2).

8.3.2.3 REMOVALS

The Committee **agrees** that given past difficulties in modelling the full western North Atlantic (including allocation of past catches) and the decision to treat the feeding aggregation as the appropriate management unit, trials will begin in 1960 under an assumption that the age-structure in that year is steady. The direct catch series for this period is known. However, given possible migration routes (e.g. from telemetry data), it was noted that known direct catches occurred from whaling stations off the east coast of Canada after 1960 that may have included some 'West Greenland' animals. An approach to account for this has been developed. The Committee **agrees** that this will be incorporated into the catch series in the revised trial specifications, but that no future direct catches off Canada will be simulated.

In addition to direct catches, the question of bycatch in both West Greenland and of West Greenland animals elsewhere in their range needs investigation. For West Greenland, noting that the crab fishery which was primarily responsible for bycatch has now peaked, a conservative (from a conservation perspective) method for generating future bycatch has been developed. A similar method for accounting for bycatch outside West Greenland has been developed for bycatch and ship strikes. The Secretariat will work with Canadian scientists and others to investigate the available information on bycatch and ship strikes and develop a final removals table for consideration.

8.3.2.4 BIOLOGICAL PARAMETERS

Prior distributions need to be specified for three biological parameters: (a) non-calf survival rate; (b) age-at-maturity; and (c) maximum pregnancy rate. The values for these parameters used in the actual trials will encompass a narrower range than these priors because the priors will be updated by the data on abundance and trends in abundance during the conditioning process. Considerable discussion of this took place at the intersessional Workshop based on the range of estimates in the literature. The Committee **endorses** the priors shown in Annex E, Appendix 2. Recognising the considerable uncertainty, *Robustness Trials* have been developed to investigate the sensitivity to these priors.

8.3.2.5 NEED

Need envelopes are an important component of developing a trial structure and are the responsibility of the relevant Governments. They are used to allow for advice to be provided in the future on any increased need requests without having to conduct major *Implementation Reviews* or new *SLA* development. The need 'envelope' usually includes maintenance of the current limit, is bounded by a 'high need' case and then includes a middle option. A need envelope for humpback whales was submitted to the intersessional Workshop by Greenland (SC/D12/AWMP4) and these reflected the Greenlandic preference for humpback whales over fin whales and Greenland's desire for flexibility and a 'backup' to account for any unforeseen decline in the common minke whale strike limits. The need envelope is summarised in Annex E.

8.3.2.6 *SLA*S TO BE CONSIDERED

All trials will be conducted for a bounding case and for two 'reference *SLA*s', in addition to any other *SLA*s which might be proposed by developers:

(1) the *Strike Limit* is set to the need;
(2) the *Strike Limit* is based on the interim *SLA* (IWC, 2009b); and
(3) the *Strike Limit* is based on a variant of the interim *SLA* which makes use of all of the estimates of abundance, but downweights them based on how recent they are.

Guiding principles for *SLA*s are discussed under Item 8.2 above.

Developers are provided with the following information: total need for the next block; catches by sex; mortalities due to bycatch in fisheries and ship strikes; and estimates of absolute abundance and their associated CVs.

8.3.2.7 TRIAL STRUCTURE

After considering the report of the intersessional Workshop and the new information available at this meeting, the Committee agrees to the detailed trial specifications given in Annex E, Appendix 2. Some further discussion and parameterisation of one of the trials (that on asymmetric environmental stochasticity) is required and an intersessional steering group has been established to oversee this (Annex R).

The factors considered in the trials are summarised in Table 2 while the trials themselves are given in Annex E, Appendix 2, tables 5 and 6. The Committee **endorses** the trial specifications.

As noted under Item 8.2, the Committee also **endorses** the performance statistics, tables and plots proposed.

Table 2

Factors tested in the trials.

Factors	Levels (reference levels shown underlined)	
	Humpback whales	Bowhead whales
$MSYR_{1+}$	1%, 3%, 5%, 7%	1%, 2.5%, 4%
$MSYL_{1+}$	0.6	0.6, 0.8
Time dependence in K*	Constant, Halve linearly over 100 years	
Time dependence in natural mortality, M*	Constant, Double linearly over 100 years	
Episodic events*	None, 3 events occur between years 1-75 (with at least 2 in years 1-50) in which 20% of the animals die, events occur every 5 years in which 5% of the animals die	
Need envelope	A: 10, 15, 20; 20 thereafter B: 10, 15, 20; 20->40 over years 18-100 C: 10, 15, 20; 20->60 over years 18-100 D: 20, 25, 30; 30->50 over years 18-100	A: 2, 3, 5; 5 thereafter B: 2, 3, 5; 5 -> 10 over years 18-100 C: 2, 3, 5; 5 -> 15 over years 18-100
Future Canadian catches	N/A	A: 5 constant over 100 years B: 5-> 10 over 100 years C: 5-> 15 over 100 years D: 2.5 constant over 100 years?
Survey frequency	5 years, 10 years, 15 years	
Historic survey bias	0.8, 1.0, 1.2	0.5, 1.0
First year of projection, τ	1960	1940
Alternative priors	$S_{1+} \sim U[0.9, 0.99]$; $f_{max} \sim U[0.4, 0.6]$; $a_m \sim U[5, 12]$	N/A
Strategic surveys	Extra survey if a survey estimate is half of the previous survey estimate	
Asymmetric environmental stochasticity parameters	To be finalised by an intersessional group	

*Effects of these factors begin in year 2013 (i.e. at start of management). The adult survival rate is adjusted so that in catches were zero, then average population sizes in 250-500 years equals the carrying capacity. Note: for some biological parameters and levels of episodic events, it may not be possible to find an adult survival rate which satisfies this requirement.

8.3.3 Bowhead whales

8.3.3.1 STOCK STRUCTURE

The current working hypothesis in the Scientific Committee is a single Baffin Bay-Davis Strait stock of bowhead whales (see Annex E, fig. 2). However, pending the availability of some genetic analyses, the Scientific Committee had agreed that the possibility that there are in fact two different stocks present in the overall area, with the second located in the Foxe Basin-Hudson Strait region, cannot be ruled out (e.g. see IWC, 2009b).

Given that the objective is to develop an *SLA* for the Greenland hunt of bowhead whales, the Committee **agrees** to proceed first on a conservative basis that assumes that the absolute abundance of bowhead whales on the West Greenland wintering area is informed by abundance estimates from data for that region only (see below). Only if such an *SLA* proved unable to meet need would abundance estimate information and stock structure considerations from the wider area be taken into account.

8.3.3.2 ABUNDANCE

The absolute abundance estimates can be found in Annex E, table 3. It is not possible to combine the Foxe Basin-Hudson Bay 2003 survey with the 2002 Prince Regent Inlet survey to obtain an estimate for the entire Davis Strait-Baffin Bay-Foxe Basin area. The Committee therefore **agrees** to condition the operating model using data for Davis Strait-Baffin Bay stock only.

It is not known whether the 2002 survey in Prince Regent Inlet will be regularly conducted, although a new survey is anticipated, whereas it is known that regular surveys will be conducted off West Greenland. The Committee therefore **agrees** to conduct trials: (a) in which the estimate for Prince Regent Inlet is treated as an estimate of absolute abundance; and (b) in which the estimates from West Greenland are treated as estimates of absolute abundance.

With respect to relative estimates of abundance, the Committee **agrees** that they should be considered in a similar manner to those for humpback whales. Details can be found in Annex E, item 3.3.1.2. These estimates are also included in the trial specifications (see Annex E, Appendix 2).

While the sex ratio of animals in West Greenland is ~80:20 in favour of females (Heide-Jørgensen *et al.*, 2010), it is expected that the sex ratio for the total population is 50:50 (based on historic catches over the whole region and present Canadian catches). The trials will assume that the proportion of males available to the surveys will be the observed average male/female ratio in the biopsy samples.

The Workshop **agrees** that the information provided to the *SLA* will be the results of surveys off West Greenland (relative indices if the operating model is conditioned to the estimate of abundance for Prince Regent Inlet and absolute if the operating model is conditioned to the estimate of abundance for West Greenland).

8.3.3.3 REMOVALS

For reasons similar to those agreed for humpback whales above, the Committee **agrees** that population projections should begin from a recent year (1940). This is earlier than for humpback whales because of the extended age-structure of the population. All post-1940 direct catches of bowhead whales by Canada and Denmark (Greenland) are at present assumed known and thus that there may be no need to consider an alternative catch series. The Secretariat will consult with Reeves on post-1940 Canadian catches.

The Secretariat is consulting with Canada with respect to the agreed allowance for the hunters, to determine whether it applies to landed whales only or includes strikes.

The Workshop agreed that four scenarios regarding future Canadian catches should be considered as detailed in Annex E, item 3.3.1.3 and included in the trial specifications. The sex-ratio for the West Greenland catches will be set to the sex ratio observed in the biopsy samples taken off West Greenland over the 2002-11 period while that for the Canadian catches will be set to the observed sex-ratio which is being confirmed by the Secretariat.

Known bycatch of bowhead whales in this stock's range and further information on bycatch or ship strikes that can be found by the Secretariat in consultation with Canadian scientists will be included in the revised trials specification. The Committee noted that if the number of ship strikes increases as the Northwest Passage opens up, this could trigger an *Implementation Review*.

8.3.3.4 BIOLOGICAL PARAMETERS

In the absence of information for this region, the Workshop agreed to use the priors for f_{max}, S_{1+}, and a_m used for the *Implementation* for the Bering-Chukchi-Beaufort Seas bowhead whales, noting that these incorporate considerable uncertainty for all three parameters.

8.3.3.5 NEED

SC/D12/AWMP4 presented by Greenland had proposed three scenarios, each of which involves an increase to the need from 2 to 5 at the start of the projection period followed by either: (1) no increase of need; (2) a doubling; and (3) a tripling of need in a linear fashion over the total time period. This is shown in Annex E.

8.3.3.6 TRIALS

After considering the report of the intersessional Workshop and the new information available at this meeting, the Committee **agrees** to the detailed trial specifications given in Annex E, Appendix 2. As for the humpback whale case, some further discussion and parameterisation of one of the trials (that on asymmetric environmental stochasticity) is required and an intersessional steering group has been established to oversee this (see Annex R). The factors considered in the trials are summarised in Table 2 while the trials themselves are given in Annex E, Appendix 2, tables 5 and 6. The Committee **endorses** the trial specifications.

As noted under Item 8.2, the Committee also **endorses** the performance statistics, tables and plots proposed.

A number of the preliminary results considered under Item 8.3.4 illustrated that it would be difficult to meet conservation objectives satisfactorily when the need level was high, especially if Canadian catches (which are taken by a non-IWC member country) increase. The SWG discussed whether it would be advisable to reconsider how strike quotas and incidental removals (i.e. by Canadian hunters) are accounted for in the *SLA* computations. However, the Committee **agrees** to continue with the current framework but also **agrees** that this topic should be further considered at the next intersessional Workshop.

8.3.4 Results of initial work on SLA*s*

The Committee welcomed papers SC/65a/AWMP02, SC/65a/AWMP04 and SC/65a/AWMP05 that produced initial exploratory results by two sets of developers based on the draft trial specifications developed at the intersessional Workshop. It was noted that at this stage, each set of developers had developed their own approaches to choose amongst the *SLA* candidates which they had tested. The Committee noted that this was an acceptable approach for developers to take when investigating the performance of their initial *SLA*s before deciding to put 'official' candidates forward, but re-iterated that final choices would need to be based on the full set of performance statistics agreed for the trials.

8.4 Scientific aspects of an Aboriginal Whaling Scheme

In 2002, the Committee **strongly recommended** that the Commission adopt the Aboriginal Subsistence Whaling Scheme (IWC, 2003). This covers a number of practical issues such as survey intervals, carryover, and guidelines for surveys. The Committee has stated in the past that the AWS provisions constitute an important and necessary component of safe management under AWMP *SLA*s and it **reaffirms** this view as it has for the previous 11 years.

8.5 Greenland conversion factors

In 2009, the Commission appointed a small scientific working group (comprising several Committee members) to visit Greenland and compile a report on the conversion factors used by species to translate the Greenlandic need request which is provided in tonnes of edible products, to numbers of animals (Donovan *et al.*, 2010). At that time, the group provided conversion factors based upon the best available data, noting that given the low sample sizes, the values for species other than common minke whales should be considered provisional. The group also recommended that a focused attempt to collect new data on edible products taken from species other than common minke whales be undertaken, to allow a review of the interim factors; and that data on both ‘curved’ and ‘standard’ measurements are obtained during the coming season for all species taken. The group’s report was **endorsed** by the Committee (IWC, 2011b, p.21).

Since then, the Committee has received progress reports but has commented that more detail and information is required. Last year, the Committee reiterated its recommendations from 2010 and 2011 (IWC, 2013c, p.22):

(1) the provision of a full scientific paper to the next Annual Meeting [i.e. IWC/65] that details *inter alia* at least a full description of the field protocols and sampling strategy (taking into account previous suggestions by the Committee), analytical methods, and a presentation of the results thus far, including information on the sex and length of each of the animals for which weight data are available; and

(2) the collection and provision of data on Recommendation No. 2 of Donovan *et al.* (2010) comparing standard versus curvilinear whale lengths, this should be done for all three species on as many whales as possible.

8.5.1 New information

SC/65a/AWMP07 reported on the collection of weights and length measures from fin, humpback and bowhead whales caught in West Greenland. To improve the data collection process, information meetings involving biologists, hunters, wildlife officers and hunting license coordinators were held in the larger towns in 2012, and an information folder was produced and distributed to the hunters. The data collection process was also combined with an existing research project on hunting samples in order to get a stronger involvement of biologists. When researchers participate in hunts they train the hunters in measuring the lengths (curved and standard) and they make sure that the meat is weighed.

Until now the reporting rate has been lower than expected, with the data obtained in 2012 being from only one fin whale and one humpback whale, and the total number of reports since 2009 being from six bowhead whales, six humpback whales and three fin whales. These data provide preliminary yield estimates for all edible products of 9,014kg (SE: 846) per humpback whale, of 6,967kg (SE: 2.468) per fin whale, and of 8,443kg (SE: 406) per bowhead whale. These numbers are all somewhat lower than the suggested yield in Donovan *et al.* (2010), and this is especially pronounced for fin whales. Nevertheless, the obtained estimates for fin whales fall within the range of previous yield weight estimates for fin whales in West Greenland.

A major reason for the low reporting rate has been the almost complete absence of weighing equipment where the whalers could weigh the different products. To increase the reporting rate, the Greenland Institute of Natural Resources has now purchased and distributed weighing equipment that can be fitted to cranes in major towns for the hunters to use for weighing when landing a catch. It was also realised that the ‘bin system’ described in previous reports (e.g. IWC/64/ASW10) is more complicated than first anticipated because there is a large variation in the size of the bins used within the same hunt and between hunters. It is therefore now recommended that hunters weigh all edible products with the crane weight when they land the meat. This approach will be investigated further in 2013 and discussed with the hunters. Owing to the logistical difficulties involved with whale hunts in Greenland (which are widespread along the huge coastline and occur at unpredictable times during a long season) and the required change in the reporting system and subsequent need for training, it is likely that it will take several years to collect sufficient data on edible products.

8.5.2 Discussion

In response to questions, a number of clarifications were made. The original intention of weighing ten boxes had been so that an average weight per box could be developed to be multiplied by the total number of boxes to obtain an estimated total weight. However, with the efficient crane weights that are now in place in three cities, and with the finding that hunters may use different sized boxes even for the same whale, it has now been decided to weigh all boxes.

There were only five cases when scientists were able to be present at a humpback catch, and this low number illustrates the logistical difficulties in having scientists present at hunts. Witting did not have the precise details of this work or of the number of wildlife officers who may be able to assist in the work but will consult in Greenland. Efficient reporting requires not only training of hunters, but also the distribution of weighing equipment, so that hunters can report on their own.

In conclusion, the Committee **agrees** that the report was an advance on those previously received (and provided the first information on curvilinear lengths). However, it also **agrees** that it still did not provide sufficient information to fulfil the recommendations of last year. While aware of the logistical difficulties involved in obtaining these data, it **repeats its recommendations** of last year given in the second paragraph of this section. It **encourages** Witting to assist in the writing of such a report to ensure that it better meets the request of the SWG next year.

9. ABORIGINAL SUBSISTENCE WHALING MANAGEMENT ADVICE

9.1 Eastern Canada and West Greenland bowhead whales

9.1.1 New information

No new information was presented.

9.1.2 New catch information
No bowhead whales were taken off West Greenland in 2012. Official catch data have not yet been received from the Canadian Government for 2012. The Secretariat reported that it is in contact with the Canadian authorities who have acknowledged the request but not yet sent the catch data. The Committee also **encourages** the Government of Canada to continue research on Eastern Canadian bowheads.

9.1.3 Management advice
Using the interim safe approach (IWC, 2009b, p.16) as endorsed by the Commission, the Committee **agrees** that the current annual limit of two strikes for Greenland will not harm the stock. It was also aware that catches from the same stock have been taken by a non-member nation, Canada. Should Canadian catches continue at a similar level as in recent years, this would not change the Committee's advice with respect to the strike limits agreed for West Greenland.

9.2 Eastern North Pacific gray whales
9.2.1 New information
SC/65a/BRG02 presented new estimates of abundance for eastern North Pacific gray whales. Shore-based counts of southbound migrating whales off California have formed the basis of abundance estimation since 1967. A new observation approach has been used and evaluated in four recently monitored migrations (2006/07, 2007/08, 2009/10 and 2010/11). The summed estimates of migration abundance ranged from 17,820 (95% Highest Posterior Density Intervals [HPDI]=16,150-19,920) in 2007/08 to 21,210 (95% HPDI=19,420-23,230) in 2009/10, consistent with previous estimates and indicative of a stable population size.

The Committee welcomes and **accepts** the new population estimates.

SC/65a/BRG05 reported on photographic identification research in Laguna San Ignacio, Laguna Ojo de Liebre and Bahia Magdalena, Mexico, during the 2012 and 2013 winters. These results demonstrate a greater amount of movement between different breeding and calving lagoons for female-calf pairs than for single adult whales.

SC/65a/BRG05 summarised the results of a standard boat census of gray whales in Laguna San Ignacio and Laguna Ojo de Liebre during the winters from 2007 to 2013. In Laguna San Ignacio, counts of female-calf pairs increased during January and February to their highest numbers in March and April. During the 2011 to 2013 winters the average number of pairs was 108 and numbers remained high in the lagoon in April; by contrast, this number was only 40 pairs during the 2007 to 2010 winters and there were no pairs in April. In Laguna Ojo de Liebre in 2013 numbers of adults increased from January to February and declined to mid-April. Single animals only use the lagoon for 3-5 days. Females with calves use lagoons for up to 18 days. In one season with the highest counts, there was an estimated total of approximately 2,500 whales that used Laguna San Ignacio.

The Committee thanked Urbán and his colleagues for the interesting results from the studies in the breeding lagoons and **encourages** the continuation of those studies that will contribute greatly to the proposed intersessional rangewide gray whale Workshop (see Items 23 and 26).

SC/65a/BRG21 presented information on the body condition of gray whales in northwestern Washington, USA, from 2004-10 to examine whether this can provide insights into the variability of gray whale fidelity to the region. Of particular interest was a comparison with similar studies for the animals feeding off Sakhalin Island (Bradford *et al.*, 2012) that suggested that body condition in northwestern Washington is generally not as good as at Sakhalin. The reasons for this are not clear.

SC/65a/BRG12 presented information on harvested gray whales in 2012. In June and September 2012, scientists examined 23 gray whales caught near Mechigmensky Bay. Females averaged about 10m in length. Animals between 7.7m and 9.5m were sub-adults. Yearlings had the highest body condition index (blubber thickness/body length) and immature animals had the lowest; some 67% of the examined animals had full or half-full stomachs. There were no 'stinky' gray whales in Mechigmensky Bay. An immature, 7.7m female had traces of milk in an almost empty stomach. The hunters did not see a large whale escorting this small one and believed it was feeding independently. In discussion it was noted that milk might remain in the stomach for several hours or a little more.

SC/65a/BRG13 reported on the stomach contents of 82 gray whales taken in Mechigmensky Bay (63 from Lorino) from 2007-09; amphipods and polychaetes predominated by biomass and frequency of occurrence. Information was also presented on coastal counts.

The Committee thanked the authors for this interesting and important work examining harvested gray whales. It encouraged the work on photo-identification of harvested whales which is now beginning.

9.2.2 Catch information
SC/65a/BRG24 and SC/65a/BRG25 presented catch data for gray and bowhead whales in Russia. The quota is expressed in terms of landed animals not strikes and the 2007-12 block quota was for 620 gray whales (maximum 140 in any one year). A total of 143 gray whales were struck in 2012 of which 139 were landed (50 males and 89 females); eight were inedible ('stinky' whales). Body length and weight data were presented. In general some 10% of the whales are stinky. While stinky whales can sometimes be detected at sea and avoided, sometimes the whale has to be butchered before it is found to be stinky. For the period 2008-12, 638 gray whales were struck, 11 were lost and 627 whales were landed of which 24 were inedible, i.e. 603 edible whales were landed. Ilyashenko stated that stinky whales were not counted against the quota by the Russian authorities, since they do not meet the food needs of the indigenous people.

The Committee noted that the total number of gray whales struck during the 2008-12 period was 638 animals of which 24 of the 627 whales landed were inedible ('stinky') whales. The Commission expressed its limits for the 2008-12 period in terms of whales taken (620). While matters related to struck, landed and 'stinky' whales are matters for the Commission, the Committee noted that from an *SLA* perspective, all struck whales are considered removals.

9.2.3 Management advice
As was the case last year, the Committee **agrees** that the *Gray Whale SLA* remains the appropriate tool to provide management advice for eastern North Pacific gray whales taken off Chukotka; the question of the Makah hunt and whales from the Pacific Coast Feeding Group (PCFG) is considered under Item 8.1. The Commission adopted catch limits for a six-year block in 2012, i.e. 2013-18. The total number of gray whales taken shall not exceed 744 with a maximum in any one year of 140. The Committee **agrees** that these limits will not harm the stock.

9.3 Bering-Chukchi-Beaufort (B-C-B) Seas bowhead whales

9.3.1 New information

Three papers (SC/65/BRG01, SC/65a/BRG09 and SC/65a/BRG11) presented the improvements in field methods, the details of the acoustic and visual field observations and the new estimation method that underlie a new abundance estimate of this bowhead stock for 2011. The 2011 survey was among the most successful. The details are discussed fully in Annex F, item 2.1 and only a short summary is provided here.

SC/65a/BRG11 presented an overview of the spring 2011 bowhead whale abundance survey conducted near Point Barrow, Alaska. The 2011 survey was unique in that it included multiple simultaneous data collection efforts, these included: ice-based visual observations, an independent observer (IO) survey (to estimate detection probabilities), acoustic surveillance and an aerial photo identification survey. A total of 3,379 new whales was seen from the primary perch. This is close to the record (3,383 in 1993); however in that year it was estimated that 93% of the whales passed within view of the perch in contrast to 58% in 2011. Information was also provided on extensive photo-identification effort (aerial) and acoustic work.

SC/65a/BRG09 reported much higher levels of bowhead acoustic activity in comparison to recording efforts in past seasons that included high rates of singing and call sequences. The mean rate of acoustically located events in 2011 (calls/hr) was some 5.7 times higher than in 1993. Viewing conditions were similar to past surveys including substantial periods of watch missed due to poor visibility and closed leads. Telemetry and acoustic data suggest several hundred whales passed without the possibility of being seen.

SC/65a/BRG01 presented a new estimate of the total abundance for this population. The estimate is based on two large datasets: visual sightings and acoustic locations from spring 2011. A Horvitz-Thompson type estimator was used, based on the numbers of whales counted at ice-based visual observation stations. It divided sightings counts by three correction factors: (1) for detectability (and see Givens *et al.*, 2012, discussed by the Committee last year); (2) for whale availability using the acoustic location data (SC/65a/BRG09); and (3) for missed visual watch effort. The mean correction factors are estimated to be 0.501 (detection), 0.619 (availability) and 0.520 (effort). The resulting 2011 abundance estimate is 16,892 (95% CI; 15,704, 18,928). The annual increase rate is estimated to be 3.7% (95% CI; 2.8%, 4.7%). These abundance and trend estimates are consistent with previous findings.

The Committee thanked the authors, recognising the substantial field and analytical work that underlies the new abundance estimate. Discussion of the analytical approach can be found in Annex G, item 2.1. In conclusion, the Committee **accepts** this estimate and **endorses** it for use with the *Bowhead Whale SLA*. It further notes that under the guidelines outlined in the proposed Aboriginal Whaling Management Scheme (see Item 8.4), which has not been agreed by the Commission, a new survey would be required by 2021.

In discussion, it was noted that ice-based surveys depend very much on the availability of suitable ice conditions. The ice conditions may change within and between years and may become more difficult in the light of the climate changes observed in the Arctic. Aerial photographic surveys, which also were conducted during 2011, can form the basis of an independent mark recapture estimate of abundance (Koski *et al.*, 2010) although their precision is less than ice-based surveys.

SC/65a/BRG22 presented a study of DNA sequence variation for X- and Y-chromosome linked genes (USP9X and USP9Y) in bowhead whales using two methods to discover variable sites. The authors noted that with the PCR and sequencing primers reported, the X and Y chromosomes could be used to assess population variation in bowheads and other great whales to provide new perspectives on genetic issues such as stock structure, male reproductive success, gene flow and evolution. In discussion it was noted that bowhead whales have a relatively low level of variation in the Y chromosome due to skewness in male reproductive success. Population studies are underway.

9.3.2 New catch information

SC/65a/BRG19 provided harvest data for the Alaska hunt. In 2012, 69 bowhead whales were struck resulting in 55 animals landed. Total landed in 2012 was higher than the past 10 years (2002-11: mean of landed=38.9; SD=7.1) but similar for efficiency (no. landed/no. struck; mean of efficiency=77%; SD=0.07). Of the landed whales, 29 were females, 24 were males, and sex was not determined for two animals. Based on total length, six of the 29 females were presumed mature (>13.4m in length). All five of the mature females that were examined were pregnant.

SC/65a/BRG25 reported the results of the Russian aboriginal whaling in the Chukota region for the period of 2008-12: four bowhead whales were struck and landed out of a possible quota of 25 animals for that period. No bowhead whales were reported as struck and lost.

9.3.3 Management advice

The Committee **endorses** the abundance estimate of 16,892 (95% CI: 15,704-18,928) for spring 2011. It was noted that the next survey should be completed by 2021 based on the provisional guidelines in the Aboriginal Whaling Scheme (see Item 8.4).

The Committee **agrees** that the *Bowhead Whale SLA* continues to be the most appropriate way for the Committee to provide management advice for this population of bowhead whales. The Commission adopted catch limits for a six-year block in 2012, i.e. 2013-18. The total number of strikes shall not exceed 336 with a maximum of 67 in any one year (with a carryover provision). The Committee **agrees** that these limits will not harm the stock.

9.4 Common minke whale stocks off Greenland

The Committee noted that the Commission had not reached agreement on strike limits for Greenland at the 2012 Annual Meeting (see IWC, 2013a). It based its management advice on the same limits considered last year. In providing this advice it noted that the Commission has endorsed the interim safe approach (based on the lower 5th percentile for the most recent estimate of abundance) for providing advice for the Greenland hunts developed by the Committee in 2008 (IWC, 2009b, p.16); it was agreed that that this should be considered valid for two blocks, i.e. up to the 2018 Annual Meeting. This applies to all of the Greenland hunts below (i.e. Items 9.4-9.6).

9.4.1 West Greenland

NEW INFORMATION

In the 2012 season, 144 minke whales were landed in West Greenland and 4 were struck and lost. Of the landed whales, there were 109 females, 33 males and 2 of unknown sex. Genetic samples were obtained from 112 of these whales. Last year, the Committee re-emphasised the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP Workshop (see

Table 3

Most recent estimates of abundance for the Central stock of common minke whales.

Small Area(s)	Year(s)	Abundance and CV
CM	2005	26,739 (CV=0.39)
CIC	2007	10,680 (CV=0.29)
CG	2007	1,048 (CV=0.60)
CIP	2007	1,350 (CV=0.38)

Annex D). The Committee **welcomes** the fact that nearly 80% of the catch had been sampled in 2012 and **encourages** continued sample collection.

This year, the Committee adopted a revised estimate of abundance for the 2007 survey. The revised published estimate (16,100, CV=0.43) was slightly lower than that first agreed in 2009. The Committee noted that this estimate is an underestimate of the total population by an unknown amount.

MANAGEMENT ADVICE
In 2009, the Committee was for the first time able to provide management advice for this stock. This year, using the agreed interim approach and the revised estimate of abundance given above, the Committee **advises** that an annual strike limit of 164 will not harm the stock. It **draws attention** to the fact that this is 14 whales fewer than its advice of last year due to the revised 2007 abundance estimate.

9.4.2 East Greenland
NEW INFORMATION (INCLUDING CATCH DATA AND AGREED ABUNDANCE ESTIMATES)
Four common minke whales were struck (and landed) off East Greenland in 2012. Two were females and the sex of the other two was unknown. The Committee was **pleased** to note that genetic samples were obtained from all of minke whales caught in East Greenland (these could be used *inter alia* to determine the sex of the unknown animals). The Committee **again emphasises** the importance of collecting genetic samples from these whales, particularly in light of the proposed joint AWMP/RMP Workshop (see Annex D).

MANAGEMENT ADVICE
Catches of minke whales off East Greenland are believed to come from the large Central Stock of minke whales. The most recent strike limit of 12 represents a very small proportion of the Central Stock (see Table 3). The Committee **repeats** its advice of last year that a strike limit of 12 will not harm the stock.

9.5 Fin whales off West Greenland (AWMP)
9.5.1 New information
A total of four fin whales (all females) were landed, and one was struck and lost, off West Greenland during 2012. The Committee was **pleased** to note that genetic samples were obtained from three whales. It **re-emphasises** the importance of collecting genetic samples from these whales, particularly in the light of the proposed work to develop a long-term *SLA* for this stock.

9.5.2 Management advice
Based on the agreed 2007 estimate of abundance for fin whales (4,500; 95%CI 1,900-10,100), and using the agreed interim approach, the Committee **repeats** its advice that an annual strike limit of 19 whales will not harm the stock.

9.6 Humpback whales off West Greenland
9.6.1 New information
A total of seven (two males; four females; one unknown sex) humpback whales were landed (three more were struck and lost) in West Greenland during 2012. The Committee was **pleased** to learn that genetic samples were obtained from all of these whales and that Greenland was contributing fluke photographs to the North Atlantic catalogue – four have been submitted from whales taken since 2010. The Committee again **emphasises** the importance of collecting genetic samples and photographs of the flukes from these whales, particularly with respect to the MoNAH and YoNAH initiatives (Clapham, 2003; YoNAH, 2001).

This year, the Committee **accepts** the revised fully corrected abundance estimate for West Greenland from the 2007 survey of 2,704 (CV=0.34) for the strip census abundance estimate (see Item 8.3.2.2 above). The agreed annual rate of increase of 0.0917 (SE 0.0124) remains unchanged.

9.6.2 Management advice
Based on the revised agreed estimate of abundance for humpback whales given above and using the agreed interim approach, the Committee **agrees** that an annual strike limit of 10 whales will not harm the stock.

9.7 Humpback whales off St Vincent and The Grenadines
9.7.1 New information
No new information or catch data were provided in time for consideration by the Scientific Committee although information has been requested by the Secretariat. There is one sample collected from a humpback whale taken on 11 April 2012 in the SWFSC tissue archive. The Committee **welcomes** this information.

Iñíguez reported information obtained from local newspapers on hunts in St Vincent and The Grenadines: a 35ft male (8 March 2013); a 41ft female and a 35ft male (both 18 March 2013); and another whale with no length or sex information (12 April 2013).

Regarding the same stock, he referred to reports that residents of Petite Martinique, Grenada, spent hours attempting to drive a mature whale onto a beach using five inflatable boats, two large trader boats and a speedboat on 22 November 2012. The whale finally escaped but was harpooned four times. He has no further information on the fate of this whale.

9.7.2 Management advice
The Committee repeated its previous strong recommendations that St Vincent and The Grenadines:

(1) provide catch data, including the length of harvested animals, to the Scientific Committee; and
(2) that genetic samples be obtained for any harvested animals as well as fluke photographs, and that this information be submitted to appropriate catalogues and collections.

The Committee has agreed that the animals found off St Vincent and The Grenadines are part of the large West Indies breeding population (abundance estimate 11,570; 95%CI 10,290-13,390). The Commission adopted a total block catch limit of 24 for the period 2013-18 for Bequians of St Vincent and The Grenadines. The Committee **repeats** its advice that this block catch limit will not harm the stock.

The Committee **draws the Commission's attention** to the unofficial reports of attempts to land a humpback whale in Grenada; the Schedule specifies that the quota applies only to Bequians of St Vincent and The Grenadines. It requests that the Secretariat contacts the Government of Grenada to obtain official information on this incident.

10. WHALE STOCKS

10.1 Antarctic minke whales

The Committee is undertaking an in-depth assessment of the Antarctic minke whale. Details of the discussions summarised below can be found in Annex G. The primary abundance data are those collected from the 1978/79 to 2003/04 IWC-IDCR/SOWER cruises (e.g. Matsuoka *et al.*, 2003) that had been divided into three circumpolar series (CPI, CPII and CPIII). Two methods for estimating abundance from CPII and CPIII have been developed in recent years. Last year, the Committee formally agreed abundance estimates (IWC, 2013c, p.27). These were developed by basing the estimates on one method (the OK model, Okamura and Kitakado, 2012) and applying adjustment factors based on analyses from the other method (the SPLINTR model, e.g. Bravington and Hedley, 2012).

While the agreed estimates were suggestive of a decline in abundance between CPII and CPIII, the decline was not statistically significant either at a circumpolar level or at a *Management Area* level, given the inferred amount of annual variability in distribution (see Item 10.1.2). The Committee has been working for some time on explaining variability in abundance of Antarctic minke whales, both by the development of population dynamics models (Item 10.1.3) and by examining possible changes in environmental conditions during the period of the CPII and CPIII surveys (Item 10.1.2). Regarding the latter, the Committee has been investigating possible ways to estimate abundance of Antarctic minke whales within the unsurveyed pack ice region (since the IWC-IDCR/SOWER cruises were only able to survey in open water), and to discover the extent to which changes in sea ice concentration and many other environmental processes may have been affecting the open water abundance estimates.

10.1.1 Consideration of technical aspects of the agreed abundance estimates for CPII and CPIII

No further developments were presented to the Committee this year, although the items identified last year (IWC, 2013c, p.28) remain pertinent. The model refinements required will be assisted by the recent work described in SC/65a/IA15, in which a new IWC simulated data scenario is developed based on empirical data from Antarctic minke whale video dive time experiments conducted on the 2004/05 IWC SOWER cruise.

The Committee welcomed the new datasets, recognising that it was unlikely that improved methods would be available next year, but that further progress was expected by the meeting after. The results of this exercise (improved simulated datasets and estimation methods) should be of value not only to this species but also to many abundance estimation tasks faced by the Committee.

The estimates agreed last year were presented as two sets of numbers with two sets of CVs; Annex G, item 2.2.2, clarifies the reasons why the estimates were presented this way, and what the limitations are when interpreting these numbers.

In summary and also to provide clarity on what can be said at this stage in relation to trends, the Committee noted the following issues.

(1) At the scale of the circumpolar surveys, there is no statistically significant difference between the two population estimates. This of course does not mean that the number of Antarctic minke whales did not change at all. Rather, the uncertainty around the two estimates is sufficiently large that it is not possible to conclude with confidence whether the abundance increased, decreased, or remained about the same.

(2) The same is true at the scale of the six IWC Management Areas; there are no statistically significant trends detected.

(3) Nevertheless, the point estimate of change at a circumpolar level is quite large, and the same is true for some of the Management Areas. While not significant statistically, the differences are suggestive that some real changes in abundance may have occurred, particularly in areas near the large embayments of the Ross and Weddell Seas. The Committee is continuing to investigate issues of habitat utilisation and movement patterns of Antarctic minke whales which may further inform its understanding and ability to interpret these survey results (see Item 10.1.2).

10.1.2 Continue to examine reasons for the difference between abundance estimates from CPII and CPIII

10.1.2.1 AERIAL SURVEYS

The Committee has for some years been working towards explaining a putative decline in Antarctic minke whale abundance between CPII and CPIII. Aside from the statistical catch-at-age modelling work described in Item 10.1.3, a particular focus has been on investigating possible changes in the relative proportions of whales within the pack ice, since such regions were inaccessible to the IDCR/SOWER vessels. Papers describing Australian surveys using fixed-wing aircraft (Kelly *et al.*, 2011; 2012) and German surveys from a vessel-based helicopter (Williams *et al.*, 2011) have been considered by the Committee at previous meetings, and although no new work on these surveys was presented at SC/65a, further analyses are expected to be received next year.

10.1.2.2 NEW MODELLING WORK

Without further information from direct observations, the Committee is restricted to analyses based on extrapolations of sightings in open water areas to within-ice regions for investigating the relative proportions of whales that may have been within the ice regions during the CPII and CPIII period. SC/65a/IA11 presented one such approach for doing so, using models which assumed a relationship between whale abundance and ice concentration. It also examined causal relationships between Antarctic minke and humpback whale distribution; the Committee considered that this approach was more promising for open water areas than within pack ice regions where humpback whales do not enter.

10.1.2.3 NEW INFORMATION

SC/65a/IA12 described a study of Antarctic minke whales in their sea ice habitat during the austral summer of 2012-13, in two regions of the Antarctic: the Ross Sea and the western Antarctic Peninsula. In less than a month of fieldwork (of which only a portion was dedicated to Antarctic minke whale research), the researchers deployed 16 satellite-linked data recorders and two short-term archival data recorders; they also collected biopsy samples and took a large number of photo-identification images of well-marked individuals.

In discussion of SC/65a/IA12, the Committee congratulated the authors on their achievement: this is the first time that reliable tag deployment has been achieved on this species. For investigation of differences in abundance estimates between CPII and CPIII, the Committee noted that the diving data collected from one type of tag deployed is also directly relevant to the interpretation of aerial survey estimates of abundance in different sea-ice conditions. The Committee **recommends** that this work should continue (and see Item 26).

There was considerable discussion (see Annex G, item 2.3) about *inter alia*: the particular conditions, location and group size and behaviour needed for successful tag deployment or biopsy sampling; the utility of photo-identification for abundance estimation; the feeding behaviour inferred from the telemetry result; and the relative merits and demerits of lethal and non-lethal sampling for in-depth assessment of Antarctic minke whales.

10.1.2.4 DID MINKE WHALE ABUNDANCE DIFFER BETWEEN CPII AND CPIII?

The Committee noted the apparent contradiction in retaining this item on its agenda when the difference in point estimates of abundance are not statistically significant at the usual 5% level (Item 10.1.1; see also Annex G, item 2.4). There is some evidence of differences (for example as seen consistently from the integrated statistical catch-at-age (SCAA) modelling – see Item 10.1.3 below), but the wide uncertainty around the estimates cannot exclude the possibility that overall abundance has not changed between CPII and CPIII. The Committee **agrees** to rename this item as: 'What are the factors that drive minke whale distribution and abundance?'

10.1.3 Apply statistical catch-at-age models

Population dynamics modelling provides a way to explore possible changes in abundance and demographic parameters within Areas IIIE-VW, where appropriate data are available. The inputs are catch, length, age, and sex data from the commercial harvests and both JARPA and JARPA II programmes, as well as abundance estimates from IDCR/SOWER. For over a decade, the Committee has been developing population dynamics models of Antarctic minke whales, and following early attempts using an ADAPT-VPA approach (e.g. Butterworth *et al.*, 2002), the Committee concluded that SCAA modelling was the most appropriate framework, since *inter alia,* the latter approach is able to incorporate variability in age-reading (and consequent errors in age-at-length). Following the abundance estimates agreed from IDCR/SOWER last year, this year it has been possible for the first time to study the performance of the models using a fairly complete set of agreed inputs.

SC/65a/IA04 presented an updated statistical method for quantifying age-reading error, i.e. the extent of bias and inter-reader variability among age-readers. The method was applied to data for Antarctic minke whales taken during Japanese commercial (1971/72-1986/87) and scientific (1987/88-2004/05) whaling.

The methodology and conclusions of SC/65a/IA04 were based on a careful experimental study to compare readers (see Annex G, item 2.1). To estimate the bias and variance, the method needs to assume that at least one of the readers produces age estimates which are either unbiased or have a known degree of bias, and that ageing errors between readers but on the same earplug are independent. These assumptions are unavoidable for any analysis of ageing error where no absolute ground-truth is available, and the Committee **agrees** that the approach and results of SC/65a/IA04 provide useable input data for the SCAA analysis in SC/65a/IA01.

SC/65a/IA01 reported on the most recent application of SCAA to data for Antarctic minke whales, thus incorporating the agreed IDCR/SOWER abundance estimates and the age-at-length data for recent years of JARPA II, neither of which had been available when results from these models have been presented previously to the Committee. This work has been directed by the Committee and funded through the Committee's budget. The SCAA approach allows for multiple breeding stocks, which can be allowed to mix across several spatial strata on the summer feeding grounds where catches are taken. It also allows carrying capacity and the annual deviations in juvenile survival to vary over time. Most analyses indicated that Antarctic minke whale abundance in Antarctic Areas III-E to VI-W increased from 1930 until the mid-1970s and declined thereafter, with the extent of the decline greater for minke whales in Antarctic Areas III-E to V-W than for those further eastward.

In discussion of SC/65a/IA01, the Committee noted that the modifications to the SCAA model suggested last year plus the addition of the new data had now produced largely acceptable fits (see also table 1 of Annex G). The SCAA has received extensive scrutiny and improvement over the years of its development (far more than is usual for similar fishery assessment models used in management), and appears to have stood up well. Nonetheless, some issues do remain; detailed technical suggestions to investigate these are given in Annex G, item 8. The Committee considered the interpretation of the current results in SC/65a/IA01 (plus additional runs of the model made during the meeting), bearing in mind also the numerous sensitivity analyses and alternative formulations explored in previous years. Overall, some conclusions appear to be quite robustly supported, while others are more sensitive to details of model formulation or data selection. Resolution of the issues identified will allow more confident interpretation of the results next year.

10.1.4 Work plan

The work plan for the in-depth assessment of Antarctic minke whales is described in Annex G, item 8 and will be furthered by two intersessional Working Groups – one on SCAA issues for further investigation, and one on remaining IDCR/SOWER data management. The Committee's views on the work plan for the sub-committee on In-depth Assessments is given under Item 24.

10.2 Southern Hemisphere humpback whales

The report of the IWC Scientific Committee on the assessment of Southern Hemisphere humpback whales is given in Annex H. The Committee currently recognises seven humpback whale breeding stocks (BS) in the Southern Hemisphere, labelled A to G; (IWC, 1998b), which are connected to feeding grounds in the Antarctic. An additional population that does not migrate to high latitudes is found in the Arabian Sea. Assessments of BSA (western South Atlantic), BSD (eastern Indian Ocean) and BSG (eastern South Pacific) were completed in 2006 (IWC, 2007b), although it was concluded that BSD might need to be re-assessed with BSE and BSF in light of mixing on the feeding grounds. An assessment for BSC (western Indian Ocean) was completed in 2009 (IWC, 2010d) and for BSB in 2011 (IWC, 2012c).

10.2.1 Assessment of Breeding Stocks D, E and F

In 2011, the Committee initiated the re-assessment of BSD, and the assessment of BSE and BSF. As shown in Fig. 3, these stocks correspond, respectively, to humpback whales wintering off Western Australia (BSD), Eastern Australia (sub-stock BSE1) and the western Pacific Islands in Oceania including New Caledonia (sub-stock BSE2), Tonga (sub-stock BSE3) and French Polynesia (sub-stock BSF2). For simplicity, the combination of BSE2, BSE3 and BSF2 will be referred to as Oceania.

10.2.1.1 NEW INFORMATION

SC/65a/SH13 presented the results of an updated analysis recommended last year by the Committee (IWC, 2013g p. 217). It analysed mixing proportions of humpback whale breeding stocks BSD, BSE and BSF in Antarctic Areas IIIE to VI. The analysis was based on 575 samples obtained in the Antarctic during JARPA/JARPA II and IDCR/SOWER and 1,057 samples from low latitudes of the South Pacific and eastern Indian Ocean. Analysis of approximately the first half of the mtDNA control region yielded 137 haplotypes, and mixing proportions and Fst were analysed under two stock structure hypotheses. Under the most general hypothesis of six breeding stocks, BSD predominated in Areas IIIE, IV-W and IV-E. BSE1 predominated in Area V-W, BSE2 dominated in Area V-E and BSE3 dominated in Area VI. BSF sub-stocks did not predominate in any Antarctic area, although BSF1 was partially represented in Area VI.

The Committee thanked the authors for completing the work in time for on-going assessment modelling. Technical aspects of the paper were discussed by the Working Group on Stock Definition (see Annex I) and mixing proportions for alternate Antarctic area boundaries were calculated for the assessment models (see Item 10.2.1.2).

SC/65a/SH08 described the first photo-id and biopsy sampling surveys for humpback whales and small cetaceans around nine islands in eastern French Polynesia's Tuamotu and Gambier Islands (BSF2). The Committee welcomed this information on BSF2 and **recommends** additional sampling in this remote area of the South Pacific from which few data are available.

Rankin *et al.* (2013) estimated calving intervals of humpback whales at Hervey Bay, East Australia based on a long-term photo-id catalogue of 2,973 individuals. Two methods of calculation (multi-event mark-recapture modelling and truncation) led to similar estimates of calving intervals: 2.98 years (95% CI: 2.27-3.51) and 2.78 years (95% CI: 2.23-3.68) respectively.

The technical details of this paper were not presented, but the Committee noted that these calving intervals do not strongly suggest a population undergoing a high rate of population increase (e.g., Noad *et al.*, 2011). The cause of this apparent discrepancy requires further evaluation.

10.2.1.2 REVIEW ASSESSMENT MODELS

The Committee reviewed the progress of assessment modelling of breeding stocks BSD, BSE and BSF. Last year, a three-stock model with feeding and breeding ground interchange was proposed to address two inconsistencies that arose in single-stock assessments: (1) the model-predicted population trajectory for BSD was unable to simultaneously fit the absolute abundance estimate of 28,830 whales in 2011 (Hedley *et al.*, 2011a) and the high growth rate suggested by the relative abundance series; and (2) the model-predicted minimum population size in Oceania violated the N_{min} constraint informed from haplotype data.

Intersessionally, three-stock (BSD+BSE1+Oceania) and two-stock (BSD+BSE1) models were developed that included mixing on the feeding grounds. These did not substantially improve model fit unless customary Antarctic stock boundaries were shifted eastward to allow for more Antarctic catches to be allocated to BSD and fewer to Oceania. SC/65a/SH01 presented the results of single-stock, two-stock and three-stock models that used the original Antarctic boundaries, as well as new proposed boundaries based on this finding.

During the meeting, further model runs were attempted to improve model fits to the BSD data. An examination of

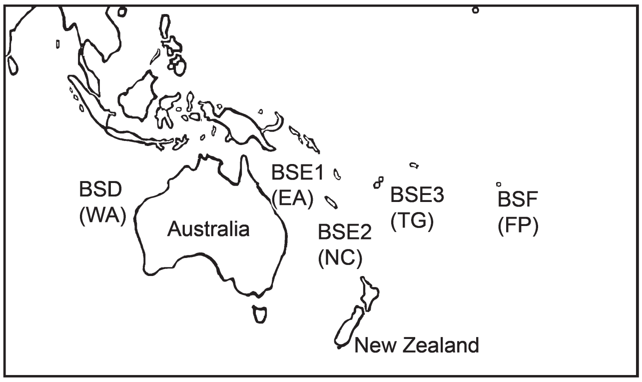

Fig.3. Distribution of Southern Hemisphere humpback whales breeding stocks grounds BSD, BSE1, BSE2, BSE3 and BSF2. Note the following abbreviations: WA=Western Australia, EA=Eastern Australia, NC=New Caledonia, TG=Tonga and FP=French Polynesia.

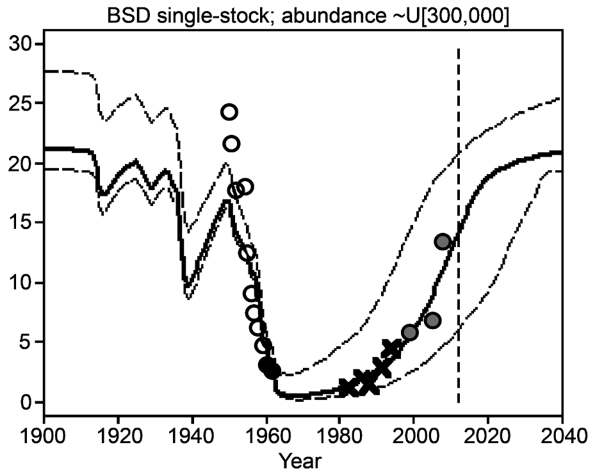

Fig.4. Posterior median population trajectories for BSD, showing the trajectories and the 90% probability envelopes. Results are shown for a single-stock model using the original catch boundaries. Plots show fits to the Chittleborough (1965) CPUE series (open circles), the Bannister and Hedley (2001) and relative abundance series (crosses), the Hedley *et al.* (2011b) relative abundance series (grey circles). The model is fit to both the Hedley *et al.* (2011b) and Bannister and Hedley (2001) relative abundance series only. The BSD abundance prior is set at U[0; 30,000]). The Chittleborough (1965) CPUE series is shown as consistency check. The trajectory to the right of the vertical dashed 2012 line shows projection into the future under the assumption of zero catch.

the BSD absolute abundance estimate (Hedley *et al.*, 2011a) identified irregularities in the underlying survey data which called into question the validity of the estimate. This could not be resolved during the meeting, but given this, and the strong influence of this estimate on the model results, single-stock BSD models were used to explore the effects of a lower, fixed abundance estimate and a model that was not fitted to absolute abundance but included an uninformative prior on this value. These models for BSD produced relatively good fits to all the relative abundance series (see Fig. 4). The Committee recognised that any abundance measurement method that could provide a lower bound to this prior (i.e. a value other than zero) would be useful in improving future model fits to BSD, and **recommends** that analyses to achieve this be attempted.

Three-stock models were also run using mixing proportions calculated with revised Antarctic area boundaries (Annex H, Appendix 2). One key result was that in order to fit the BSD relative abundance trends, the model removed more westerly Antarctic catches from BSE1, which

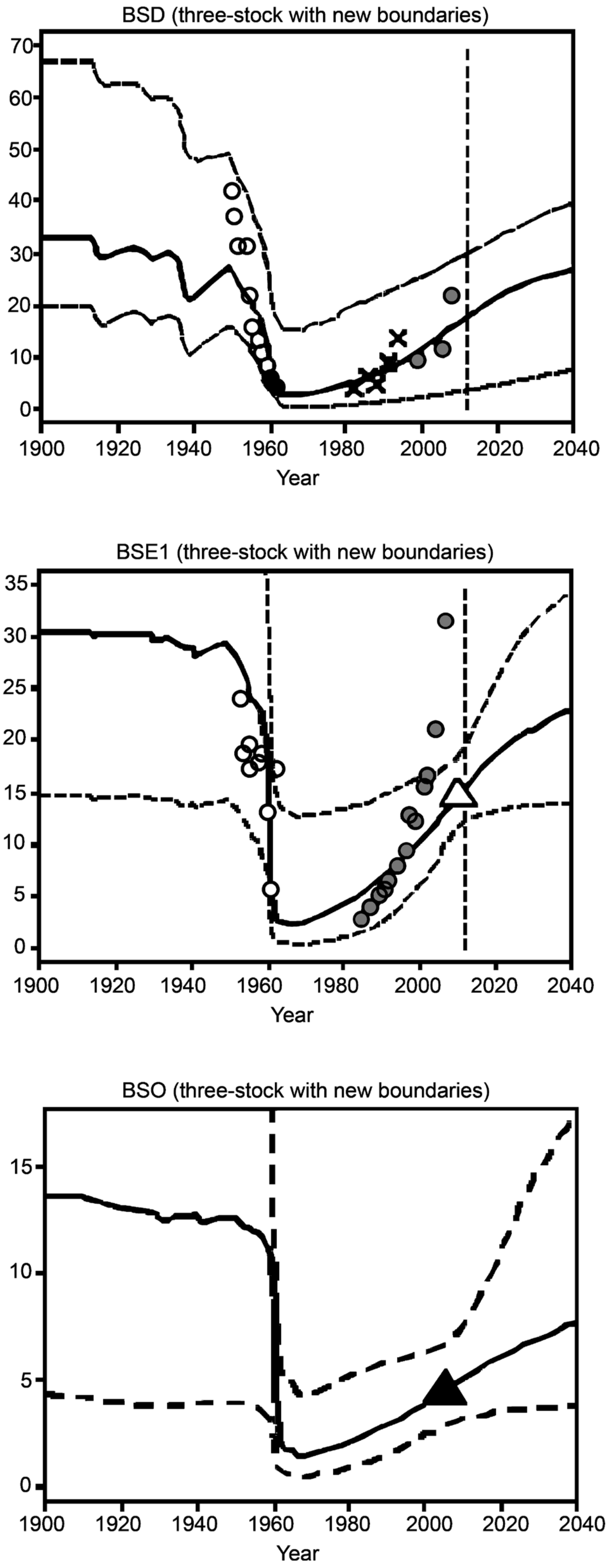

Fig.5. Three-stock model results assuming 'new' Antarctic catch boundaries proposed in SC/65a/SH01. The BSD abundance prior is set at U[0; 30,000]). BSO refers to Oceania (New Caledonia (E2)+Tonga (E3)+French Polynesia (F2)). SC/65a/SH01 details the data fitted for each breeding stock but in essence these are the Bannister and Hedley (2001) and Hedley *et al.* (2011b) relative abundance series for BSD (crosses and grey circles, respectively), the Noad *et al.* (2011) abundance estimate and relative abundance series for BSE1 (open triangles and grey circles, respectively), and the Constantine *et al.* (2011) photo-id mark-recapture data for Oceania. The black triangle for Oceania is the separate abundance estimate from mark-recapture data reported by Constantine *et al.* (2011) and the open circles for BSD and BSE1 are the CPUE data from Chittleborough (1965); these data are not fitted directly, but shown as consistency checks.

in turn led to the removal of Antarctic catches from Oceania to allocate to BSE1. Even so, the whales removed from BSE1 by the model did not deplete the population enough by the late 1960s (when most harvesting ceased) to reflect the rapid recent increases shown later by the east Australian surveys (Noad *et al.*, 2011). Use of an uninformative prior abundance on BSD in these models (with and without new Antarctic boundaries) did not improve the fit of the model to the BSE1 relative abundance data (see Fig. 5). Furthermore, none of the model formulations were consistent with the mixing proportions estimated by genetic data from the feeding grounds. Additional details of these results are provided in Annex H.

Other potential explanations for poor model fit were explored. Cooke (2009) describes situations in which attempts to fit a deterministic density-dependent population model to a recovering whale stock sometimes fail, because there are insufficient historic catches to account for the recent increase. His analyses suggested that lack of model fit should not be regarded as an anomaly to be explained, but a normal situation that is to be expected beyond a certain level of recovery and can be better fitted by accounting for environmental variability. Attempts to repair the lack of fit by allowing an arbitrary increase in carrying capacity could be expected to make the overestimation worse. Possible ways of addressing this in the current assessment models were discussed.

With respect to model fits to Oceania in SC/65a/SH01, the Committee **recommends** replacing the photo-id mark-recapture data with genetic mark-recapture data.

SC/65a/SH07 presented other progress toward modelling the population dynamics for East Australia and Oceania. This paper used logistic Bayesian FITTER models to co-measure population trajectories for pairs of South Pacific breeding grounds which share common high latitude feeding grounds. Two stock models were undertaken for East Australia (BSE1)/New Caledonia (BSE2), Tonga (BSE3)/ French Polynesia (BSF2) and East Australia (BSE1)/ Oceania (BSE2+BSE3+BSF2). In these preliminary results, East Australia carrying capacity varied between models (medians 26-42,000) while population increase rates were uniformly high. Median estimates of carrying capacity for New Caledonia ranged from 5,200-6,100, for Tonga 5,600-8,700 and for French Polynesia 4,000-5,700, with median recovery levels of 13-33%, 31-44% and 24-32% respectively.

The Committee thanked the authors for this work and noted several technical issues that still need to be addressed, including the use of a uniform prior on carrying capacity which leads to a biased estimate of MSYR.

In conclusion, the Committee **strongly agrees** that the assessment of breeding stocks D, E and F should be completed at next year's meeting. The following final **recommendations** were made to complete this work:

(1) a lower bound on the BSD abundance estimate should be obtained;
(2) a single-stock model for BSD will be run for a range of choices of the Antarctic feeding ground catches between 120°E and 150°E;
(3) two stock BSE1-Oceania models (with further breeding stock division within Oceania) will be explored; and
(4) if time permits after sufficient exploration of the models above, more complex options may be examined. These could include a three-stock model covering all of BSD, BSE1 and Oceania, together perhaps with more complex models for the dynamics of BSD, as discussed above.

The work plan for completing this work is provided in Item 10.2.6.

10.2.1.2 FUTURE WORK

SC/65a/SH09 described efforts by the South Pacific Whale Research Consortium to plan future sampling in Oceania with a view toward a future humpback whale assessment. Simulations and power analyses were used to evaluate planned field research in light of three main objectives: (1) to determine population size with a coefficient of variation of less than 20%; (2) to determine if the population is increasing or decreasing; and (3) to detect if population growth is significantly different from that of East Australia. Details are available in Annex H. The Committee welcomed this work, noting the importance of such planning and the value to future assessments of BSE2 and BSE3.

A modified POPAN model (Carroll *et al.*, 2013a) was discussed that explicitly accounts for heterogeneity in capture probability related to breeding cycles. The latter can cause substantial positive bias (+19%) in female abundance estimates and may be a consideration in the mark-recapture modelling of many cetacean species.

10.2.2 Review new information on other breeding stocks

New information was available for humpback whale Breeding Stocks B, C and G.

10.2.2.1 BREEDING STOCK B

SC/65a/SH24 collated humpback whale data from small boat surveys off Namibia (~23°S), 2005-12. Photo-id images were compared with catalogues from Gabon (2000-06) and West South Africa (WSA, 1983-2007). No confirmed matches were found, likely due to catalogue size and sampling period. However, a study of wounds from cookie cutter sharks (*Isistius brasiliensis*) and killer whales was used to infer relationships among these three areas in BSB.

The Committee welcomed this study, noting the potential utility of indirect indicators of stock structure for the Namibia region, where insights from photo-id and genetic data are still limited.

SC/65a/IA13 reported on cetacean sighting survey results in Gabon coastal waters from 4-10 September 2011 and in the Gulf of Guinea (Côte d'Ivoire, Ghana, Togo and Benin) from 23 March to 6 April 2013. The Committee thanked the authors for presenting these survey data. More information is available in Annex H, item 3.2.

10.2.2.2 BREEDING STOCK C

Two papers were received on satellite tagging projects to study the movements of humpback whales in this breeding stock. SC/65a/SH22 reported movements of twelve humpback whales satellite tagged off northeast Madagascar (BSC3). A wide range of movements were observed, including use of areas not previously recognised as preferred habitat. No tagged whales travelled to the west coast of Madagascar, Mozambique or the Mascarene Islands, where breeding aggregations are well documented. Observed movements between Madagascar and central-east Africa were likely not detected previously because of a lack of surveys in northern BSC1.

The Committee welcomed this work and noted its value for helping to clarify stock structure within BSC. Details of further discussion are available in Annex H.

SC/65a/SH02 described the results of satellite tagging eight humpback whales in the Comoros Islands (BSC2) in 2011 and 2012. Whales either remained at their breeding site for several weeks after tagging (n=3), dispersed to the northwest (n=2) or to southwest (n=3) coast of Madagascar. Of those tracked toward the Antarctic, one moved south-eastward towards the French sub-Antarctic islands and the other travelled to Antarctic Area III. These are the first detailed reports of humpback whale movement for this breeding sub-stock.

10.2.2.3 BREEDING STOCK G

SC/65a/SH04 described the results of small-boat surveys in the Gulf of Chiriqui (western Panama) during the austral winter season from 2002 through 2012. Initial catalogue comparisons have established matches to southern Costa Rica, and to feeding areas off Chile and Antarctica. Future plans include genetic analysis, comparing mother-calf habitat use to other breeding areas and long term acoustic monitoring. Discussion of this paper focused on the prevalence of mother/calf pairs in the area, which will be investigated further by the authors. This discussion can be found in Annex H.

10.2.3 Review new information on feeding grounds

Three studies (SC/65a/SH10, SC/65a/SH20 and SC/65a/O09) reported sightings of humpback whales during surveys in the Antarctic. Further details can be found in Annex H, item 3.3.

10.2.4 Antarctic Humpback Whale Catalogue

SC/65a/SH15 presented the interim report of IWC Research Contract 16, the Antarctic Humpback Whale Catalogue (AHWC). During the contract period, the AHWC catalogued 938 images representing 774 individual humpback whales submitted by 36 individuals and research organisations. Catalogue details are provided in Annex H, item 3.4.

The Committee recognises the contribution of the AHWC to humpback whales studies in the Southern Hemisphere and **recommends** its continuation (and see Item 26).

10.2.5 Other new information

SC/65a/SH05 reported on a study of Type 1 satellite tag performance and health impacts in humpback whales. This study has already informed tag modifications that have substantially increased tag duration, and are expected to reduce impacts on individuals. The Committee **thanks** the authors for this work, noting its value to future satellite tagging research.

10.2.6 Work plan

The Committee **confirms** that it will complete its assessment of Breeding Stocks D/E/F at next year's meeting, and thus also the Comprehensive Assessment of Southern Hemisphere Humpback Whales. Further details are given under Items 23 and 24.

10.3 Southern Hemisphere blue whales

10.3.1 Review new information

10.3.1.1 ANTARCTIC BLUE WHALES

Several papers reported results from the SORP Antarctic Blue Whale Project. SC/65a/SH21 provided an overview of activities undertaken on the Antarctic blue whale voyage between January and March 2013. This 47-day voyage focused on an area south of 60°S between 135°E and 170°W. Acousticians processed 26,545 Antarctic blue whale calls in 'real-time' and acoustically 'targeted' 51 groups of vocalising animals for photo-id and biopsy sampling. Further detail on tracking, sampling and other activities are provided below and in Annex H, item 5.1.1.

SC/65a/SH18 summarised the long-range acoustic tracking undertaken during the Antarctic Blue Whale Project. DIFAR sonobuoys were used to detect, localise and track Antarctic blue whales. In total, 85% of acoustic targets resulted in visual encounters and yielded 32 encounters with groups of blue whales. The project demonstrated the ability of acoustic tracking to locate Antarctic blue whales that are widely dispersed over a large area as well as the capacity to acoustically track whales for days at a time.

SC/65a/SH11 reported on the 50 Antarctic blue whales photo-identified as a result of acoustic-tracking during the 2013 voyage. The re-sighting rate of individuals during the voyage was similar to recent IWC SOWER cruises. Time between re-sights ranged from one to 27 days and straight-line distances ranged from 15km to 1,172km. Three individuals were matched to the Antarctic Blue Whale Catalogue and one had moved a minimum of 6,550km and 145° of longitude. Photo-identification data collected during the voyage will contribute towards a new abundance estimate of Antarctic blue whales using mark-recapture methods.

SC/65a/SH03 reported on the movements of satellite tagged Antarctic blue whales on their feeding grounds in 2013. Two tags collected movement data for 14 and 74 days, over 1,433km and 5,300km, respectively. Both whales performed long-scale movements interspersed with patches of searching, often in close association with the ice edge. Additional satellite tag deployments are planned to increase understanding of fine and large scale movements of Antarctic blue whales.

The Committee discussed these papers largely in the context of the ultimate aim of the Antarctic Blue Whale Project to estimate abundance through mark-recapture methods. It also highlighted the success of the SORP Antarctic Blue Whale Project to date and the significant advance it represents in non-lethal research on blue whales in the Southern Ocean. Additional details of this discussion can be found in Annex H, item 5.1.1.

SC/65a/O09 summarised sightings of blue whales during JARPAII of 2012/13. Details can be found in Annex H, item 5.1.1.

10.3.1.2 PYGMY BLUE WHALES

Three papers provided new information on blue whales off New Zealand. SC/65a/SH12 reported on blue whales observed and photo-identified in the coastal waters of New Zealand from 2004-13. Of 18 whales identified, 14 were observed during the SORP Antarctic Blue Whale Voyage in 2013, on transit to the Antarctic. Further details are available in Annex H, item 5.1.2.

SC/65a/SH19 reported additional findings from a combination of acoustics and visual observations at New Zealand, including data obtained during the 2013 SORP Antarctic Blue Whale Voyage noted above. Acoustic tracking confirmed blue whales to be the source of low frequency sounds recorded in this area. Comparison to recordings from 1964 and 1997 suggested that song types have persisted over several decades, are distinct from the Antarctic blue whales, and indicate a year-round presence around New Zealand. Blue whale song in this region has changed slowly, but consistently, over the past 50 years.

Torres (2013) presented evidence that the South Taranaki Bight is a blue whale foraging habitat and called for a greater understanding of their habitat use patterns to manage anthropogenic activities.

The Committee discussed the taxonomic status of blue whales in New Zealand waters. Based on available data on morphology, timing, distribution and acoustics, these whales are most likely to represent a form of pygmy blue whales. This is consistent with a growing body of evidence that populations of pygmy blue whales show considerable variation across the Southern Hemisphere.

The Committee **reiterates** that the relationship among pygmy blue whales in different areas is unclear and merits further investigation.

10.3.1.3 BLUE WHALES OFF CHILE

SC/65a/SH17 provided an update on surveys, photo-identification and biopsy research off the Isla de Chiloe and Isla de Chañaral (northern Chile) in 2013. Research at multiple sites has highlighted the importance of continued monitoring and increased photo-identification efforts to better understand the dynamics of the blue whales in this area. Concerns were also raised about the overlap of blue whales and vessels at the mouth of Chacao Channel. One blue whale stranding was documented north of this area in 2013, but cause of death was not determined.

The taxonomic status of Chilean blue whales was discussed by the Committee. They are intermediate in size between Antarctic and pygmy blue whales (Branch *et al.*, 2007). Furthermore, blue whales off Chile and Australia are as different genetically from each other as each is from Antarctic blue whales. Ongoing genetic analyses using additional samples from the Southern Hemisphere, Eastern Tropical Pacific and North Pacific will be undertaken to try to resolve their taxonomic status (see SC/65a/SH25).

10.3.1.4 PHOTO-IDENTIFICATION CATALOGUES

SC/65a/SH16 reported on the comparison of Antarctic blue whale photographs from JARPA to the Antarctic Blue Whale Catalogue (ABWC). Thirty-one individual Antarctic blue whales were photo-identified during JARPA cruises in the Antarctic during 12 austral summer seasons between 1992/93 and 2004/05. Photos were obtained in IWC Management Areas III, IV, V and VI. No new matches were found. This work brings the ABWC catalogue total to 305 individuals and notably increases available coverage from Area III (n=165) and in Area V (n=93). The Committee **recommends** that the 380 additional JARPA II blue whale photographs be compared to the ABWC.

SC/65a/SH23 describes efforts to consolidate all blue whale catalogues in the Southern Hemisphere. The Southern Hemisphere Blue Whale Catalogue (SHBWC) now contains 884 individual blue whales. Catalogues from South America, the Eastern Tropical Pacific (ETP) and Antarctica are now included and catalogues from the Indonesia/Australia/New Zealand area are in the process of being added. Comparisons between the eastern South Pacific and ETP have been completed and no matches were found. Comparisons between ETP and the Southern Ocean, as well as those from eastern South Pacific and the Southern Ocean are approximately 50% complete, with no matches found. The Committee **recommends** that the SHBWC continue its work and that all relevant data holders submit their photos to the catalogue.

10.3.1.5 NEW GENETIC INFORMATION

Attard *et al.* (2012) reported on hybridisation between pygmy and Antarctic blue whales, and a genetic estimate of the proportion of blue whale sub-species in the Antarctic. Further details and the discussion is provided in Annex H, item 5.1.5.

10.3.2 Work plan

The Committee's views on the work plan are given under Item 24.

10.4 North Pacific sei whale in-depth assessment

10.4.1 Review intersessional progress

Last year, an issue had been identified with the division of Japanese catch records between sei and Bryde's whales in the period 1955-72. This year the Committee heard that this had been a misunderstanding: the division of the catch figures had already been accomplished in the context of the Bryde's whale assessment.

Owing to other Committee priorities, it had not been possible to complete the incorporation of the Soviet and Canadian catch records intersessionally; this remains in the work plan for the forthcoming year (see Item 10.4.3).

10.4.2 Assessment

Although it was not possible to proceed with the assessment, analyses were presented that will inform the assessment when it is undertaken. Relating to stock structure, SC/65a/IA05 described the results of microsatellite DNA analysis conducted on North Pacific sei whale samples obtained from the 2010-12 IWC-POWER surveys (Annex G, item 5.2). The genetic data from 14 microsatellite loci from these samples were compared with previously reported genetic data from JARPN II (from 2002-07) and from commercial whaling samples (from 1972-73) across a range of locations within the North Pacific. The study supports the author's previous view that the open waters of the North Pacific were occupied by the individuals from a single stock of sei whales. This paper was discussed extensively by the Working Group on Stock Definition (Annex I), which made three recommendations for further analyses: (i) estimate the power of the data set to detect subtle population structure that might nevertheless be important for management; (ii) undertake a clustering analysis using STRUCTURE or a similar approach; and (iii) undertake a relatedness analysis when the sample size is sufficient to expert to find a reasonable number of close relatives.

It was reported that the recommended studies will be carried out, but not before 2016 because of other priorities. The Committee did not expect that these analyses would materially change the current understanding of stock structure; it **agrees** that it is not necessary to await the results before proceeding with the in-depth assessment.

Two preliminary analyses using sightings data from IWC-POWER were presented. SC/65a/IA09 provided a standard line transect analysis to estimate abundance of sei whales from the 2012 IWC-POWER survey (see Annex G, item 3 for a map showing the survey area). SC/65a/IA10 modelled the spatial distribution of fin, sei and humpback whales using data from the first three IWC-POWER surveys (2010-12). The Committee welcomed this analysis, and made a number of technical suggestions. Updated and revised analyses from both SC/65a/IA09 and SC/65a/IA10, using all available data, will be undertaken intersessionally; the Committee looks forward to receiving these and considering them in more detail at the in-depth assessment next year.

10.4.3 Work plan

Corrected Soviet catch data are documented by Ivashchenko *et al.* (2013). The Committee **agrees** that these represent the best possible reconstruction of the Soviet catch history in the North Pacific at this time, and that they should be incorporated into the IWC database (if this has not already been done). The Committee requests that Allison complete the remaining catch history additions or revisions (such as the revised Canadian catch data) during the coming intersessional period.

10.5 North Pacific gray whales

10.5.1 New information on stock structure and movements

There was considerable discussion of genetic information (see especially SC/65a/BRG16) on gray whale stock structure for the North Pacific both within the working group on stock definition (see Annex I, item 3.1.3) and the sub-committee on bowhead, right and gray whales (Annex F, item 3.1.2). Considerable attention was paid to developing the range of plausible hypotheses about the gray whales that summer in the Sea of Okhotsk near Sakhalin Island. The outcome of these discussions was the development of a list of seven hypotheses presented in Annex F, Appendix 3.

SC/65a/BRG04 summarises the results of the second year of the collaborative Pacific-wide study developed under the auspices of the IWC. The paper reported on the comparison of the gray whales photo-identified off Sakhalin Island (n=232) and the Kamchatka Peninsula (n=150) with the Mexican gray whale catalogue (n=4,352). A total of nine confirmed matches was found. Two whales were observed in the three places, three in Sakhalin and Mexico and four in Kamchatka and Mexico. These results provide new information important to the evolving understanding of gray whale population structure in the North Pacific.

The Committee thanks all the collaborators for the excellent progress on this project. The comparison of photographs between Sakhalin Island and Kamchatka, Russia with photos from lagoons in Baja California Sur, Mexico provides improved understanding of the connections between feeding and breeding/calving areas and interactions between western and eastern gray whales.

The Committee received papers summarising the work of two ongoing photo-identification and biopsy programmes off Sakhalin Island. Details are given in Annex F, item 3.2.1 and only a short summary is provided here. SC/65a/BRG03 reviewed findings from the ongoing 18-year collaborative Russia-US research programme on western gray whales summering off north eastern Sakhalin Island, Russia. When 2012 data are combined with results from 1994-2011, a catalogue of 214 photo-identified individuals has been compiled.

SC/65a/BRG08 reported on the programme being undertaken by the Russian Institute of Marine Biology (IBM) team that has been working off Sakhalin Island since 2002 and Kamchatka since 2004. The Sakhalin photo catalogue now contains 219 individual gray whales over the period of 2002-12. At present, the Kamchatka Gray Whale Catalogue contains 155 gray whales identified in 2004 and 2006-12 of which 85 were also photographed offshore of Sakhalin. Information on body condition was also presented. While the population remains small and therefore vulnerable, individual animals appeared to be in good body condition in 2012 compared with indicators from previous years. Few skinny whales were observed and those that were, had restored their body condition to normal over the course of the summer feeding season.

SC/65a/BRG18 reported on the results of the shore- and vessel-based surveys conducted in August-September 2012 under the Western Gray Whale Monitoring Program funded by Exxon Neftegas and Sakhalin Energy. The authors concluded that the results of the 2012 distribution surveys and photo-identification studies indicate that the Sakhalin gray whale feeding aggregation is gradually increasing in size and that the distribution of the whales remains similar to previous years.

The Committee welcomed these papers, recognising the importance of long-term monitoring of the animals off Sakhalin. It **strongly recommends** that the studies continue.

In addition to the work in Russia, the Committee received information from Japan and Korea. SC/65a/BGR20 reported on the status of conservation and research on North Pacific gray whales from May 2012 to April 2013 in Japan (including sightings surveys and morphological comparisons), while SC/65a/BRG26 reported on sighting surveys in Korean waters from 2003 to 2011. Neither the Japanese nor the Korean surveys saw any gray whales.

The Committee thanks Japan and Korea for providing this information and continuing work on gray whales. It **encourages** further comparison of skeletal morphology of gray whales across the North Pacific. It also thanked Japan for providing photographs of a juvenile gray whale sighted off Japan in March 2012; comparison with both Sakhalin and eastern catalogues produced no matches.

Given the large amount of new information related to population structure of gray whales in the North Pacific and the potential implications of this for conservation and management advice (see also Annex E, item 2), the Committee **endorses** a proposal for a rangewide review of the population structure and status of all North Pacific gray whales with an initial focus on an international Workshop (Annex F, Appendix 2).

10.5.2 Conservation advice

SC/65a/BRG27 presented an updated population assessment of the Sakhalin gray whale aggregation using photo-id data collected from 1994 to 2011 in the Piltun area by the Russian-US team. Details are provided in Annex F, item 3.2.1. The results showed evidence for between-year variability in calving rates and calf survival rates. The calving rate was found to be correlated with the calf survival rate with a two-year time lag. Under the assumptions made, no immigration in recent years was detected, suggesting that the population has been demographically self-contained, consistent with a high degree of maternally-directed feeding site fidelity. The 1+ (non-calf) population size in 2012 is estimated at 140 (±6) whales, increasing at 3.3 (±0.5) % per annum.

A number of matters for further consideration were raised. Work is underway to incorporate both Sakhalin catalogues into the assessment but certain issues needed to be resolved first. The Committee **agrees** that if possible both datasets should be included in a final assessment. Given the implications for conservation, a more thorough investigation of immigration should occur and the incorporation of body condition information into the model was also encouraged.

Annex F, Appendix 5 provided an update on the progress of the Western Gray Whale Advisory Panel (WGWAP), which is convened by IUCN.

10.5.4 Conservation advice

The Committee **reiterates** its support for the important work of the IUCN. As previously, the Committee **recommends** that oil and gas development activities (including exploratory seismic surveys) in areas used by gray whales be undertaken only after careful planning for mitigation and monitoring, noting the guidance provided by the WGWAP in this regard[16].

10.6 Southern Hemisphere right whales

The Committee completed an assessment of Southern Hemisphere right whales last year and the report is published as IWC (2013f).

10.6.1 Review new information

The Committee received a number of papers providing new information on southern right whales and details can be found in Annex F, item 4. A short summary of this work is provided below.

SC/65a/BRG10 reported on the results of the aerial survey for right whales in South African waters in October 2012 funded by the IWC and part of a long-term monitoring programme. The number of identified cow-calf pairs was the fifth highest since surveys began in 1979, and an exponential fitted to the data over the 34-year period provides a significant rate of increase (0.0625±0.0035 SE per annum).

SC/65a/BRG17 extended the analyses of Brandão *et al.* (2012) which applied the three-mature-stages (receptive, calving and resting) model of Cooke *et al.* (2003) to photo-identification data from the long-term monitoring programme available from 1979 to 2010 for southern right whales in South African waters, by taking two further years of data into account. The 2012 number of parous females was estimated to be 1,321, the total population (including males and calves) 5,062, and the annual population growth rate 6.6%.

Carroll *et al.* (2013b) provided information of a return of southern right whales to former habitat around the main islands of New Zealand including the first evidence of female site fidelity to the mainland New Zealand calving ground. There was some discussion as to whether this represented a re-establishment of primary habitat by a remnant stock that survived in the New Zealand sub-Antarctic.

Carroll *et al.* (2013a) reported on methods to extend the 'superpopulation' capture-recapture model (POPAN) to explicitly account for heterogeneity in capture probability linked to reproductive cycles, such as the 2-5 year birth intervals observed in southern right whales. This model extension, referred to as POPAN-τ, has potential application to a range of species that have temporally variable life stages. The authors demonstrate the utility of this model in simultaneously estimating abundance and annual population growth rate (λ) in the New Zealand southern right whale from 1995-2009, with a total 'superpopulation' estimate from the best model of around 2,100 (95% CL1,836-2,536).

SC/65a/O09 reported that four schools and five individuals of southern right whales were sighted in 2012/13 of JARPA II in the Antarctic. One southern right whale was photographed for photo-identification.

10.6.2 Complete assessment

SC/65a/BRG15 reported on a Workshop on the ongoing southern right whale die-off at Península Valdés. The 2010 IWC Workshop on this topic (IWC, 2011f) reviewed the significant number of right whale calf deaths and *inter alia* drew attention to the increasing incidence of parasitic behaviour of kelp gulls which peck at the outer skin and then feed on the blubber of live whales, and recommended that management measures be taken with respect to kelp gulls displaying this behaviour.

SC/65a/BRG15 also reviewed the most recent information on gull lesions and calf mortality. There is a strong signal of gull attacks as a unique, increasing, and acute element of the lifecycle of young right whale calves. The participants developed hypotheses on the mechanisms by which these attacks and injuries can lead to death and agreed to continue to work on these. The Workshop commended the work of the SRWHMP team.

Solving the kelp gull harassment problem is a priority action within the CMP developed for this region. Information was received on a feasibility study was carried out last year testing the use of different gun types - a 12-gauge shotgun was deemed to be the most successful. The reactions of the southern right whales to gun discharge were also recorded and no changes in their behaviour were observed. For the 2013 southern right whale season the objective is to continue this programme.

[16]*http://www.iucn.org/wgwap/wgwap/seismic_survey_monitoring_and_ mitigation_plan/.*

The Committee **expresses concern** over the continued large annual mortality of calves at Península Valdés, and its potential significance to the population. The increase in gull populations is driven by anthropogenic factors such as open landfills and discharge from fisheries. It **recommends** that investigation of the causes of this mortality, including the hypothesis that gull attacks are contributing to calf deaths, should continue as a matter of priority and **recommends** that strategies and actions to reduce the risk of gull attacks on southern right whales at Península Valdés should be further developed and implemented. The Committee **commends** the SRWHMP for their hard work and diligence in trying to resolve this situation and **encourages** continuation and further support of this important work.

The Committee received information on progress with the IWC Conservation Management Plan for the Southern Right Whale Southwest Atlantic Population as a result of a Workshop held in Argentina (SC/65a/BRG07). The overall objective of the CMP is to protect SRW habitat and minimise anthropogenic threats to maximise the likelihood that SRW will recover to healthy levels and recolonise their historical range. The CMP (details in Annex F, item 4.4) developed nine high priority actions, ranging from public awareness and capacity building through research to mitigation. Iñíguez has been appointed co-ordinator of the programme for a two-year period and a Steering Committee has been established including range state representatives, the Chairs of the Conservation Committee, Scientific Committee and the CMP SWG and the IWC Head of Science. A panel of experts will also be established.

The Committee **welcomes** the progress with the CMP and is willing to assist with scientific advice if required.

The Committee also **endorses** the holding of a workshop to develop and implement a strategy to minimise kelp gull harassment on southern right whales as proposed by the CMP. Such a workshop would be held in early 2014 and developed in consultation with the Province of Chubut. A budget request for partial funding is given under Item 26.

SC/65a/BRG14 noted that the southern right whale is listed as 'least concern' in the IUCN Red List of Threatened Species. Although not a threatened species, data from a review of strandings and sightings reveal a real reduction in southern right whales records for the southeast coast of Brazil. The authors stated that this should be considered as a cause of conservation concern.

Galletti Vernazzani *et al.* (In press) reported on behaviour and habitat use patterns of eastern South Pacific southern right whale sub-population. This population is likely to contain less than 50 mature individuals, and has been classified as critically endangered by IUCN. In 2012, the IWC endorsed a CMP to promote its long-term recovery. One of the highest priorities of the CMP is to identify the breeding area(s) which is difficult given the length of the coastline and and the low number of individuals. The first resighting between years of a known individual, the southernmost sighting of a cow-calf pair and the first documented record of likely reproductive behaviour in these whales has been reported in a small area off coastal waters off northwestern Isla Grande de Chiloe (Isla de Chiloe), southern Chile. This new information highlights the importance of this area for this population and suggests that it is part of a breeding area. Isla de Chiloe is the northern limit of the Chilean fjord system and was a former whaling ground for southern right whales, therefore it seems that whales are reoccupying their former range. However, a large wind farm project and associated port is being proposed to be built at northwestern Isla de Chiloe and it is likely it will affect this important habitat for this critically endangered population.

The Committee welcomed this information and, in light of this critically endangered status and the importance of this area for the recovery of the population, it **strongly recommends** relocation of the wind farm project away from shore, and **reiterates** the need for the urgent development of an environmental impact assessment that considers possible impacts on cetacean habitats.

10.7 North Atlantic right whales

10.7.1 Review any new information

No new information was presented.

10.7.2 Conservation advice

The Committee **repeats** its concern over North Atlantic right whale stocks and notes that it is a matter of urgency that every effort be made to reduce anthropogenic mortality (e.g. see IWC, 2012a). It requests that updated information on the status of any of these stocks be provided to the next Annual Meeting.

10.8 North Pacific right whales

10.8.1 New information

The Committee welcomed new information of sightings of North Pacific right whales: (1) one animal amongst several bowhead whales in July 2011 in the Western Okhotsk Sea; (2) two separate animals in 2012 as part of the JARPN II programme (both photographed and one biopsy sample); and (3) one animal (photographed) southeast of Kodiak Island during the 2012 IWC-POWER cruise.

10.8.2 Conservation advice

The Committee **reiterates** its previous concern over the status of this endangered species throughout the North Pacific. Noting that significant new data has accumulated from survey work in recent decades, especially in the western North Pacific and Sea of Okhotsk, the Committee **recommends** that the survey data on North Pacific right whales (including search effort, sightings, photo-id and biopsy results) be synthesised and presented by Matsuoka and colleagues to next year's meeting.

10.9 North Atlantic bowhead whales

10.9.1 Review any new information

No new information was presented.

10.10 Okhotsk Sea bowhead whales

10.10.1 New information

The Committee received considerable new information on bowhead whales from Ulbansky Bay in the Okhotsk Sea in 2011 and 2012 (SC/65a/BRG28 and SC/65a/BRG29). Details can be found in Annex F, item 2.2. Local observations indicate bowhead whales appeared in early May and were present in the area during the study from early July to early September. Large groups (up to 43 in 2011 and 51 in 2012) were seen. An individual biopsied in 2001 was recaptured in 2012. Approximate abundance based on the 2012 genetic recaptures (105 whales genotyped in 1995-2011 with 5 recaptures in 31 whales biopsied in 2012) suggest values about twice that of the earlier estimate of about 300 animals. However, false negatives resulting from differences in laboratory analyses for earlier samples could result in fewer recaptures and cause positive bias to any estimates. For mtDNA analyses, complete sequences of the control region were obtained for 64 individuals. Seven haplotypes were found including one not found in the earlier study by MacLean (2002), who also identified seven haplotypes.

In discussion, the Committee commended Shpak and colleagues for their excellent work. It **strongly encourages** further research on this small and little-studied stock, including: (1) continue biopsy collection in the Shantar region during summer; (2) calibration of samples collected in 1994-2001 and 2011-12 via an exchange of samples between US and Russian laboratories; (3) determining if whales in the various Bays of the Shantar region represent an homogeneous group; and (4) examining the relationship between bowhead whales observed in spring in the Shelikhov Bay and those from the Shantar region.

It was further noted that combining data from bowhead genetic studies conducted in the 1990s would allow updated capture-recapture (minimum) population estimates.

Brownell reported on new plans for offshore oil and gas development in the northern Okhotsk Sea. It was noted that oil and gas exploration lease blocks were purchased 50 to 14km offshore of the city of Magadan approximately in water depths of 120 to 180m. It is expected that exploration will start in 2017 and drilling by the mid-2020s. This area is north of Sakhalin Island and likely in the areas used by Okhotsk Sea bowhead whales when they migrate back and forth across the north Okhotsk Sea. In discussion it was noted that bowhead whales use the Shelikov region in spring but that there have been no reported sightings of bowhead whales off Magadan. There have been sightings of gray whales.

10.11 Arabian Sea humpback whales

10.11.1 Review new information

SC/65a/SH06 reported recent information on a discrete and non-migratory population of humpback whales in the Arabian Sea. A small vessel survey was conducted in Oman in 2012, and made three humpback whale sightings (five individuals) in 1,250km of survey effort. Sightings occurred in the Gulf of Masirah, which was previously identified through habitat modelling as a critical area for the population. Passive acoustic data are pending analysis and units will be re-deployed over the next year. Photo-id data were not adequate to revise population estimates as requested last year. Fishing and shipping in the region were reported in the context of potential threats to this population.

Information was also provided on progress toward the regional conservation initiative mentioned in SC/65a/SH06. Members of the intersessional correspondence group on the Arabian Sea population, together with regional NGO partners have begun work to establish a regional research and conservation programme for this population. The programme would help to initiate and foster collaborative research amongst range state partners, increase local capacity and generate awareness of Arabian Sea humpback whale conservation issues. Additional details are available in Annex H, item 4.

The Committee welcomed these important updates on the Arabian Sea humpback whale population. Given the critical status of this population, it **recommends** that this research be allocated a high priority. The regional conservation initiative was strongly supported as a positive opportunity for range states to work together towards improving the status of this population. Such work could also benefit a CMP, should one ultimately be established for this population (see Item 10.11.2).

Plans were described to satellite tag Arabian Sea humpback whales with implantable tags. Tagging would involve no more than 20% of the population, which has most recently estimated at 84 individuals (Minton *et al.*, 2011), and would address priority research questions identified previously by the Committee. The proponents stated that they have carefully reviewed the present state of tag development and will be following international best practice including using a well-designed and tested tag and an expert tagging team. Further project details and precautions are outlined in Annex H, item 4.

The Committee noted the importance of the proposed work, given how little is known about the Arabian Sea humpback whale population. While the proposed sample size is modest, even a small number of tags has the potential to significantly increase what is known about this population. At least seven dead humpbacks have been detected in the last 10 years and this casts doubt on the sustainability of the population, e.g. it exceeds the estimated Potential Biological Removal (PBR) for this population (Wade, 1998). As noted above, Oman has experienced a rapid increase in the development of fisheries, high speed ferries and coastal infrastructure projects, many of which overlap with known humpback habitat. Given the observed mortality and known threats, there is an urgent need for better information on movement and habitat use. This project has the potential to considerably improve knowledge in the short term and is in fact the only way to collect this information given the nature of this population and the available resources.

It was noted in discussion that the results of recent satellite tag assessment studies on the health of animals (SC/65a/SH05) will be available in the next few years and that consideration should be given to waiting for those results. However, the Committee also recognised the urgency of this issue and the potential benefit to the conservation management of this critically endangered population. The Committee **recommends** that this work be undertaken as a high priority. An important caveat is that any untested tag modifications should be evaluated on other populations and not used first on Arabian Sea humpbacks.

10.11.2 Progress toward the development of a Conservation Management Plan

In 2010, the Committee recommended the development of a Conservation Management Plan (CMP) for Arabian Sea humpback whales. A CMP could address concerns for this population as well those for other species of large whale. To date, neither of the two range state members of the IWC (India, Oman) has yet volunteered to lead the development of a CMP, although there is some recognition of urgent conservation concerns and research needs.

10.12 International cruises

10.12.1 IWC-POWER cruises in the North Pacific

The Committee has now agreed objectives for the IWC-POWER programme, and this year reviewed the results of the 2012 cruise (Item 10.12.2), the Planning Meeting report for the 2013 survey (Item 10.12.3) and discussed plans for the 2014 cruise (Item 10.12.4).

The 2014 cruise will mark the end of the short-term phase of the programme, completing coverage of a large area of the North Pacific (see Annex G, fig. 2). This phase had been designed to cover the whole survey area in as short a time as possible to provide baseline information on distribution and abundance for several large whale species/populations. Alongside sightings data, dedicated time for biopsy sampling and photo-identification work has been allocated, providing information on stock structure, movements and potentially further information on abundance.

10.12.2 Review of the 2012 IWC-POWER sighting survey

The 3rd IWC-POWER cruise was successfully conducted from 13 July-10 September 2012, in the eastern North Pacific using the Japanese Research Vessel *Yushin-Maru No.3* (SC/65a/IA08). The cruise was organised under the auspices of the IWC. Researchers from Japan, Korea and the US participated in the survey. The cruise had five main objectives (see Annex G, item 3.1). The survey plans had been endorsed by the Committee (IWC, 2012a, p.32). The Committee **agrees** that it was duly conducted following the guidelines of the Committee.

Further details of the cruise, including summaries of the sightings made, may be found in Annex G, item 3.1. The Committee, thanks the Cruise Leader, researchers, captain and crew for completing the third cruise of the IWC-POWER programme. The Governments of Canada and the USA had granted permission for the vessel to survey in their respective waters, without which this survey would not have been possible. The Governments of the Republic of Korea and the USA provided one scientist each, and the Government of Japan again generously provided the vessel and crew, as it had done for the 2010-11 cruises. The Committee recognised the value of the data contributed by this and the other IWC-POWER cruises, collected in accordance with survey methods agreed by the Committee, covering many regions not surveyed in recent decades, and addressing an important information gap for several large whale species.

In discussion of the 2012 POWER cruise results, the Committee heard that weather conditions in the North Pacific in summer tend to be poor. For future planning of the medium- and long- term phases of the programme, the Committee agreed that the sighting conditions during the 2010-14 cruises should be investigated. This is relevant both to the feasibility of estimating abundance of various whale species from current North Pacific surveys, and also for considering any changes in design required for subsequent cruises after 2014. These considerations were referred to the IWC-POWER Technical Advisory Group (TAG) Workshop scheduled for later in 2013 (see also Annex G, Appendix 2).

10.12.3 Planning for 2013 IWC-POWER cruise

SC/65a/Rep01 presented the report of the detailed Planning Meeting for the 2013 IWC-POWER cruise. The Meeting received preliminary results from the 2012 IWC-POWER cruise and these were used, along with overall objectives of the first phase of the IWC-POWER surveys, to formulate a plan for the 2013 cruise, which will take place between 30-40°N, and from 135-160°W. The vessel (kindly supplied by Japan) will depart on 12 July 2013. The Meeting also agreed to a suggestion to highlight the IWC-POWER surveys on the IWC website with the ultimate aim of inspiring multinational collaboration in the survey programme. Fortunately, there will be no problems arising from requirements for CITES permits during the 2013 survey as the tracklines do not enter any EEZs; however, the problems will return in 2014, when the planned survey design will take the vessel into US waters (see Item 10.12.4 below). The Committee was informed that the Japanese and US authorities are working to solve this issue. SC/65a/Rep01 also covered a number of items related to the short, medium and long-term objectives of IWC-POWER, which were later discussed by the IWC-POWER TAG (Annex G, Appendix 2).

The Committee **thanks** the members of the Planning Meeting for their report and **endorses** their recommendations.

10.12.4 Recommendations for 2014 cruise

SC/65a/O05 outlined the plan for the IWC-POWER cruise in 2014. The proposed research area is the eastern north Pacific, between 170°E and 160°W, from 30°N to 40°N (Annex G, fig. 2). Photo-id and biopsy experiments are also planned. The plan was drawn up following general guidelines agreed in 2012 at the Tokyo Planning Meeting (SC/65a/Rep01). Information collected from this survey will provide essential information for the intersessional Workshop to plan for a medium-long term international survey programme in the North Pacific.

On receiving these plans, the Committee **recommends** that permission be sought to operate in the US EEZ far enough in advance for the 2014 cruise. The Committee was informed that the Japanese and US governments are working to solve the problems before the 2014 survey. It thanked the Government of Japan for its generous offer of providing a vessel for this survey.

The Steering Group for IWC North Pacific Planning appointed last year was re-established, convened by Kato (see Annex R). Final planning will take place at a Planning Workshop to be held in Tokyo (see Item 26).

10.12.5 IWC-SOWER cruises (progress on website, publications and analyses)

Last year, the Committee nominated an Editorial Board, and tasked it with responsibility for the preparation of a commemorative IDCR/SOWER volume. As Convenor, Bannister reported that in accordance with the Committee's wishes, a timetable has been developed, a contents list has been proposed and authors have been approached to prepare brief outlines of their contributions.

The volume is intended to be a book reviewing the cruises: not a series of original scientific papers, but rather a series of review chapters bringing together all the work that has been accomplished so far (see Annex G, item 4.1). The volume will provide an introduction to the IDCR/SOWER programme and its fieldwork, including its original aims and objectives, and cruise narratives. There will be major chapters on whale distribution and movements, particularly of minke and blue whales, on taxonomy and population structure, on acoustics, and on abundance (including the development of DESS). An extremely important chapter will be devoted to conclusions and lessons for the future, with emphasis on achievements and lessons learned.

The Committee thanked Bannister and the Editorial Board, and looked forward to an update next year.

In order to facilitate analyses for some of the planned contents, the Committee considered that the production of standard datasets (similar to those produced for the analysis of Antarctic minke whales) would be useful. The Secretariat will make the data available when requested although additional information must be provided if any additional verification is needed to that which is already incorporated into IWC-DESS.

10.12.6 Other cruises

10.12.6.1 REPORT OF JAPANESE CETACEAN SIGHTING SURVEYS IN THE NORTH PACIFIC IN 2012

SC/65a/O04 reported on three systematic dedicated sighting surveys conducted in 2012 summer by Japan (ICR) as a part of JARPN II to examine the distribution and abundance of large whales in the western North Pacific. Over 8,700 n.miles were searched in total, and of the baleen whales, Bryde's whales were most frequently encountered, with only five individual minke whales observed in the offshore strata.

The Committee welcomed this report and **recognises** the value of the data. As noted under Item 10.12.2, sighting conditions might need to be accounted for when estimating abundance in the North Pacific (particularly for common minke whales), and indeed when designing surveys for that purpose. Although the small number of sightings of common minke whales in the offshore strata might well be largely due to poor weather, it was considered premature to conclude that no abundance estimate could be made without first seeing a weather-stratified analysis.

10.12.6.2 PLANS FOR A JAPANESE CETACEAN SIGHTING SURVEYS IN THE NORTH PACIFIC IN 2013

Plans for a systematic dedicated sighting survey in the North Pacific by Japan (ICR) as part of JARPN II in 2013 are described in SC/65a/IA03; the survey is currently underway. The main objective is to examine the distribution and estimate the abundance of common minke and sei whales for management. Notwithstanding a possible minor trackline design issue, the Committee **endorses** the proposal.

10.12.6.3 REPORT OF CETACEAN SIGHTING SURVEYS IN THE ANTARCTIC IN 2012/13

Plans for a dedicated sighting survey in the Antarctic in the 2012/13 austral summer were presented last year and subsequently endorsed by the Committee (IWC, 2013a, p.41). Two research vessels were to survey Area III E, Area IV, and the western part of Area V, using the same methods as in the IWC-SOWER surveys, and in accordance with the guidelines agreed by the SC (IWC, 2005b). Unfortunately the research could not be conducted due to violent interference from an anti-whaling NGO (SC/65a/IA07).

The Committee noted and expressed its concurrence with the Commission's previous consideration of this issue and its 2011 Resolution on Safety at Sea (2011-12) in which the Commission and its Contracting Governments condemned any actions that were a risk to human life and property in relation to the activities of vessels at sea. In particular, the Committee expressed its regret that the actions prevented the sighting survey from being conducted, just as in 2011/12. Following the cessation of the IDCR/SOWER programme in 2009 (and notwithstanding smaller-scale national projects to collect sightings data in particular regions), surveys such as in SC/65a/IA07 provide the only dedicated cetacean sightings that are synoptic over a wide area, and as such are extremely valuable for the work of the Scientific Committee.

10.12.6.4 PLANS FOR CETACEAN SIGHTING SURVEYS IN THE ANTARCTIC IN 2013/14

A systematic cetacean sighting survey for abundance estimation is planned in the Antarctic in the 2013/14 austral summer, as part of JARPA II (SC/65a/IA06). The planned research area comprises Area IV, Area V and the western part of Area VI, from December 2013 to March 2014. Details, which also incorporate biopsy sampling and photo-id work, are in Annex G, item 4.3.

In discussion, the Committee recognised the difficulty of fully reviewing a proposal without detailed design information, but noted that this seems unavoidable given security considerations (see Item 10.12.6.3). The use of consistent protocols over time makes this series of cruises a valuable resource, not least for analysing ice effects. The Committee recalled that photos of blue, right, and humpback whales from similar surveys in the past have been submitted to the relevant catalogue-holders for those species (and will continue to be submitted in future). The Committee broadly **endorses** the proposal, **recommending** that the proposed trackline design be changed if a survey of the Ross Sea was actually able to proceed.

10.13 Other

10.13.1 Photographic archiving

SC/65a/IA14 presented a progress report of a major archiving and cataloguing exercise being undertaken by the Secretariat for the photographic collections arising out of the IDCR/SOWER and continuing IWC-POWER cruises. The photographs have a wide range of potential uses ranging from photo-identification through education to contributing to assessments of human impacts.

The Committee **expresses** its appreciation for the efforts of Taylor and Donovan in archiving and cataloguing the collections and looks forward to a further update next year.

10.13.2 Sperm whales

SC/65a/SH14 investigated the potential population recovery of sperm bulls off Albany, Western Australia. This segment of the population was reduced by commercial whaling by 74% between 1955 and 1978. In 2009, an aerial survey was undertaken to replicate the behaviour of the 'spotter' planes employed by the Albany whaling fleet from 1968-78. The mean number of sperm bulls seen on transect per day (morning) in 2009 was substantially lower than the mean number seen in any of the years between 1968 and 1978. The authors emphasised the preliminary nature of the results, but considered them indicative of a lack of increase in the number of sperm whales frequenting this area compared to when whaling was taking place.

The Committee discussed possible interpretations of these findings, including the potential for population shifts due to ecological changes. It also noted a relevant discussion on sperm whales off New Zealand in Annex M, item 8.8. However, the possibility of population decline led the Committee to discuss the feasibility of undertaking a future assessment of sperm whales. There was general agreement that such an assessment would concentrate on sperm whales in the Southern Hemisphere, but include equatorial nursery groups and the Arabian Sea. The Committee discussed the availability of data on: (1) population structure within ocean basins; (2) population size within ocean basins (and abundance in smaller areas); (3) catch history; and (4) considerations in the development of a new assessment model.

The Committee **agrees** that data availability and feasibility of future assessment would continue to be evaluated intersessionally and reported to the Committee next year. It **recommends** that a dedicated agenda item be added for this species for next year's meeting. More details can be found in Annex H, item 6.1.

11. STOCK DEFINITION

This agenda item was established in 2000, and has been handled since then by a Working Group. The Terms of Reference for this Working Group were changed in 2012 to reflect the evolving needs of the Committee. During this meeting, the Working Group continued to develop guidelines for preparation and analysis of genetic data within the IWC context (see Item 11.1), provided the Committee with feedback and recommendations concerning stock structure related methods and analyses presented to other sub-committees (see Item 11.2), and developed a draft reference glossary of stock related terms, to aid consistent definition of 'stocks' in a management context for the Committee (see Item 11.4 and Annex I, Appendix 5). The report of the Working Group is given as Annex I.

11.1 Guidelines for DNA data quality and genetic analyses

Two sets of reference guidelines have been developed and endorsed by the Committee (IWC, 2009d) and form 'living documents' that can be updated as necessary[17]. The first set addresses DNA validation and systematic quality control in genetic studies. The second set provides guidelines for some of the more common types of statistical analyses of genetic data used in IWC contexts, and contains examples of management problems that are regularly faced by the Committee. Three new sections were added to the data quality guidelines during SC/65a. Substantial progress on the genetic analysis guidelines was also made during this meeting and this document will now be completed intersessionally (see Item 11.5). Both guidelines will also be published in the peer-reviewed literature.

11.2 Statistical and genetic issues related to stock definition

A number of Committee stock related papers were discussed by the Working Group. These were submitted to the following sub-committees: Revised Management Procedure (Annex D), Bowhead, Right and Gray Whales (Annex F), In-Depth Assessments (Annex G), Other Southern Hemisphere Whale Stocks (Annex H) and Review of Special Permit Proposals (Annex P). Technical comments on these papers are given in Annex I.

Gray whale stock structure was discussed in the context of SC/65a/BRG16 and Annex I, Appendix 2. An initial set of hypotheses were developed from these documents to describe the stock structuring of western and eastern gray whales, with particular reference to the Sakhalin Island feeding ground. These initial hypotheses are shown in Annex I, Appendix 3. They will be further developed intersessionally and assigned levels of plausibility. This will contribute to the proposed rangewide Workshop on gray whale stock structure and status (see Item 26).

A general comment was raised that is relevant to many discussions of stock related papers presented to the Committee. With new 'next-generation' DNA sequencing (NGS) techniques, it is now relatively inexpensive to increase the number of genetic markers analysed, so that more information can be gained from each sample in a population study. More genetic markers are often called for in circumstances where the existing marker set cannot detect population differentiation, either due to lack of discriminatory power or lack of population subdivision. Increasing the number of genetic markers increases the power to detect subtle population structuring and can facilitate future studies of relatedness patterns among sampled animals. Simulation analysis of the power of DNA markers to measure departures from panmixia and to reject demographically significant (i.e. sufficiently high) migration rates between putative differentiated populations can provide a useful means of measuring whether the existing DNA marker dataset is sufficient to answer the management question being posed. In all Committee studies, it is important to consider the level at which structure population needs to be detected in order for it to be of management concern. Increased numbers of loci can increase power to detect subtle population structure and also allow for improved inference of the population history underlying the substructure. However, they can also increase resolution to the point where even individuals can be discriminated and can also amplify spurious signals from genotype errors and small departures from random sampling. With the rapid recent developments in NGS technology and analysis, there are some emerging issues of relevance to the Scientific Committee, in terms of: (1) assessment of NGS data quality, and how best to curate such data; and (2) new methods for measuring stock structuring and measurement of other statistical quantities of interest to the Committee. New and published papers on this topic are therefore solicited for submission next year, where they will be considered in the context of the existing Committee guideline documents on DNA analysis and quality (see Item 11.5).

[17]*http://iwc.int/scientific-committee-handbook#ten.*

11.3 Testing of Spatial Structure Models (TOSSM)

The aim of TOSSM is to facilitate comparative performance testing of population structure methods intended for use in conservation planning. From the Committee's perspective, the IWC-developed TOSSM software package allows evaluation of methods for detection of genetic structure, in terms of how well the methods can be used to set spatial boundaries for management. It is available for all to use and simulated datasets exist for three of the five stock-structure archetypes previously proposed by the Committee (IWC, 2009b, p.51). Progress has been made on the work items suggested at last year for the Pacific Coast Feeding Group (PCFG) of gray whales (see Item 8.1) and will be presented at the 2014 Annual Meeting.

The Committee noted that the potential for using simulated datasets generated by TOSSM for work to evaluate dispersal rates and new methods for genetic clustering, as proposed under RMP (Annex D, Appendices 3 and 4), particularly in relation to stock hypothesis under review for the Scientific Committee.

11.4 Terminology and unit-to-conserve

Defining and standardising the terminology used to discuss 'stock issues' is still a long standing objective of the Working Group on Stock Definition, in order to help the Committee report on these issues according to a common reference of terms. Appendix 5 of Annex I has been developed by the Working Group with the aim of encouraging consistent use of stock related terms within Committee reports and in papers submitted to the Committee. The Appendix provides initial draft definitions of Committee terms such as 'biological stock', 'sub-stock', 'population' and 'management stock' which will be further discussed and refined intersessionally by members of the Committee. A list of agreed terms will be finalised next year. A challenging example set of cetacean populations that have been discussed by the Scientific Committee over the last five years will be chosen and their stock 'definitions' agreed intersessionally, also for presentation and discussion at next year.

11.5 Work plan

The Committee's work plan is given under Item 24.

12. ENVIRONMENTAL CONCERNS

The Commission and the Scientific Committee have increasingly taken an interest in the possible environmental threats to cetaceans. In 1993, the Commission adopted resolutions on research on the environment and whale stocks and on the preservation of the marine environment (IWC, 1994a; 1994b). A number of resolutions on this topic have been passed subsequently (e.g. IWC, 1996b; 1997; 1998a; 1999a; 1999b; 2001a). As a result, the Committee formalised its work on environmental threats in 1997 by establishing a Standing Working Group that has met every year since.

12.1 State of the Cetacean Environment Report (SOCER)

SOCER provides an annual update, requested by the Commission, on: (a) environmental matters that potentially affect cetaceans; and (b) developments in cetacean populations/species that reflect environmental issues. It is tailored for a non-scientific audience. The 2013 SOCER (Annex K, Appendix 4) had the Mediterranean and Black Seas as the regional focus. Publications summarised ranged from impacts of fisheries removals on cetacean prey to strategies aimed at reducing bycatch in the severely reduced population of common dolphin, to contaminants in Mediterranean cetaceans. Disease continued to be an important issue in the Mediterranean. Finally, an overview published by ACCOBAMS identified the main threats to cetaceans in the Mediterranean and Black Seas.

Globally, numerous studies on climate change and ocean acidification are starting to show impacts on marine species. Data on the impacts of underwater noise are increasing with new models becoming available on stress responses in cetaceans linked to underwater noise.

The Committee encourages continued contributions to this effort. Next year, the focus of the SOCER will be on the Atlantic Ocean region.

12.2 Pollution

12.2.1 Update on POLLUTION 2000+ Phase II progress

At the intersessional POLLUTION 2000+ Phase II Workshop, held in 2010 (IWC, 2011a), four objectives for the cetacean pollutant exposure and risk assessment modelling component were agreed: (1) improve the existing concentration-response function for PCB-related reproductive effects in cetaceans (completed in 2011); (2) derive additional concentration-response functions to address other endpoints (e.g. survival, fecundity) in relation to PCB exposure (completed in 2012); (3) integrate improved concentration response components into a population risk model (individual-based model) for two case study species: bottlenose dolphin and humpback whale; and (4) implement a concentration-response component for at least one additional contaminant of concern.

SC/65a/E04 provided a summary of the intersessional work that was completed in POLLUTION 2000+, Phase III. The objective of this work was to develop a framework for assessing the health risks associated with contaminant exposure on cetacean populations. Two previous papers on the first phases of this work are Hall *et al.* (2011) and Hall *et al.* (2012).

Bioaccumulation of contaminants and their population level effects were explored using a stochastic model that integrates measured tissue concentrations with a dose-response relationship to estimate potential impact on population dynamics. Two examples were examined using this framework: bottlenose dolphins and humpback whales. One of the model outputs was an annual accumulation rate for blubber PCB levels (e.g. 1.2 mg/kg lipid for female bottlenose dolphins and 0.2 mg/kg lipid for Gulf of Maine humpback whales). These exposure levels would produce no discernible effects on population growth. Analyses of model parameter sensitivity and uncertainty indicate that the model is reasonably robust and would be acceptable for making population inferences and management decisions.

An approach that would allow concentrations of total blubber PCBs in cetaceans to be estimated from data on concentrations in their prey was also explored, assisting in situations where biopsy samples are not obtainable. In an example again using bottlenose dolphins, data on energy requirements and consumption rates on concentrations of total PCBs in prey were combined in a physiology-based toxicokinetic model.

These modelling approaches provide a risk assessment tool that can be used to determine the population consequences of exposure to contaminants. The model framework also has the potential for investigating the impact of a variety of stressors on cetaceans and is currently being converted into a web-based program with a user-friendly interface that will be accessible from the Commission website.

Since the Pollution 2000+ Phase III risk assessment work plan is near completion, the Committee began planning the next phase. The Committee established a Pollution 2020 steering group, which will next focus on assessing the toxicity of microplastics and polycyclic aromatic hydrocarbons and dispersants in cetaceans (see Annex K, item 11.2 and Appendix 2).

The Committee **commends** the progress on Pollution 2000+ Phase III objectives and **strongly supports** its continued work to further develop the necessary tools to assess cetacean pollutant exposure risk. The Committee **agrees** to the Pollution 2020 framework plan.

12.2.2 Oil spill impacts

After the Deepwater Horizon oil spill in April 2010, oil spill response was followed immediately thereafter by a Natural Resource Damage Assessment (NRDA) to investigate the injuries and impacts to cetaceans in the Gulf of Mexico. The NRDA investigation has included stranding response in the northern Gulf of Mexico; photo-id and biopsy surveys for bay, sound and estuary dolphins; aerial and boat-based surveys, including biopsy and tagging activities, for cetacean abundance and distribution in coastal and offshore habitats; and live capture/release health assessments.

An Unusual Mortality Event (UME) was declared in November 2010 for cetaceans in the northern Gulf of Mexico that started in February 2010 and now includes over 1,000 cetacean strandings. The Deepwater Horizon oil spill has not been ruled out as a possible contributing factor to this UME, which is the longest lasting and largest dolphin mortality event in US recorded history. In addition to the UME investigations, live capture/release health assessments of bottlenose dolphins from Barataria Bay, Louisiana (oiled area) and Sarasota Bay, Florida (reference site) were performed in 2011. Dolphins from Barataria Bay showed significant health issues, including pulmonary lesions and adrenal abnormalities, as compared to animals in Sarasota Bay. Chemical analyses associated with these stranded and live-capture dolphin studies have been completed and are currently being validated. In addition, a number of monitoring and assessment efforts on cetaceans have been conducted in offshore areas, including photo-id, passive acoustic monitoring, and tagging studies on pelagic species (e.g. sperm whales), as well as aerial and boat-based surveys.

The Committee **expresses great concern** about the continued high number of dolphin strandings in 2013. The Committee **agrees** that funding gaps are problematic for long-term monitoring projects, recognising that 3-5 year funding cycles are not geared toward such studies. The Committee welcomes the new information on marine mammal studies in the Gulf of Mexico and **encourages** scientists to provide restoration ideas for cetaceans to NOAA.

Information on oil spill preparedness was also presented. Details were provided on the Arctic Council's efforts to address oil spill preparedness (and response) based on the 1990 International Convention on Oil Pollution Preparedness

Response and Cooperation (OPRC), administered by the International Maritime Organization (IMO), to which all eight Arctic States are Parties[18]. Additionally, the Committee was given details on the US National Research Council's review of the capabilities, limitations, and needs for responding to an oil spill in the Arctic[19], as well as the US Arctic Research Commission's recently published white paper examining the state of oil spill preparedness, response and damage assessment in the Arctic[20].

Several workshops focused on Arctic resource development and policy will be held in the next year. Developing recommendations related to cetacean conservation and management may provide the Convenors of these workshops with information necessary for sound decision-making. The Committee **reiterates** its previous conclusion (IWC, 2011b, p.41) that a review of the capacity for oil spill response in the Arctic was an urgent priority in the aftermath of the Deepwater Horizon oil spill. The Committee **concludes** that it would be useful to know more about the current capacities and mechanisms of oil spill recovery. Given the amount of activity occurring related to oil spill preparedness and the fact that oil spill preparedness and response plans are being developed, the Committee **recommends** an increased exchange of information between the IWC Secretariat and the Arctic Council's Emergency Prevention, Preparedness, and Response Working Group (EPPR-WG).

12.2.3 Other pollution-related issues

In response to the statement in Resolution 2012-1 encouraging the World Health Organization (WHO) to conduct reviews of recent scientific publications regarding contaminants in certain cetacean products and give updated advice for consumers, the Committee **recommends** that the Secretariat reinitiate discussions with the WHO as a preliminary step, to ensure that they are in need of this information and would be willing to receive it, prior to moving forward on this Item.

Hunt *et al.* (2013) focused on methods that can produce information on parameters relevant to stress physiology, reproductive status, nutritional status, immune response, health and disease using non-lethal sampling techniques (see Annex K, item 7.3.2). Field application of these techniques has the potential to improve our understanding of the physiology of large whales, better enabling assessment of the relative impacts of many anthropogenic as well as ecological pressures. SC/65a/BRG23 reported on the progress of a programme to analyse biopsy samples of gray whales feeding off of Sakhalin Island, Russia that will include pregnancy testing, determination of stable isotope ratios and genetic analyses.

The Committee **commends** the recent advances in methods for non-lethal sampling, noting that information on stress physiology, reproductive status, nutritional status, immune response, health and disease are valuable to health assessment efforts. The Committee **endorses** this work and **strongly recommends** further development and improvement of these methodologies. The Committee **commends** the application of such techniques to the gray whales feeding off of Sakhalin Island, Russia.

The Committee received several contaminant-related papers associated with the Icelandic Research Programme, including those reporting concentrations of legacy persistent organic pollutants, trace elements, radioactivity and new contaminants of concern in Icelandic minke whales. A summary of the findings of these studies is listed in Annex K, item 7.3.3. The Committee thanked the Icelandic scientists for summarising these findings.

[18] *http://www.Arctic-council.org/index.php/en/reources/news-and-press/press-room/733-press-release-15-may-kiruna-2.*

[19] *http://www.dels.nas.edu/study-in-progress/responding-spills-Arctic/DELS-OSB-09-02.*

[20] *http://www.Arctic.gov/publications/oil_spills.2012.html.*

12.3 Cetacean Emerging and Resurging Disease (CERD)

In 2007, the Committee recognised the need for increased research and standardised reporting in a wide range of disciplines dealing with cetacean health (IWC, 2008d), which led to the creation of the Cetacean Resurging and Emerging Disease (CERD) Working Group.

12.3.1 Update from CERD Working Group

An update to the CERD work plan agreed in 2011 (IWC, 2012e, Appendix 3) included: (i) identification of regional and national experts/points of contact via Steering Committee membership; (ii) creation of a listserve and a website; (iii) creation of a Framework Document; and (iv) identification of and contact with organisations synergistic with the goals of CERD.

12.3.2 CERD website and work plan

Data on infectious and non-infectious diseases, general cetacean disease, nutritional disorders and biotoxins have been compiled and await entry. Additional input on skin diseases, visual health assessment and mortality events or unusual mortality events (UMEs) is needed. Although significant progress had been made the final website had not yet been completed. It was noted that an internship programme with projects aimed at expanding specific sections related to skin diseases, mortality events and visual health assessment would aid in this process.

The Committee **agrees** that supporting the aggregation of website information and input, and the ability to post and manipulate high-resolution images and video, are critical to the success of the CERD website. The Committee also **agrees** that there is value in linking to social websites in order to direct inquiries and information to the CERD website (for appropriate material). The Committee **encourages** continued development.

12.3.3 Strandings and mortality events

SC/65a/SM27 reported on a mass stranding event (MSE) in which 20-30 short-beaked common dolphins stranded on a beach in the Rio de Janeiro State, Brazil, and were returned to the water by tourists. The authors proposed that these pelagic dolphins were probably acoustically trapped or restricted by some noise source that caused them to panic and swim toward the beach and strand. An update also was received on a highly unusual event involving the long-term displacement and mass stranding of approximately 100 melon-headed whales that occurred in May-June 2008 in northwest Madagascar. An Independent Stranding Review Panel was formed to review all the information and a report is expected in a few months. Details of the response can be found in Annex K, item 8.3. The Committee **commends** industry and response organisations for a tremendous and successful effort in responding to and investigating this event.

Park *et al.* (2012) reported on a mass mortality of 249 finless porpoises that occurred on 3 February 2011 at a dyke in the Saemangeum Sea, Korea. This MSE was due to freezing surface water in the enclosed area and the animals died of suffocation. The Committee **expresses concern** about this MSE, especially with respect to the potential impact of dykes and encouraged the continued evaluation of animals in this area. The Committee **commends** the efforts made to investigate the stranding event.

SC/65a/BRG15 reported on a workshop held in April 2013 dealing with the ongoing southern right whale die-off at Península Valdés, Argentina. A previous IWC Workshop on the southern right whale die-off in 2010 (IWC, 2011f) drew attention to the increasing incidence of parasitic behaviour of kelp gulls, which peck at the outer skin and then feed on the blubber of live whales at Península Valdés. The recent workshop developed an additional hypothesis on the possible contribution of gull attacks to calf mortality at Península Valdés (see Annex F, item 4.4 for additional details).

The Committee **commends** the investigative team in Argentina for their thorough investigation. The Committee **encourages** continued work to evaluate the cause(s) of these mortalities, the implications to the population and the effectiveness of planned gull mitigation measures (and see Item 26).

Information on the International Workshop for Capacity Building on Marine Mammal Stranding (NOAA-IMARPE) was also received. The Government of Peru requested this workshop to help increase capacity for cetacean stranding response after a large die-off of common dolphins occurred in early 2012, in northern Peru. For more details see Annex K, item 8.3. Additional information on strandings and the detection of human-induced mortality was provided to a joint meeting of the SWG on Environmental Concerns and the Working Group on non-deliberate Human Induced Mortality. Furthermore, two papers on categorisation of human-induced trauma and interactions in cetaceans (Moore and Barco, 2013; Moore *et al.*, 2013a) were presented. Summaries of these papers can found in Annex J, item 6.

12.3.4 Other disease-related issues

The Committee received a summary of three disease-related papers reporting on the occurrence and prevalence of parasitic organisms and pathogens in Icelandic minke whales, associated with the Icelandic Research Programme. Discussion points related to these papers are listed in Annex K, item 8.4. The Committee thanked the Icelandic scientists for summarising these findings.

12.4 Anthropogenic sound

12.4.1 New information on the effects of anthropogenic sound on cetaceans

SC/65a/HIM01 discussed underwater bow-radiated ship noise in the Canary Islands (Spain), where a large fleet of commercial ferries operates on a year-round basis, and at the same time a high number of stranded cetacean carcasses in the area have shown injuries typically attributed to ship strikes. Whales may be capable of hearing approaching vessels at reasonable distances, enabling them to react fast enough to avoid collision; however, there are numerous factors to be considered in evaluating the actual collision risk. Overall, ferry traffic appears to contribute significantly to noise pollution in the Canary Islands archipelago.

SC/65a/E03 reported that significant progress has been made on the issue of marine noise pollution beginning in the mid-1990s. Within a few years, agencies such as the US Marine Mammal Commission had acknowledged the significance of marine noise pollution, as did some regional conventions, and later other legislative measures, such as the EU Marine Strategy Framework Directive – which specifically addresses noise – were developed.

New tools are under development to assess the cumulative effects of noise, such as cumulative noise and cetacean distribution mapping. Marine Spatial Planning and Marine Protected Areas are increasingly considering noise and disturbance, and industry is investing in noise reduction and alternative technologies. For at least some noise sources, there seems to be a general consensus that time-area closures represent one of the most effective available means of reducing impacts on marine mammals. Ship-quieting technologies for commercial vessels are also being developed. For further details see Annex K, item 9.1.

The Committee **encourages** time/area closures and the development of new quieting technologies to address noise pollution. The Committee **encourages** further scientific investigations to better understand the effects of sound on cetaceans and their habitats and to better understand the effectiveness of mitigation measures.

12.4.2 Update on new tools and approaches to mitigate effects of anthropogenic sound on cetaceans

The status of current noise management is one of traditional focus on relatively short-term and relatively small-scale human activities, emphasising thresholds of noise exposure from high intensity and short duration sources, with limited abilities to incorporate knowledge of background noise or look at the broader cumulative impacts. However, recently there has been a shift underway to focus on more ecologically-relevant spatial and temporal scales, in order to address chronic, perhaps lower intensity, sources.

Work being undertaken on soundscape mapping was presented last year. An update on progress intersessionally was provided and a joint IWC/IQOE (International Quiet Ocean Experiment) technical Workshop on soundscape modelling was proposed (see Annex K, item 9.2.1; the full proposal can be found as Annex K, Appendix 3). The goals of the Workshop are to exchange, evaluate and analyse soundscape modelling methodologies, examine and assess priority regions and important sound sources, and develop scientific recommendations.

The Committee **commends** the work on soundscape modelling. The creation of 'soundscapes' and noise maps was considered a valuable initiative. The Committee **encourages** the Workshop planners to consider not only the identification of sites of highest noise impacts, but also the direct benefits that could be realised by the reduction of noise impacts. A direct link to conservation outcomes such as reducing noise impacts on cetaceans could be of particular interest to the Commission. For additional discussion of the proposed Workshop, see Annex K, item 9.2.1.

The Committee **strongly supports** this proposal for a Workshop to be held intersessionally (Item 26).

12.5 Climate change

12.5.1 Update on recommendations from previous climate change Workshops

No updates on previous climate change Workshop recommendations were submitted for review and no papers were submitted under this topic.

12.5.2 Other climate change-related issues

The Committee recognised that climate change is an issue of increasing importance and should be kept on the agenda. In order to better identify topics for future climate change studies, the Committee **agrees** to the formation of an intersessional correspondence group (see Annex R). The Committee **agrees** to use the outputs of the intersessional group to develop future priorities under this topic.

12.5.3 Planning for Intersessional Arctic Anthropogenic Impacts Workshop

In 2010, the Commission requested that the Committee develop an agenda for a Workshop on Arctic Anthropogenic Impacts on Cetaceans. The Committee drafted an agenda and formed a Workshop steering group to further develop a plan for the Workshop (IWC, 2012f). A revised agenda that focused on anthropogenic activities related to oil and gas exploration, commercial shipping and tourism was developed by the Workshop steering group and presented last year (IWC, 2013j, p.255).

In discussion, it was noted that this will be a Commission Workshop and is planned for the next intersessional period. The agenda, venue, timing and participant list are still being developed.

The Committee recognises that the topic of anthropogenic impacts to cetaceans in the Arctic is broad and complex and **encourages** further efforts to address these impacts. The Committee noted that the activities recommended above under Item 12.2.2 on oil spill preparedness and responses represent one immediate effort to better coordinate with Arctic IGOs.

12.6 Other habitat-related issues

12.6.1 Interactions between Marine Renewable Energy Devices (MREDs) and cetaceans

SC/65a/E02 reviewed public knowledge of the Marine Renewable Energy Devices (MRED) Workshop report from last year (IWC, 2013b), as well as its larger impacts, to better understand whether the recommendations from such reports are reaching the appropriate audiences and providing them with useful information. Workshop participants were surveyed and whilst the respondents found the Workshop useful personally and the meeting generally well run, the replies provided little evidence yet that the Workshop has had any influence on policy-making or other processes related to marine renewables. There is also little sign of any footprint of the Workshop in any recent scientific or other related literature. Related to this, several participants raised concerns about the inability to find and access the report, as well as how to cite it.

The Committee **agrees** that the visibility and accessibility of its reports needs to be improved and **encourages** the Secretariat and the Committee to consider additional mechanisms to enhance access to, and distribution of, Committee reports.

12.7 Work plan

This is discussed under Item 24.

13. ECOSYSTEM MODELLING

The Ecosystem Modelling Working Group was first convened in 2007 (IWC, 2008c). It is tasked with informing the Committee on relevant aspects of the nature and extent of the ecological relationships between whales and the ecosystems in which they live.

Each year, the Working Group reviews new work on a variety of issues falling under three areas:

(1) reviewing ecosystem modelling efforts undertaken outside the IWC;
(2) exploring how ecosystem models can contribute to developing scenarios for simulation testing of the RMP; and
(3) reviewing other issues relevant to ecosystem modelling within the Committee.

The report of the Working Group on Ecosystem Modelling is given as Annex K1.

13.1 Review ecosystem modelling efforts undertaken outside the IWC

13.1.1 Modelling of the direct relationship between baleen whale populations and the abundance of their prey

Two invited presentations were made on ecosystem models of the effects on predators of fishing on forage fish, summarising the results of two large studies commissioned by the Marine Stewardship Council, MSC (Smith *et al.*, 2011) and the Lenfest Ocean Program (Pikitch *et al.*, 2012), that were completed in recent years. An important message from these studies is that fishing of forage fish down to their MSY level may have major impacts on predators, including birds and marine mammals, in some ecosystems. SC/65a/EM03, which summarised the MSC study, explored the effects of different levels of depletion of forage fish in five different ecosystems (the southern Benguela Current, the northern Humboldt Current, the California Current, the North Sea, and southeastern Australia) using three modelling frameworks (Ecopath with Ecosim [EwE], OSMOSE and Atlantis). The results showed a trade-off between yield from the forage fish species and impacts on the rest of the ecosystem. Although the broad results were relatively robust to the type of model used, predictions about impacts of and on particular species or groups varied considerably between models, suggesting that their use for 'tactical purposes' is not yet warranted.

SC/65a/EM05, which summarised the Lenfest study, conducted a meta-analysis of 72 published studies that used Ecopath models on a variety of marine ecosystems, with the goals of characterising the role of forage fishes and fisheries, and of providing general recommendations for conservative fisheries management. Further analyses using EwE models for 10 ecosystems suggested that minimum biomass levels to avoid predator declines should be about 75% of the unfished biomass – much higher than those predicted by single-species, MSY-based management. A tiered management approach was recommended where more conservative harvest limits are applied when there is high uncertainty about forage fish dynamics or predator dependencies. This study did not evaluate the impacts on marine mammals, and the general approach would need modification to address important aspects of whale populations which do not exhibit the high degree of variability that is characteristic of forage fish populations, or the effects of 'prey switching' that occurs when several forage species are present in an ecosystem.

The Committee **concurs** with the authors of the presented studies that the models used in the studies to date are useful for their broad-scale strategic conclusions, but are not yet suitable guides for short-term tactical management decisions. The Committee **agrees** that, in broad terms, the case has been established that forage fisheries are expected to impact predator populations including cetaceans, and considers that the priority for this Group should now be on more detailed models for specific cases involving whales, with more attention being paid to the dynamics, including stochastic factors. The Committee **agrees** that the framework discussed in Item 13.2 is a promising basis for modelling the effect of changes in prey species on whale populations.

13.1.2 Update from CCAMLR's Ecosystem Monitoring and Management Programme (WG-EMM) on krill and its dependent predators

The Committee held a joint Workshop with CCAMLR in 2008 (IWC and CCAMLR, 2010). Since then, the

Committee has identified significant knowledge gaps in aspects such as spatial variability and trends in prey species, on the relationships between predators and prey, and on the effects of environmental variability on predators. Given CCAMLR's considerable expertise on these aspects, the Committee **agrees** that the Chair of the Committee should write to CCAMLR in time for the meeting of the WG-EMM in Bremerhaven, Germany, in early July 2013, to discuss how to establish future collaborations.

13.2 Explore how ecosystem models can contribute to developing scenarios for simulation testing of the RMP

De la Mare (2013) described a modelling framework originally presented at the fourth MSYR Workshop (SC/65a/Rep05) that uses spatially resolved individual animal behaviour and detailed energy budgets to determine reproductive success and mortality in an environment where food has a patchy spatial distribution. One immediate application relates to the characterisation of yield curves for populations in stochastic environments, including assessing the relative advantages of defining yield curves in terms of number or biomass.

The Committee identified nine issues (listed in Annex K1, item 3) relating to ecosystem effects and the RMP that could be usefully explored either with this individual-base model (IBM) or with simplified emulator models that mimic the behaviour of the IBM. The Committee appointed a correspondence group under de la Mare to develop specific trials for the RMP for one of these issues (characterisation of yield curves for populations in stochastic environments) and **agrees** to make two of the remaining items a high priority for next year:

(1) effects of competition, including effects on whales from fisheries on prey species; and
(2) observable environmental and population characteristics likely to be indicators of ecosystem effects.

The Committee **encourages** analyses on these issues and **agrees** to invite outside expertise as needed.

13.3 Review of other issues relevant to ecosystem modelling within the Committee

13.3.1 Update on Antarctic minke whale body condition analyses

For the last three years, the Committee has discussed apparent declining trends in blubber thickness and body condition in Antarctic minke whales (Konishi *et al.*, 2008) over the 18 years (1987-2006) of the JARPA special permit programmes (e.g. IWC, 2013i). At the heart of the discussion has been the validity of the statistical methods that were used to derive these trends and more specifically whether the models fitted so far adequately captured the main sources of variability in the data, given the nature of the sampling (de la Mare, 2011; 2012). This discussion is relevant to ecosystem modelling because the findings have implications for energetics, reproductive fitness, foraging success and the prey base itself, all of which are important as input in models.

Previously, the Committee has requested further analyses of the data, including:

(1) determining whether the models fitted so far capture all the main features of the data,
(2) determining whether the estimate of trend could be made more precise,
(3) analysing the two sexes separately,
(4) including the interaction of slopes by latitudinal band with year as a random effect, and
(5) investigating independence issues by using mixed-effects models with trackline as a random effect (IWC, 2011e; 2012d).

Two reanalyses of the data were conducted at the 2011 meeting (IWC, 2012d, p.260), one using the jack-knife method with one year as the unit on the published regression model, the other using mixed-effect models to account for some of the variance structure. Both reanalyses resulted in a much higher variance of the estimated trend, but the point estimates were little changed and were still significant.

This year, SC/65a/EM04 presented jack-knife estimates of the variance of the trend by taking individual years or groups of up to three years as the jack-knifing unit. Unexpectedly, the variance of the trend estimate was much less than the variance calculated by Skaug (2012) from the model itself. This led to considerable discussions within the Working Group on the appropriate statistical procedures to use. These are detailed in Annex K1 under item 4.1 and are not repeated here. In addition, a new analysis of total body fat was also presented (Annex K1, Appendix 6) that the authors believed supported the earlier conclusion of a decline in energy storage in Antarctic minke whales during the JARPA period but that others questioned.

The Committee **reiterates** its recommendations from previous years that the outstanding issues raised at recent meetings should be examined (for details see Annex K1, item 4.1). A number of additional suggestions were also made this year. The Committee **encourages** additional analyses to be undertaken on both the blubber thickness and body fat data and noted that papers should ideally be submitted to the forthcoming JARPA II review Workshop (see Item 17.3).

13.3.2 Other, if new information is available

SC/65a/EM02 outlined plans for conducting ecosystem modelling for baleen whale species in Antarctic Area IV, based on data from the JARPA and JARPA II programs. Two types of approaches will be employed; one is a comprehensive, 'whole ecosystem' model (EwE), and the other is a 'model of intermediate complexity' for ecosystem assessments (a multi-species production model). Baleen whales and krill play key roles in both, and the results will be applied to available time series data of baleen whales, seals and krill. Results from these two approaches will be reported at the JARPA II review.

The Committee **welcomes** these plans but suggested that the aims of the modelling exercise be better clarified. The author explained that one aim is to compare the results from a broad-sweep model such as EwE that encompasses most components of the ecosystem with those from a model that includes more detail on the dynamics of the main species of interests. Documentation of the input sources will be provided and options for diagnostic tests of the predictions should be developed. This information should be included in any paper presented to the forthcoming JARPA II review.

SC65a/EM01 presented a preliminary report from a multi-species modelling effort to study the role of minke whales in the marine ecosystem around Iceland, including consumption of sand eel and cod. In its initial phase the focus is on implementing single-species models in the Gadget statistical framework, but the medium to long-term plans are to build multi-species models and to compare different modelling approaches such as Gadget, FishSums, EwE and Atlantis, in order to assess their value to the management of living resources in Icelandic waters as part of the MareFrame project.

The Committee **welcomes** these efforts and **encourages** further refinements to include the effects of environmental variability on prey species and to incorporate prey switching in the next version. It was also noted that these exercises typically require a substantial amount of exploration to determine what is driving the observed trends in the predicted abundance of the target species.

SC/F13/SP02rev, SC/F13/SP03rev and SC/F13/SP04rev were initially presented at the Icelandic Special Permit Expert Panel Review Workshop in February 2013 and then revised in the light of comments made by the expert panel (see SC/65a/Rep03). These papers presented new information on the feeding ecology of common minke whales based on analyses of stomach contents, fatty acid profiles in blubber and blood tissues, and stable isotopes measured in blood, muscle, and skin tissues. The studies showed pronounced spatial and temporal variations. The fatty acid and stable isotope analyses further revealed tissue specificity, indicating that the results need to be interpreted with their limitations in mind. Together, these papers indicated that the differences between the stomach contents, fatty acid and stable isotope analyses can best be explained by the different time periods reflected by these methods, such that the stomach content analysis represents the most recent feeding and is therefore the best measure for local diet composition within the time-frame of their model, while the other two methods reflect feeding before arrival on the Icelandic feeding grounds in spring.

Tamura and Murase welcomed the information on diet data from these studies stating that they are useful in ecosystem models. Detecting changes in prey requires long time-series of data and fatty acid analyses complement data from stomach analyses.

SC/65a/O02 presented estimates of seasonal energy deposition in minke whales from Icelandic waters, based on measured increase in weight and energy of different tissues. Minke whales increase their weight by 27% over the feeding season, but due to increases in energy density of tissues, the total increase in energy content of the body is around 90%. Most of the energy is stored in adipose tissue (blubber and visceral fat), but posterior dorsal muscle and bone tissue are also important sites for energy storage.

13.4 Development of a list of priority populations as candidates for Conservation Management Plans

The Committee **agrees** that the Ecosystem Modelling Working Group can best assist in this process in the context of provide specific advice once CMPs have been identified (see Item 21).

13.5 Work plan

The Committee's views on the work plan for Ecosystem Modelling can be found under Item 24.

14. SMALL CETACEANS

14.1 Review current status of selected populations of small cetaceans in east Asian waters (China [including Taiwan], Korea, Japan and Russia [white whales only])

This year, the priority topic was to review the current status of selected populations of small cetaceans in east Asian waters (see Annex L, fig. 1). The selection of species was based primarily on concerns about conservation status and the expectation that new information would be available.

14.1.1 Narrow-ridged finless porpoise (Neophocaena asiaeorientalis)

14.1.1.1 TAXONOMY AND NOMENCLATURE

SC/65a/O01 proposed that the general acceptance of two identified species in the genus *Neophocaena* – the narrow-ridged finless porpoise (*N. asiaeorientalis*) and the Indo-Pacific finless porpoise (*N. phocaenoides*) – should be recognised by the IWC. The change in taxonomy was based on clear morphological differences, genetic data and partial sympatry of the two forms in the Taiwan Strait (Jefferson and Wang, 2011). The Committee **endorses** the updating of the IWC list of recognised species (see Item 20).

SC/65a/SM24 presented a genetic analysis of finless porpoises in Japanese waters. The Committee **agrees** that these results confirmed previous ecological, morphological and molecular studies showing that there are at least five separate local populations of finless porpoises in Japanese waters that should be treated as different management units.

14.1.1.2 BYCATCH: REPUBLIC OF KOREA

Korea reported a total bycatch of more than 1,000 finless porpoises in 2011, including 249 that died under ice after being trapped inside a newly constructed 33km dike within the Saemangeum reclamation project (Yellow Sea). In 2012, Korea reported bycatches of 2,050 finless porpoises in the Yellow Sea and 128 in the Sea of Japan/East Sea (see details in Annex L, table 1).

Deliberate killing of cetaceans has been illegal in Korean waters since 1986 and a requirement has been in place since 1996 to monitor whale meat coming from incidental catches. This was amended in 2011 to intensify monitoring of the circulation of whale meat in markets. Currently, every incidental catch must be reported to the Korean Coast Guard and a tissue sample from each animal must be submitted to the Cetacean Research Institute for its DNA registry established to detect and trace illegal catches. The Korean government has intensified its monitoring effort since 2011 and consequently the reported number of finless porpoises bycaught in the Yellow Sea has increased dramatically. Korea will prepare a mitigation programme to reduce the finless porpoise bycatch, including consideration of gear modifications, changes to fishing practices and 'pingers'.

Zhang *et al.* (2005) provided uncorrected (and thus minimum) estimates of finless porpoises of 21,532 animals in offshore waters and 5,464 animals in near-shore waters along the west coast of the Korean Peninsula (South Korean waters) to Jeju Island. At that time (IWC, 2006b), the Committee had welcomed the studies and looked forward to their future refinement. The Committee noted that the current bycatch of 2,000 porpoises would be about 7.4% of an estimate of total uncorrected abundance of 27,000 porpoises in 2004.

The Committee **appreciates** the valuable information on finless porpoise bycatch provided by the Korean scientists. It **encourages** researchers and managers to continue their efforts to improve reporting and investigate ways to assess and manage the bycatch, particularly given the uncertainty regarding sustainability. The Committee **recommends** that an analysis be conducted to estimate past bycatches of finless porpoises using data on historical and recent fishing effort together with recently documented bycatch levels. It further **recommends** that available abundance data on finless porpoises in Korean waters be summarised for consideration at next year's meeting together with bycatch data to allow a better evaluation by area. The Committee **commends** the Korean authorities for their efforts to reduce this bycatch and **requests** that a report summarising progress on bycatch mitigation measures be submitted next year.

14.1.1.3 BYCATCH: JAPAN
Reported bycatch in Japan is low; a provisional figure of only 15 finless porpoises were reported as bycaught for January-December 2011[21]. Provisional data on strandings in Japan over the same time period indicated a total of 181 finless porpoises of which 178 were necropsied; it is not known to what extent the strandings were a result of bycatch.

14.1.1.4 IUCN RED LIST STATUS[22]
In 2012, IUCN listed *N. asiaeorientalis* as Vulnerable (see Annex L, item 3.1.4, for full details). Reeves reported that a new assessment of the Yangtze subspecies *N. asiaeorientalis asiaeorientalis* will soon be published listing the subspecies as Critically Endangered.

14.1.2 Populations of Tursiops aduncus *in Korean and Japanese waters*
Wang and colleagues (Wang *et al.*, 1999, 2000a, 2000b) distinguished the Indo-Pacific bottlenose from the common bottlenose dolphin using genetic, osteological and external morphological data. Around Japan, Kurihara and Oda (2006; 2007) concluded that the Indo-Pacific bottlenose dolphin occurs in at least three locations: (1) Amami Islands; (2) Amakusa-Shimoshima Island; and (3) Mikura Island. Kim *et al.* (2010) confirmed the presence of this species around Jeju Island, Korea.

14.1.2.1 JAPAN
SC/65a/SM26 summarised the abundance of, and threats to, nine populations of Indo-Pacific bottlenose dolphins in the Japanese Archipelago (details are given in Annex L, item 3.2.1). The Committee **notes with concern** an apparently serious bycatch problem around Amakusa-Shimoshima Island (Shirakihara and Shirakihara, 2012). It **recommends** that this problem is monitored closely and that efforts are made to reduce bycatches.

SC/65a/SM29 reported on a stranding of a 2.7m male Indo-Pacific bottlenose dolphin in Kagoshima for which gross and histological examinations suggested the animal had a Lobomycosis-like disease. Analyses are underway to confirm this diagnosis.

The Committee **agrees** that it is important to understand the origins and routes of spreading of this disease and **recommends** further investigation and continued close monitoring of the population around Amakusa-Shimoshima Island in western Kyushu.

While recognising the responsibility of the range state for the conservation and management of small cetacean species, Japan reconfirmed its position on the involvement of IWC in the management of small cetaceans and reserved its position on all management recommendations regarding small cetaceans.

14.1.2.2 KOREA
Korean scientists provided information on the year-round resident population of Indo-Pacific bottlenose dolphins in the coastal waters of Jeju Island. The total population was estimated[23] as 124 (95% CI=104-143) in 2008 and 114 (95% CI=109-133) in 2009 using photo-identification mark-recapture methods. The animals are most regularly observed along the northern coast of the island. Bycatch has been investigated since 2009 and the annual bycatch rate was estimated at 7%, with most of the animals being trapped in pound nets (a type of set net or trap). More than 80% of the dolphins have been alive when found in pound nets; if released alive, a gradual increase in the local dolphin population might be expected.

An effort is underway to release three dolphins back into the wild in summer 2013 after being instrumented with satellite tags in the area of Jeju Island (where they were caught before being sold illegally to Korean oceanaria). They are among at least 11 bottlenose dolphins brought into captivity from the Jeju population in the last four years.

The Committee thanked H-W Kim and colleagues for providing information on the small local population of bottlenose dolphins around Jeju. It **encourages** their work to continue and **requests** updates on this including the satellite-tagged released animals and efforts to release dolphins in fishing gear.

14.1.3 Short-finned pilot whales (Globicephala macrorhynchus) *in Japan*
SC/65a/SM12 reviewed available information on the status of the southern and northern form short-finned pilot whales in Japan. Available abundance estimates of both forms are more than twenty years old. Catches have declined but the cause or causes are uncertain. Changes in catch composition of the northern form in the 1980s, with a declining proportion of old and large individuals (probably mostly males) observed in the catch, was inferred to indicate a decline in the population. No recent information has been published on the catch composition of either form. In the absence of an analysis of relevant data on effort, catch locations, etc., the most parsimonious assumption would be that the decline in catches has been due to a decline in the availability of pilot whales in the whaling areas.

In the absence of new information, the Committee **recalls** its previous concerns regarding these stocks (IWC, 1987; 1992). A **recommendation** relating to catches of small cetaceans by Japan (including this species) is given under Item 14.4.1.

Morishita stated that the declines in catches of small cetaceans in Japan are largely attributable to economic factors such as low prices of the products, high fuel prices and the effects of the 2011 earthquake and tsunami.

14.1.4 Dall's porpoise (Phocoenoides dalli)
SC/65a/SM11 reviewed available information on the status of Dall's porpoise populations taken in hand harpoon hunts in Japan. Details are given in Annex L, item 3.4. The most recent available abundance estimates of the hunted *dalli*-type population date from 2003 (Miyashita *et al.*, 2007)[24]. The Committee previously recommended that a complete survey of the ranges of the populations be undertaken as soon as feasible (IWC, 2009e).

Catches of both forms have declined, particularly those of the *dalli* form, with only 16% of the quota taken in 2010. Available data are insufficient to determine the cause of catch declines and no up-to-date information on catch composition has been published for either form of the species. In 2012-13 the catch limits were set at 7,147 *dalli*-type and 6,908 *truei*-type porpoises; around 4% of the 2003 abundance estimates.

The Committee notes that abundance estimates are now ten years old and catch limits are still probably unsustainable (Wade *et al.*, 2008). The Committee **reiterates** its previous concerns (IWC, 2002a, pp.57-8; 2008a, p.51). A **recommendation** relating to catches of small cetaceans by Japan including this species is given under Item 14.4.1.

[21]*http://www.jfa.maff.go.jp/j/whale/w_document/pdf/130531_progress_report.pdf.*
[22]*http://www.iucnredlist.org/.*
[23]The Committee did not review this estimate.
[24]The estimates were not assessed by the Committee.

14.1.5 White whales of the Okhotsk Sea

SC/65a/SM23 summarised available information on population structure, abundance and historical catches of white whales in the Okhotsk Sea. Based on aerial surveys in 2009-10, the entire population was estimated to be a minimum of 6,113 (CV=0.068), and when corrected for availability bias was estimated at 12,226 (see Annex L, Appendix 2 for more details). Two-thirds of satellite-tagged animals (2007-10, *n*=22) that summered in the Sakhalin-Amur region stayed in or visited the eastern part of the Shantar region in the autumn. In the winter, the whales travelled northward and offshore, where they used different wintering grounds. None of the 22 animals went to the area which a single tagged animal from western Kamchatka visited in winter.

SC/65a/SM23 also reported genetic data that suggested the existence of at least two Okhotsk populations: northeastern Okhotsk Sea and western Okhotsk Sea. Animals from the western population have been subject to live-capture for the last 30 years under an annual quota system. The average annual catch from 2000-12 was 23 (range 0 to 44). In 2012, the quota for the North-Okhotsk subzone was increased by a factor of five (to 212) and then in 2013 to 263; 44 were live-captured in 2012. There is a quota of 45 for the West-Kamchatka subzone in 2013.

After reviewing the information from both SC/65a/SM23 and a recent assessment by Reeves *et al.* (2011) the Committee **concludes** that the Russian domestic quota of 263 for the North-Okhotsk subzone was at least 6 to 8 times higher than that likely to be sustainable for the Sakhalin-Amur portion of the total regional population. In practical terms, the live captures are likely to be conducted at a single site which means they will target only the Sakhalin-Amur summer aggregation which raises concerns about local depletion.

Given this, the Committee **recommends** that the live-capture quota for the North-Okhotsk subzone be reduced to a level that is consistent with available scientific data and that at least four summer aggregations in the North-Okhotsk subzone should be managed separately such that the total allowable quota is broken down into separate quotas for Sakhalin-Amur, Ulbansky Bay, Tugursky Bay and Udskaya Bay (a fifth aggregation, in Nikolaya Bay, should have a zero quota as the number of animals using that bay is very small; SC/65a/SM23).

The Committee further **recommends** that no removals are authorised for the West-Kamchatka subzones, until sufficiently rigorous analyses of sustainability are provided that are at least as rigorous to those currently available for the North-Okhotsk subzone.

14.2 Report on the Voluntary Fund for Small Cetacean Conservation Research

14.2.1 Update on the 2011 awarded projects

Of the nine projects awarded in 2011, four were completed in 2012 and two projects will be completed in 2013. A further three will end at the beginning of 2014. See details in Annex L, item 4.1.

At this meeting, information was received from five projects (Annex L, item 4.1). The Committee was informed that the Secretariat is preparing a dedicated section for the IWC website on projects funded by the Small Cetacean Conservation Research Fund that will summarise projects' main achievements and ongoing activities.

14.2.2 Update on the 2013 selection process

Thanks to recent voluntary funding from Italy, the Netherlands, UK, USA, WWF-International and World Society for Protection of Animals, the Small Cetacean Conservation Research Fund (SCCRF) was replenished sufficiently to allow funding of a few new projects, fully or partially depending on their budget requests. A new call for proposals was announced by the Secretariat in April 2013. A total of 19 proposals were received by the deadline. In accordance with the agreed procedure, the Review Group (Bjørge, Donovan, Fortuna, Gales, Reeves, Rojas-Bracho) recommended five projects from this year's call for proposals (Table 4). The Committee **endorses** these five projects.

Table 4

Summary of projects recommended to be funded by the Voluntary Fund for Small Cetacean Research, and their principle investigators (PI).

PI	Project title
Chen	Defining the units of conservation and historic population dynamics for two small cetacean species affected by directed and incidental catches in the North Pacific. (F)
Kelkar	Strengthening the meaning of a freshwater protected area for the Ganges river dolphin: looking within and beyond the Vikramshila Gangetic Dolphin Sanctuary, Bihar, India. (P)
Mustika	A pilot study to identify the extent of small cetacean bycatch in Indonesia using fisher interview and stranding data as proxies. (P)
Rajamani	Capacity building in conducting cetacean abundance surveys in southeast Asia through a training workshop and actual surveys. (P)
Wakid	Investigating the abundance of Ganges river dolphin (*Platanista gangetica gangetica*) and factors affecting their distribution in Indian Sundarban. (F)

Key: F=full funding; P=partial funding.

Given the large number of requests and the limited funding available, for future calls for proposals the Review Group had recommend that priority is given to projects with clear potential for effective conservation outcomes in areas of particular need (e.g. critical conservation problem known or suspected, but not likely to be addressed without support). The Committee **agrees** with this recommendation.

14.3 Progress on previous recommendations

14.3.1 Vaquita

The plight of the critically endangered vaquita has been discussed by this Committee and the International Committee for the Recovery of the Vaquita (CIRVA) for many years. In recent years, the focus of the recommendations has been that the only way to prevent the extinction of this species is to eliminate gillnets from its entire range.

SC/65a/SM13 provided information on the continuation of the Acoustic Monitoring Scheme for Vaquita. Preliminary analyses show with 60% credibility that the acoustic encounter rate has decreased between the sampling periods, indicating continued decline of the population.

The new Mexican Administration established the 'Advisory Commission to the Presidency of Mexico for the Recovery of Vaquita' which includes the Minister of Environment, the National Commissioner of Fisheries, two members of Congress, NGO representatives, four scientific advisors, fishing representatives and the Navy. At its first meeting in February 2013, one key agreement was to eliminate gillnets and other entangling nets throughout the vaquita's range and to establish a compensation programme for fishermen. At its second meeting in March 2013, it was agreed that Federal and State Government officials and representatives of civil society would visit the fishing communities to inform the fishermen of the alternatives that the federal government has prepared to address the social problems arising from vaquita conservation measures in the region. It was also agreed that the head of the National Institute of Ecology and Climate Change would explore the feasibility of carrying out a new vaquita population survey cruise in Autumn 2013.

On 6 June 2013, the Mexican government approved the new Mexican Official Standard NOM-002-PESC that requires fishermen to switch from shrimp gillnets to alternative fishing gear (specifically purpose-built light trawls) over a three-year period (30%, 30% and 40% annual reduction over the three-year period).

The Committee **commends** the Government of Mexico for establishing the Advisory Commission to the Presidency of Mexico for the Recovery of Vaquita and for the final approval of the Mexican Official Standard NOM-002-PESC.

CIRVA members produced an analysis, required by the Government of Mexico, which uses a Bayesian model to estimate current (i.e. 2013) abundance of the vaquita population. The posterior distribution for 2013 abundance indicates a best estimate of 189 individuals. This result confirms the urgent need to remove all entangling nets from the vaquita's range to allow the population to recover.

In light of the significance of this updated estimate, the Committee **agrees** to include the full analysis as an appendix to its report (see Annex L, Appendix 3). The Committee **notes with great concern** the model's prediction that if the status quo is maintained, the species population will continue to decline towards extinction.

It is a recurring problem that the rarer a species is, the harder it becomes to collect sufficient sightings to generate robust abundance estimates and detect population declines. As a result, the Committee **strongly endorses** the decision to embed empirical estimates of vaquita abundance and trends (such as in this case the acoustic monitoring data) into rigorous statistical models, using all available relevant data and information to predict population trajectories. The Committee **expresses** confidence that the best estimate of vaquita abundance in 2013 is **189 individuals** (see Annex L, Appendix 3).

In addition, the Committee **reiterates its previous recommendations** that further actions to eliminate bycatch should **not** be delayed in favour of efforts to collect more population survey data.

14.3.2 Hector's dolphin

SC/65a/SM07 reported on efforts to improve estimates of abundance for local populations of Hector's dolphins using capture-recapture (CR) methods based on genotyping and photo-identification. The authors presented three consistent abundance population estimates: (1) a genotype CR (Lincoln-Petersen estimator with Chapman Correction); (2) a photo-identification CR; and (3) a single-sample, linkage disequilibrium method, giving the effective number of breeding individuals in the parental generation. Details are given in Annex L, item 5.2.

14.3.2.1 MAUI'S DOLPHIN

Maui's dolphin is the North Island (New Zealand) coastal endemic sub-species of Hector's dolphin. The Committee was informed that the management measures it recommended last year were incorrectly attributed to a proposal by the New Zealand Government. The Committee **acknowledges and regrets** this mistake.

SC/65a/SM06 presented an update on the status of Maui's dolphins. The population has declined significantly with the latest genetic mark-recapture analysis in 2010/11 estimating a population size of 55 individuals one year and older (Hamner *et al.*, 2012). The author suggested that unless their full range out to the 100m depth contour (including harbours) is protected against gillnetting and trawling (95.5% of human-caused mortality; Currey *et al.*, 2012), Maui's dolphins will decline to 10 adult females in six years and become functionally extinct (<3 breeding females) in less than 20 years, even under maximum population growth (0.018 according to Slooten and Lad, 1991). Additional threats to Maui's dolphins (besides bycatch) include seismic survey work in or near their habitat and a plan to begin development of the world's largest marine iron sand mining operation.

SC/65a/SM22 reviewed the response of the New Zealand Government to the 2012 recommendations of the Committee for urgent action. Although some measures were taken to limit bycatch, the author considered that they were insufficient because they did not cover the entire range. The paper stated that the protected area should be expanded, all gillnetting and trawling should be banned within it (including harbours), and restrictions should be placed on oil and gas development and on other potentially harmful activities where the dolphins are found, including a buffer zone.

Currey *et al.* (2012) described the risk assessment undertaken in June 2012 to inform the Maui's Dolphin Threat Management Plan. The risk assessment identified 23 activities or processes that pose a threat to the sub-species, with bycatch in commercial set net, commercial trawl, and recreational/customary set net fisheries assessed as likely to have the greatest impacts. The risk posed by the cumulative impact of all threats was assessed as significant, resulting in a high likelihood of, and a potentially rapid rate of, population decline. The spatial overlap between dolphin distribution and commercial fishing effort helped to identify specific areas where risk posed by commercial fishing activities remained, given management measures already in place. There was a reported capture of a dolphin in the south end of the Maui's range in January 2012 but no specimen was available to determine whether it was a Maui's dolphin or a specimen of the other Hector's dolphin subspecies. In response, interim measures were put in place in July 2012 that either restrict fisheries activities or require 100% observer coverage in the set net fishery in much of the area where the risk assessment indicated a continuing risk to Maui's dolphins from commercial fisheries.

Maas stated that the 100m depth contour is used to define the offshore limit of the range for Maui's dolphins; this ranges from 4 to 39 n.miles. However, Currey noted that the risk assessment expert panel estimated the offshore distribution as out to 7 n.miles based on modelling, public sightings, strandings and historical information on the dolphins' alongshore range. The fishery restrictions are based on distance from shore and vary between 2 to 7 n.miles.

New Zealand has a limited observer programme for Maui's dolphins in the trawl fisheries and the limited data suggests some risk of bycatch in trawl gear. The great uncertainty surrounding aspects of Maui's dolphin ecology and distribution makes evaluation of the efficacy of management very difficult. Emergency measures could be triggered by further bycatch.

The Committee **agrees** that management measures must be precautionary. If any fisheries with the potential for bycatch were to remain active within the range of Maui's dolphins, 100% observer coverage would maximise the chance of identifying any bycatch and providing information that might trigger immediate further area closures.

In conclusion, the Committee **reiterates its extreme concern** about the survival of Maui's dolphin given the evidence of population decline, contraction of range and low current abundance. The Committee **agrees** that the human-caused death of even one dolphin in such a small population would increase the extinction risk for this subspecies.

The Committee therefore **recommends** that rather than seeking further scientific evidence, the highest priority should be given to immediate management actions that will lead to the elimination of bycatch of Maui's dolphins. This includes full closures of any fisheries within the range of Maui's dolphins that are known to pose a risk of bycatch of small cetaceans.

The Committee **commends** the New Zealand Government on its initial and interim measures to protect Maui's dolphins. However, the Committee **emphasises** that the critically endangered status of this sub-species and the inherent and irresolvable uncertainty surrounding information on small populations require the immediate implementation of precautionary measures. Ensuring full protection of Maui's dolphins in all areas throughout their habitat, together with an ample buffer zone, will minimise the risk of bycatch and maximise the chances of population increase.

14.3.3 Irrawaddy dolphins

SC/65a/SM05 presented work on Irrawaddy dolphins in Laos where on the Laos-Cambodia border only six individuals remain in the trans-boundary pool, compared to at least 17 present in 1993. Despite efforts at protection on both sides of the border, the continuing use of gillnets, explosives and electric fishing gear as well as the proposed Don Sahong dam will very likely cause the extirpation of this small group of dolphins.

The Committee **agrees** that the situation in Laos was of serious concern and that without urgent conservation measures in the trans-boundary pool and the surrounding area as recommended in SC/65a/SM05, the remaining dolphins will not persist for much longer.

Porter reported that individuals from six populations of Irrawaddy dolphins in Malaysia, India and Bangladesh had developed cutaneous nodules. Disease prevalence ranged from 2.2% to 13.9% with the two most affected populations inhabiting the most polluted of the six areas. In India, prevalence was significantly higher in 2009-11 than in 2004-06. The emergence of this disease in several populations is of concern given the possible link to degraded environmental conditions and the vulnerability of this species to other threat factors.

The Committee thanked Porter for this information and **encourages** further investigation in collaboration with health experts and biologists working in these (and other) regions.

14.3.4 Atlantic humpback dolphin

SC/65a/SM16rev provided an update on an IWC Small Cetacean Research and Conservation Fund (SCRCF) project on the Atlantic humpback dolphin in Congo and Gabon. Details can be found in Annex L, item 5.4.

The Committee **welcomes** the important contribution to research and conservation made by this project and looks forward to receiving further information in future meetings.

14.3.5 Indo-Pacific humpback dolphin

Updates from three projects funded under the IWC SCRCF were presented at this meeting (see Annex L, item 5.5 for details). Smith *et al.* (2013) provided an update on their project to determine the population identity for animals in the northern Bay of Bengal, Bangladesh and to contribute to the resolution of taxonomy within the genus *Sousa*; Wang (2013) reported on progress on photo-identification monitoring of the Eastern Taiwan Strait Population, and information was presented on the project on the ecology, status, fisheries interactions and conservation of coastal Indo-Pacific humpback and bottlenose dolphins on the west coast of Madagascar.

The Committee **welcomes** the important contribution to research and conservation made by these projects and looks forward to receiving further information in future meetings.

14.3.6 Harbour porpoise

SC/65a/SM21 reported on a ship board double-platform line-transect survey to assess harbour porpoise abundance in the 'GAP area' between the North Sea and the Baltic Proper. Details can be found in Annex L, item 5.6. The abundance of harbour porpoises within the survey area was estimated at 40,475 animals (95% CI: 25,614-65,041, CV=0.235). Large areas of the northern part of the study region were not surveyed due to poor weather. The GAP plan identifies key areas for porpoises and focuses conservation measures on special areas of conservation for porpoises.

The Committee **welcomes** this work and **accepts** the abundance estimate.

SC/65a/SM25 reported on a National Programme in Mauritania ('Biodiversité, Gaz, Pétrole', BGP) that includes monitoring beaches for stranded cetaceans four times per year. Between November 2012 and May 2013, high numbers of stranded harbour porpoises and other species were found. The Northwest African population of harbour porpoises is probably reproductively isolated from the Iberian and other European populations (Van Waerebeek and Perrin, 2007). No abundance estimates are available but the population is believed to be small. Of ten individuals for which the cause of death could be established (from a total of 27 examined) all appeared to be bycaught.

Based on sightings recorded from 2003-11, SC/65a/SM20 provided an uncorrected abundance estimate of 683 animals (95% CI: 345-951) of harbour porpoises in northern Spanish waters that are considered part of the separate Iberian Peninsula Management Unit (ICES, 2013). The Committee **endorses** the authors' view of the need for unbiased estimates of both abundance and bycatch for this area in order to provide reliable advice for conservation and management actions. It **strongly encourages** Portuguese and Spanish authorities to promote collaborative research projects towards this end.

14.3.7 Solomon Islands update on both live-capture and drive fisheries

Oremus *et al.* (2013) contained the final report to the Government of the Solomon Islands on small boat surveys, photo-identification and genetic sampling to assess the population status of Indo-pacific bottlenose dolphins which are subject to live capture for international trade. Since 2003, more than 100 Indo-Pacific bottlenose dolphins have been shipped from the Solomon Islands to facilities around the world. The Committee **notes** that the new survey results presented by Oremus *et al.* (2013) reinforce previously expressed concerns regarding the sustainability of live-capture removals from this small island-associated population of Indo-pacific bottlenose dolphins. This project was partially funded by the IWC SCCRF. Details are given in Annex L, item 5.7.

The Committee:

(1) **emphasises** the importance of verifying the true number of live-captures and associated dead dolphins - the new survey results **reinforce** previously expressed concerns regarding the sustainability of live-capture removals from this small island-associated population;
(2) **endorses** the recommendation of Oremus *et al.* (2013) calling for the development of a DNA register, i.e. genetic samples of all dolphins captured should be collected systematically and archived to allow verification of their origin and legitimacy; and
(3) **reiterates its previous encouragements** for comparison of existing photo-id catalogues (e.g. that of RH Defran and this study) in order to produce a synthesis of sighting information.

SC/65a/SM08 described efforts to document the numbers and species of dolphins killed recently in the traditional drive hunts on the island of Malaita in early 2013. The Committee thanked the authors for this report, and:

(1) **commends** the Government of the Solomon Islands and the Ministry of Fisheries and Marine Resources for the substantial funding provided to conduct the surveys and for facilitating the work on the traditional drive hunts;
(2) **agrees** that there is an urgent need for estimates of the abundance of small cetaceans around Malaita and, if possible, the Solomon Islands as a whole; and
(3) **expresses concern** regarding the potential depletion of local populations given the scale of the recent (and historical) catches.

In this context, the extensive programme of aerial surveys for cetaceans and other megafauna in the South Pacific being undertaken by the French Government can provide valuable and reliable baseline estimates of abundance for previously unsurveyed or little surveyed areas. It was noted that this programme is planning to survey the New Caledonia area in 2014. The Committee **recognises** the great potential conservation value that would result if it was possible to extend the surveyed area to include the Solomon Islands. The Committee therefore **recommends** that the Secretariat forward a letter on behalf of the Committee expressing its appreciation for the current survey programme, explaining the benefits of extending the 2014 survey to the Solomon Islands and respectfully requesting this to be considered if at all possible.

The Committee also **encourages** the Australian Museum, Sydney to grant the authors of SC/65a/SM08 access to pantropical spotted dolphin teeth and teeth from other specimens from the Solomon Islands hunt that could be used to compare past and modern genetic diversity.

Finally, the Committee **endorses the recommendations** of SC/65a/SM08 encouraging the Solomon Islands Ministry of Fisheries and Ministry of Environment to:

(1) collect information on all future hunts and, if possible, provide some verification of species and numbers through independent observers or photographs;
(2) collect genetic samples (e.g. skin, meat, teeth) from each hunt, to confirm species identification and monitor changes in diversity and population identity over time; and
(3) support further surveys of waters around Malaita (and other islands, if possible) to estimate the abundance of small cetaceans.

14.3.8 Boto and tucuxi

Recalling last year's recommendations regarding the illegal capture and use of botos and tucuxis for fishing within Brazilian territory, the Brazilian Government has been taking steps to counteract this activity through enforcement actions. Details of these actions can be found in Annex L, item 5.8.

The Committee **commends** Brazil for its National Action Plan for the Conservation of Aquatic Mammals and Small Cetaceans, and **welcomes** the report on implementation relative to these two species.

The Committee also **reiterates its previous recommendation** that an international scientific Workshop be organised involving scientists and managers from the range states, with the goal of addressing research and conservation priorities, standardising methodologies and planning long-term strategies.

SC/65a/SM17 reported on the distribution of botos in the Amazon delta; they are regular and widespread in Marajó Bay and the surrounding coastline of Marajó Island. To investigate genetic variation in Amazon river dolphins and make inferences about possible subspecies of boto, analyses of the control region and cytochrome b were conducted. One specimen from the east coast of Pará state appeared to represent an isolated geographic form, genetically distinct from other known subspecies.

Iriarte and Marmontel (2013) reported that interactions of botos and tucuxis with fishing activities are common in the western Brazilian Amazon, but the prevalence of incidental and intentional catches is not known.

Williams and others conducted analyses to infer trends in boto and tucuxi numbers in the Colombian Amazon. They estimated an 87% chance that the boto is declining and an 80% chance that the tucuxi is stable or increasing.

The Committee **expresses its appreciation** for this information on the boto and tucuxi.

14.4 Takes of small cetaceans

14.4.1 New information on takes

Funahashi provided the Committee with a translation of the records of directed catches and associated quotas for small cetaceans from 1997-2011 obtained from the Japanese National Research Institute of Far Seas Fisheries website (Annex L, Appendix 4, table 4).

The Committee also received from the Secretariat the summary of catches of small cetaceans in 2012 extracted from this year's National Progress Reports (Annex L, Appendix 4). The Committee agreed to further explore, intersessionally, more specific terms of reference for evaluating direct take data, including the idea of developing case studies or other analyses from this information.

The Committee thanked Funahashi and the Secretariat for their work in compiling this information for the Scientific Committee each year and reiterated the importance of having complete and accurate catch information, encouraging all countries to submit appropriately qualified and annotated catch data.

SC/65a/SM12 presented information on small cetaceans targeted by direct hunts in Japan. In 2012 there was an increase in the hunting season for Baird's beaked whales in some areas. With respect to drive hunts of other species in Taiji, the number of live captures has increased in the last decade whilst the number of animals killed has gradually declined. The increase in live captures has been accompanied by an increase in exports.

Catch limits for all species were established in 1993 and remained largely constant until 2007. Since then catch limits for most species have been reduced, with the exception of Baird's beaked whales, Pacific white-sided dolphins and northern form short-finned pilot whales which have remained constant. The catch limit for false killer whales has increased. A recent assessment submitted to the 2011 Society for Marine Mammalogy Conference indicated that for all species assessed, catch limits were above sustainable levels (Funahashi and Baker, 2011), with those of striped and spotted dolphins and false killer whales particularly high, exceeding calculated PBR values by a factor of more than five.

For all species reviewed, with the exception of Baird's beaked whales, Risso's dolphins and the Pacific white-sided dolphins (which was only recently added to the quota scheme), catches have declined and have not filled the reduced quotas. See Annex L, item 6.1 for more details.

Published assessments of the abundance of targeted populations are now ten years old or older and exceed the maximum period for which a population estimate should be considered reliable (Moore and Leaper, 2011). Given the indications of population decline in some species (IWC, 1992; 1993; 1998c; Kasuya, 1985; 1999), the long history of intensive exploitation, the lack of information on changes in catch composition and that catch limits and catches remain above sustainable levels, SC/65a/SM12 concluded that there is an urgent need to suspend catches of species taken in direct hunts in Japan and conduct up to date assessments of the exploited populations.

Regarding the species that are subject to direct exploitation in Japan (i.e. common bottlenose dolphins, striped dolphins which apparently experienced a collapse of the coastal population, spotted dolphins, Risso's dolphins, false killer whales and Pacific white-sided dolphins), the Committee expresses **concern** that catch limits exceed sustainable levels and that abundance estimates of all species are now more than ten years old, particularly given the indications of population decline in a number of the species (IWC, 1992; 1993; 1998c; Kasuya, 1985; 1999). The Committee therefore **re-iterates** its previous concerns (IWC, 1992; 1993; 1998c) and **recommends** that:

(1) up-to-date assessments of these exploited populations be undertaken, including studies of population structure and life-history;
(2) up-to-date data on struck and lost rates, bycatch rates, directed hunting effort, stock identity and reproductive status and age composition of catches be collected and made available; and
(3) catch limits take into account struck and lost and bycatch rates and be based on up-to-date population assessments, and be sustainable with allowance for population recovery.

Some members expressed a different view concerning the problems mentioned above, for example regarding the existence of coastal populations of common bottlenose dolphins and striped dolphins (see Annex L).

14.4.2 Follow up on the Workshop on 'poorly documented hunts of small cetaceans for food, bait or cash'

Ritter presented a proposal on the growing and emerging problem of poorly documented hunts of small cetaceans for food, bait or cash (sometimes referred to as the 'marine bushmeat' problem). A provisional agenda was provided for an open symposium and a two-day Workshop (Annex L, Appendix 5). The scope was limited to Africa, Madagascar, Sri Lanka and southeast Asia.

It was agreed that the Workshop steering group shall focus its initial work on:

(1) appointing new members to be included in the steering group (September 2013): new members shall be experts working in the areas the Workshop focuses on that are not related to cetacean assessment;
(2) producing a final draft budget (September 2013), including costs for the venue and for (French) interpretation;
(3) determining additional expertise to be invited to the Workshop (October 2013);
(4) identifying a definitive venue (December 2013); and
(5) liaising with international organisations dealing with bushmeat and emerging infectious diseases (e.g. Eco Health Alliance [US] and others).

The steering group shall at the same time start finding funds from NGOs and other organisations. The progress on the work on the above points shall be referred to the co-Convenors of the sub-committee on small cetaceans and the Head of Science for consideration.

14.4.3 Significant direct and incidental catches of small cetaceans: an update

Donovan drew attention to the Committee's 'Report on Significant Direct and Incidental Catches of Small Cetaceans' that was prepared for the United Nations Conference on Environment and Development (UNCED) in 1992 (Bjørge *et al.*, 1994). Whilst recognising that this was a major undertaking, he suggested that there was a need for a single, up-to-date, authoritative reference on this topic and that the sub-committee on small cetaceans was an appropriate group for producing such a document.

After a short discussion on the merit and the difficulties of this idea, the Committee **agrees** to consider it in more detail next year.

14.5 Update on the proposed joint Workshop on monodontids

In 2012, the Committee established a Steering Group (Bjørge [Convenor], Acquarone, Donovan, Ferguson, Reeves and Suydam) to plan for a global review of monodontids (IWC, 2013k, p.296). The terms of reference were: (1) continue planning for a joint Workshop on monodontids with the NAMMCO SC, the Canada-Greenland Joint Commission on Narwhal and Beluga (JCNB), the Alaska Beluga Whale Committee, and others; (2) prepare a proposal for global review with a Workshop to be held in the autumn of 2013; and (3) facilitate exchange of data between the involved groups.

After consultation with NAMMCO, the deadline of autumn 2013 was considered unrealistic. However, the NAMMCO Secretariat, with the IWC Scientific Committee as co-sponsor, has indicated it can convene a global review workshop back-to-back with the joint meeting of the NAMMCO SC Working Group on Belugas and Narwhals and the JCNB, to be held in Copenhagen in the second half of 2014 (or first half of 2015). Experts from all range states (Greenland, Canada, USA, Russia and Norway) should be invited and a list of possible participants in the workshop has been developed. NAMMCO has indicated that it is prepared to cover part of the costs for invited participants and funding for this workshop will be sought from the IWC. Suydam noted that with the workshop and funding coming together, other interested organisations would help support participant travel. In response to a question on participation of observers, Bjørge noted that he was not familiar with NAMMCO procedures but that observer participation should be possible.

The Committee **welcomes** this report and thanked the NAMMCO Secretariat for its willingness to host the meeting and help fund invited participants. Bjørge and Fortuna will work with the Secretariat to ensure that the request for IWC funding of this workshop is considered in a timely manner. The Steering Group will continue to advance the plans for the workshop intersessionally and report back at next year's meeting.

14.6 Other information on small cetaceans
The sub-committee reviewed information in several additional papers that were not relevant to its priority topics. Details are given in Annex L, item 8.

14.7 Work plan
The Committee's work plan is given under Item 24.

15. WHALEWATCHING
The report of the sub-committee on whalewatching is given as Annex M. Scientific aspects of whalewatching have been discussed formally within the Committee since a Commission Resolution in 1994 (IWC, 1995b). The Commission also has a Standing Working Group on Whalewatching that reports to the Conservation Committee.

15.1 Assess the impact of whalewatching on cetaceans
SC/65a/WW01 summarised four papers addressing the impacts of whalewatching on cetaceans: Peters *et al.* (2013) documented the effects of swim-with-dolphin tourism on the behaviour of the 'burrunan dolphin' (*Tursiops australis*[25]) in South Australia; Lundquist *et al.* (2012) sought to estimate the potential impact of dolphin watching and swimming on dusky dolphins in Kaikoura, New Zealand; Dans *et al.* (2012) investigated changes in behavioural budget of dusky dolphins in Golfo Nuevo, Patagonia, Argentina; and Ayres *et al.* (2013) collected data on hormone levels from the faeces of southern resident killer whales to assess factors in population decline. Summaries are to be found in Annex M, item 5.

The Committee noted that hormone analysis, using faecal and blow sampling, is a potentially valuable methodology for examining impacts of whalewatching. Clearly the efficacy of these methods will be species-specific. A third methodology to measure stress responses is telemetry using tags that can monitor heart rates The impact of research vessels (for all these sampling methods) can be significant and a good experimental design is needed to control for this.

The Committee **agrees** that a joint session on stress responses related to vessel presence and shipping noise be held next year by the sub-committee on whalewatching and the SWG on environmental concerns, provided sufficient information is available. The Committee **requests** the Convenors of those two sub-groups to invite experts to submit papers next year on the use of faecal and blow sampling to measure stress hormones in relation to whalewatching, as well as in relation to other stressors where the methodology could be applied to whalewatching.

New provided an update on the mathematical models for the behavioural, social and spatial interactions of bottlenose dolphins first described in New *et al.* (2012). The model has been adapted to incorporate ecological and geographical features and also has the potential to assess the relative impact of different vessel types, as well as their cumulative effects. The model is an individual-based model, so it can also be modified to assess individual characteristics. The Committee **welcomes** this work and **encourages** future development and its use in case studies.

[25]The Committee has not included *Tursiops australis* in its list of recognised species.

15.2 Review whalewatching in the Republic of Korea
Whalewatching from one vessel began in 2009 in Ulsan. Species encountered include long-beaked common dolphins, common minke whales, Pacific white-sided dolphins, false killer whales, common bottlenose dolphins and occasional finless porpoises. Tourism numbers are increasing and are expected to reach 20,000 in 2013.

There is a resident population of *T. aduncus* in the waters of Jeju Island; however, the Ministry of Oceans and Fisheries has advised against developing boat-based dolphin watching due to this population's small size, which led to a protected species designation in 2012. The local government has decided to pursue land-based dolphin watching only. The Committee **commends** the Jeju Government and the Ministry of Oceans and Fisheries for their precautionary approach and **recommends** that research be continued on the bottlenose dolphin population of Jeju.

Guidelines are being developed for Korean whalewatching and the Committee **refers** the developers to the Commission's guiding principles and the Compilation of Worldwide Whalewatching Regulations[26]. Ulsan, given the early stages of its whalewatching development, may be a suitable location for a study under the Modelling and Assessment of Whalewatching Impacts (MAWI) project (see Item 15.3.1 and Annex M, item 7.1).

15.3 Progress on Commission's Five-Year Strategic Plan including guidelines and regulations
15.3.1 Large-scale Whalewatching Experiment (LaWE) steering group

There was no intersessional communication or formal update on LaWE submitted to this year. Consequently the Committee **agrees** to re-evaluate the project.

The primary objectives of LaWE were to assess the population-level impacts of whalewatching and determine the effectiveness of suggested mitigation measures in avoiding any potential negative effects of the activity. These objectives remain relevant to the work of the sub-committee; it is important that research addressing these objectives continues. The Committee **agrees** to establish a new intersessional working group, with New as Convenor, tasked with developing a revised work plan to move forward with this project, now named the Modelling and Assessment of Whalewatching Impacts (MAWI), which will seek to build on what was learned in LaWE (see Annex M). The group, using the Five-Year Strategic Plan research objectives and actions as guidance, will seek to define the specific research questions and hypotheses that will most benefit understanding of the impact of whalewatching, identify those whalewatching locations that would be suitable and amenable for targeted studies addressing these questions, and summarise the current modelling tools available to analyse the data that will be collected. Once these issues have been addressed, it will be possible to identify a timeline, benchmarks, budgets and any additional resource or support needs.

[26]*http://iwc.int/whalewatching*.

15.3.2 LaWE budget development group
This item was not discussed, as there was no intersessional communication with this Working Group.

15.3.3 Swim-with-whale operations
A questionnaire seeking more detail on these operations was successfully beta-tested in the Dominican Republic in early 2012 and was distributed to operators in Tonga and New Caledonia in May 2013. A summary of results from these surveys will be presented at next year (see Annex M).

15.3.4 In-water interactions
A scientific study was conducted in October 2012 off La Gomera (Canary Islands), where in-water interactions with different small cetacean species were examined. During experimental in-water encounters, specific behaviours exhibited by the animals were observed, recorded and videotaped. Results from this study will be presented at next year (see Annex M).

15.3.5 Guiding principles development
SC/65a/WW03 was a draft of the guiding principles produced per Action 1.1 of the Commission's Five-Year Strategic Plan for Whalewatching. The principles include general management considerations and guidelines for cetacean watching. These guiding principles are fundamental to the development of the Handbook as part of the Commission's Five-Year Strategic Plan for Whalewatching.

The Committee **agrees** to develop a 'background document' to annotate the guiding principles, with an explanation of their origin and evolution, as well as definitions of terms and other explanatory background (which might include illustrations of descriptive content). A draft of this document will be presented next year (see Annex M).

The Committee **endorses** the guiding principles, which can be found in Annex M, Appendix 2, and **recommends** that they are posted on the Commission website.

15.4 Other issues

15.4.1 Review scientific aspects of the Commission's Five-Year Strategic Plan for Whalewatching
The Committee reviewed elements of the Five-Year Strategic Plan for Whalewatching and the Commission's Whalewatching Handbook relevant to its work. Objective 1, Research, details three action items tasked to the Committee:

1.1 Develop (and/or review), pending further comprehensive scientific research and assessment (refer to action 1.3), guiding principles to be followed in whalewatching operations including swim with and provisioning programs to minimise potential adverse impacts;
1.2 Identify data deficient and critically endangered populations likely to be subject to whalewatching. Develop precautionary guidance and advice on additional mitigation measures that may be required for whalewatching operations on such populations; and
1.3 Consider an integrated research program (a form of long term experiment) to better understand the potential impacts of whalewatching on the demographic parameters of cetacean populations. Seek to:
    - demonstrate a causal relationship between whalewatching exposure and the survival and vital rates of exposed cetacean individuals;
    - understand the mechanisms involved in causal effects, if they exist, in order to define a framework for improved management; and
    - establish standard methodologies for the conduct of assessments.

Action item 1.1 is addressed in SC/65a/WW03 and Parsons agreed to collate data for action item 1.2 and report to the Committee next year. The Committee noted that the MAWI intersessional working group will address action item 1.3 (see Annex M, item 7.1).

15.4.2 Report of 2013 IWC Whalewatch Operator's Workshop
A Whalewatch Operator's Workshop, funded by the Governments of Australia and the USA, was held in Brisbane, Australia on 24-25 May 2013. The main objective of the workshop, attended by over 60 representatives of industry, science and government, was to get input from operators and industry representatives for the Whalewatching Handbook to be posted on the Commission's website, with continued oversight by the Commission's Standing Working Group on Whalewatching and an on-going and iterative monitoring, evaluation and review of the Five-Year Strategic Plan for Whalewatching. In addition, the workshop sought to help the Commission understand what role it can play in identifying and promoting 'best practices' and responsible whalewatching, what the industry might like to see or have in an online Whalewatching Handbook, actions in the plan that might require further engagement with industry and how to continue to integrate work at the Commission with industry expertise.

The Committee **agrees** to establish an intersessional working group, with Rojas-Bracho as Convenor, to determine how the Committee can best assist and contribute to the Whalewatching Handbook (see Annex R).

15.4.3 Consider information from platforms of opportunity of potential value to the Scientific Committee
A 'citizen science' handout drafted by the Tonga Whalewatching Operators Association was examined (see details in Annex M, item 8.3).

The Committee noted that this type of handout could allow 'citizen scientists' to provide data directly to research groups and **suggests** that the simple data form developed in (the Data Reporting Scheme) is revived and made available as a resource through the Commission's website.

In late 2009, researchers began collecting data from whalewatching vessels as platforms of opportunity in Ballena Marine National Park in Costa Rica. Tour operators were trained in the use of data forms and GPS. The first year of data collection by operators has been completed and these data will be compared with data collected by researchers, to determine if there are significant differences in data quality. A paper will be prepared for next year's meeting.

Denkinger *et al.* (2013) studied cetacean presence and diversity in the Galápagos Marine Reserve (GMR) during El Niño, La Niña, and neutral conditions, using wildlife viewing vessels as platforms of opportunity. These data showed that most species seem to move out of the GMR during El Niño years.

SC/65a/SH25 reported on a meeting of the Southern Ocean Research Partnership (SORP) held on Jeju Island, Republic of Korea, on 31 May-2 June 2013. The meeting's primary objective was to present the scientific results stemming from the five on-going SORP research projects. Recommendation 4 of the meeting report asked partners in SORP to employ all platforms of opportunity and, where applicable, 'citizen science', to collect data for inclusion in SORP research projects, thereby reducing the logistical constraints of circumpolar coverage and overall expenditure. Recommendation 5 was to store and archive data collected from international, collaborative research efforts such as SORP in open-access, central repositories that have the capacity to handle both primary scientific data and information derived from 'citizen science', e.g. image catalogues.

SORP is coordinating with the International Association of Antarctic Tour Operators to solicit data from platforms of opportunity. Cruise ships were identified as excellent potential platforms, as experienced biologists are often on board as naturalist guides, making them a potential source of good-quality data. 'Citizen science' efforts should be coordinated, because photographs in particular often come from tourists and key matches can come from this source.

15.4.4 Review whalewatching guidelines and regulations

SC/65a/WW01 reviewed two studies that addressed compliance with whalewatching guidelines and regulations: Kessler and Harcourt (2013) studied the levels of compliance with regulations by commercial and recreational whalewatching boats off Sydney, Australia; and Chinon *et al.* (2013) looked at the effectiveness of a proposed regulation for white whale watching in the Saguenay-Saint Lawrence Marine Park, Quebec, Canada, using an agent-based modelling approach. Summaries are presented in Annex M, item 8.4.

The Committee noted that this modelling approach is a technique that could be applied to other locations to assess the effectiveness of whalewatching regulations.

The 2013 Compilation of Worldwide Whalewatching Regulations[27] is almost complete and should be online by August 2013.

15.4.5 Review of collision risks to cetaceans from whalewatching vessels

SC/65a/WW04 investigated the probability of vessel collisions with humpback whales in the waters of Maui County, Hawaii, USA. Surprise encounters and near-misses, defined as a group of whales sighted (at abeam and forward angles) within 300m and 80m of a vessel respectively, were used as proxies for probability of whale-vessel strikes. The rate of surprise encounters increased with vessel speed, from 1.5 encounters/hr at 5 knots to 4.2 encounters/hr at 20 knots. No near-misses occurred at 5 knots. Calves were present in 28.3% of surprise encounters and 58.3% of near-misses, which coincides with previous reports that calves may be more susceptible to vessel collisions. Continued research will contribute to developing a predictive model of vessel strikes for management purposes.

The Committee noted that risk of vessel collision should be factored into models developed under MAWI. The model to be developed in Hawaii will be compared to data from the Hawaiian reporting network for ship strikes, which also reports 'encounters' (the equivalent of near misses), to see if the model matches the network's reports.

Ritter presented relevant aspects of Neilson *et al.* (2012), which analysed all reported whale-vessel collisions in Alaska between 1978 and 2011. Many types and sizes of vessels collided with whales; however, small recreational vessels as well as commercial vessels were most commonly involved in collisions. When vessel speed was known, 49% of the collisions occurred at vessel speeds ≥12knots.

[27]*http://iwc.int/whalewatching.*

15.4.6 Swim-with-whale operations

SC/65a/WW01 summarised four papers addressing swim-with-whale operations: Curnock *et al.* (2013) explored effort and spatial distribution of tourists swimming with dwarf minke whales across time on the Great Barrier Reef, Australia; Kessler and Harcourt (2013) studied human-whale value transition in Tonga across time and the current impact of humpback whale tourism; Kessler *et al.* (2013) documented humpback whale responses to experimental swim-with-whale encounters in Tonga; and Lundquist *et al.* (2013) documented responses by southern right whales in Argentina to simulated swim-with-whale encounters. Summaries are presented in Annex M, item 8.6.

The Committee noted that Hervey Bay, Australia, is an important resting area for humpback mother-calf pairs. Currently swimming with whales is not occurring but tour operators there are interested in conducting such encounters, The Committee **recommends** that the IWC's guiding principles (see Annex M, Appendix 2) be applied to any management decisions in Hervey Bay.

SC/65a/SM26 refers to swim-with-cetacean excursions in Japan and recommends monitoring the situation. The Committee **agrees** to add this to its agenda in 2014 and invites submissions on this situation at next year's meeting.

15.4.7 Emerging whalewatching industry in Oman

The Committee received an update on the emerging whalewatching industry in Oman and an initiative to guide and regulate the industry, as previously recommended (IWC, 2013c, p.64).

The objectives of the new initiative to educate the industry are to protect whales and habitat from impact whilst raising the industry's 'best practice' standards. Progress has been made with securing support of ministries, developing an inventory of operators, assessing operator performance and drafting a set of whalewatching guidelines. Operator workshops are planned for the last quarter of 2013.

The Committee **welcomes** the progress demonstrated by this initiative, and invites the continued submission of updates on this emerging situation. It encouraged local stakeholders, including non-governmental organisations, to continue their commitment to taking this initiative forward. In addition, the Committee **recommends** that the whalewatching guidelines in Oman consider the growing body of research on swim-with-whale encounters and the guiding principles (see Annex M, Appendix 2), which discourage this activity.

15.4.8 Assessing 'whalewatching carrying capacity'

Childerhouse reported on the situation in Kaikoura, New Zealand and whalewatching targeting sperm whales. A moratorium on new commercial whalewatching permits for sperm whales at Kaikoura expired on 1 August 2012. Thus, the New Zealand Government commissioned a two-year research programme into the impact of commercial whalewatching on sperm whales at Kaikoura (Markowitz *et al.*, 2011). The research identified a decline in the abundance of sperm whales over the period since whalewatching started, although the cause of the decline is unknown. After public consultation, another 10-year moratorium was recommended and has been implemented. A 10-year period will allow for meaningful monitoring of the effects of whalewatching activity on sperm whales.

In discussion, other plausible hypotheses for the decline were suggested (see Annex M, item 8.8).

The Scientific Committee **welcomes** this research and **commends** New Zealand for active assessment and management of whalewatching in this region.

15.4.9 IWC Conservation Management Plans
This is discussed under Annex M, item 8.9 and Item 21.

15.5 Work plan
This is discussed under Item 24.

15.6 Other matters
SC/65a/WW05 reported on results from a survey of whalewatching passengers designed to identify causes of a decline in the number of whalewatchers in Hervey Bay, Australia. Details are found in Annex M, item 10.

SC/65a/SM15 summarised a genetic analysis of bottlenose dolphins in Bocas Del Toro, Panama, which showed that this small population (~150 dolphins) has a unique haplotype not seen elsewhere in the Caribbean, confirming its genetic isolation. Last year (IWC, 2013c, p.61), the Committee strongly recommended that the Panamanian authorities enforce national whalewatching regulations and recommended continued research to monitor this dolphin population and the impacts of dolphin watching. However, the Committee received information that enforcement has not happened, and that there has recently been a confirmed report of a dolphin watching vessel striking a dolphin. In light of this observed mortality, the Committee **strongly reiterates** its previous recommendations.

16. DNA TESTING

The report of the Working Group on DNA is given as Annex N. This particular agenda item has been considered since 2000 in response to a Commission Resolution (IWC, 2000a).

16.1 Review genetic methods for species, stock and individual identification
SC/65a/SD01 was prepared in response to a recommendation from the Icelandic Scientific Permit Review Workshop (SC/65a/Rep05) to provide details of the protocol used for the genetic analyses presented to the Workshop, to ensure that genetic sampling and analysis followed the IWC guidelines for genetic research. SC/65a/SD01 provided a comprehensive and clear description of the Icelandic DNA registry protocol, on which the genetic analyses presented to the Review Workshop were based. The Committee **welcomes** this document and **agrees** that it responded appropriately to the recommendation from the Icelandic Scientific Permit Review Workshop.

The Committee **encourages** the preparation of technical documents on methods for species, stock and identification for discussion at the next year meeting under this agenda item.

16.2 Review results of the 'amendments' of sequences deposited in GenBank
During the first round of sequence assessment in *GenBank* (IWC, 2009f, p.347) some inconsistencies were found but these appear to be due to a lag in the taxonomy recognised by *GenBank* or uncertainty in taxonomic distinctions currently under investigation (IWC, 2013l, pp.330). After the assessment, some of the inconsistencies were corrected but further corrections have been hampered by the fact that only the original submitter can alter taxonomy fields in *GenBank*. Last year, the Committee agreed that Cipriano should make a request to *GenBank* to add an additional field for comments (IWC, 2013c, p.64).

Cipriano contacted *GenBank* during the intersessional period and received a response that *GenBank* is willing to work with the IWC on this. They requested that a list of accession numbers associated with problematic taxonomic designations be provided. This would help *GenBank* to understand the scope of the problem while considering a mechanism to allow taxonomy corrections and notations by request.

The Committee **agrees** that the list of accession numbers involving inconsistencies (Annex N, Appendix 2) should be sent to *GenBank* by Cipriano with a letter explaining the background and the main reasons for the inconsistencies, which include:

(1) species for which the taxonomy is still being worked out (e.g. the 'Brydes whale' species complex);
(2) species that have been recently split into new (or redescribed) species (e.g. the right whales and minke whales); and
(3) subspecies for which the taxonomy is still being investigated (e.g. the recognised sub-species of blue whales and minke whales).

Cipriano will also communicate about the need for an annotation indicating uncertainty in subspecies identity for a specimen.

16.3 Collection and archiving of tissue samples from catches and bycatch
The Committee previously endorsed a new standard format for the updates of national DNA registers to assist with the review of such updates (IWC, 2013c, p.53), and the new format worked well last year. This year the updates of the DNA registers by Japan, Norway and Iceland were based on this new format. Details are given in Appendices 3-5 of Annex N for each country, respectively, covering the period up to and including 2012. The Committee **thanks** the countries involved for providing this information.

16.4 Reference databases and standards for diagnostic DNA registries
Annex N, Appendices 3-5 summarise the status of mtDNA and microsatellite analyses of the stored samples for Japan, Norway and Iceland, respectively. In almost all cases, the great majority of samples have been analysed for at least one of either mtDNA or microsatellites and in most cases both. Work on unanalysed samples is continuing although in Japan's case 100% coverage was not possible because many samples were lost in the 2011 tsunami. Details on the exact number of samples collected and analysed are provided in Annex N.

The Committee **appreciates** the efforts of Japan, Norway and Iceland in compiling and providing this detailed information of their registries. The Committee **reiterates** its view that the information provided in the new format greatly facilitated the annual review.

16.5 Work plan
The work plan is discussed under Item 24.

Members of the Committee are encouraged to submit papers in response to requirements placed on the Committee by the IWC Resolution 1999-8 (IWC, 2000a). Relevant information in documents submitted to other groups and sub-committees of the Committee will be reviewed next year. Results of the 'amendments' work on sequences deposited in *GenBank* will be reported next year.

17. SCIENTIFIC PERMITS

This Agenda Item was discussed by the Working Group on Special Permits and its report is given as Annex P. In order to assist the reader, this section provides a summary of Annex P and it also includes a summary of the expert Workshop (SC/65a/Rep03) on the Icelandic special permit held in accordance with the Committee's guidelines (IWC, 2013m).

17.1 Review report of Workshop for Icelandic special permit whaling

In 2003, Iceland presented and the Committee reviewed a special permit research programme to the Committee for review that had included proposed takes of 200 fin whales, 100 sei whales and 200 common minke whales spread over a two-year period that was intended as feasibility study (IWC, 2004). In the event, the programme was reduced to considering only common minke whales and the catch period was extended such that the 200 common minke whales were taken from 2003-07. Due to practical difficulties in Iceland, review of the final results from the programme was delayed. Following the Committee's revised guidelines and timetable for such a review (IWC, 2013m), the expert panel meeting took place in February 2013. All due dates for availability of data, documents, reports and revised documents were met.

17.1.1 Panel Chair's summary of the panel report

The Panel was chaired by Kitakado and its composition was decided upon by a steering group comprising the past four Scientific Committee chairs and the Head of Science. Difficulties in the availability of proposed candidates meant that participation by scientists who had no connection with the Committee proved very difficult. In the event, the Panel comprised the present Committee Chair and the Head of Science (in accord with the guidelines), two ex-Committee Chairs, one current member of the Committee, one scientist who has not participated in the Committee for several years and two scientists who have never participated. Expertise in all areas of the research programme was available. In addition to the proponents, four observers were present. Thirty papers were submitted by proponents (SC/F13/SP01-30) and three additional papers were submitted by other scientists (SC/F13/O01-03).

The Panel report (SC/65a/Rep03) is divided into sections based on the stated objectives of the programme: abundance; stock structure; biological parameters, feeding ecology; energetics; pollution; parasites and pathology. Each of these contained the proponents' summary of their results followed by an analysis of the results by the Panel including conclusions and specific recommendations. The final section presents the Panel's general overview and conclusions followed by a summary of all of the recommendations divided into short, medium and long-term.

The report is a long and detailed review. What follows here is a short Panel Chair's summary of only the broad conclusions (SC/65a/Rep03); it does not provide a substitute for reading the full report. In reaching its conclusions and recommendations, the Panel noted that no further special permit programme was envisaged by Iceland at present. With respect to consideration of the effect of the catches on stocks, it noted that the level of catches was considerably below the level for the CIC *Small Area* that would have been allowed under the RMP (IWC, 2011b, p.64). The Panel emphasised that its task was to provide an objective scientific review of the results of the Icelandic programme; its task was not to provide either a general condemnation or approval of research under special permit. Consideration of that would require examination of some issues way beyond the purview of a scientific panel.

The Panel made a number of general points in addition to its review of individual topics. The first related to the objectives of the programme. The general nature of the objectives of the original proposal and its characterisation as a feasibility/pilot study made it difficult for the Panel to fully review how well the programme could be said to have met its own objectives. It agreed that it is important that any special permit programme provides careful objectives and sub-objectives for which performance can more easily be assessed, as is now the case in the guidelines for proposed permits in IWC (2013m), developed since the Iceland permit was presented in 2003.

The Panel also commented that better information on sampling design and an evaluation of sample size and representativeness at the local and population level was required. While the method used was probably sufficient for a feasibility study, it would not be the case for a full programme.

A common thread throughout the report related to the need for integrated analyses of the individual components of the programme; it regarded such work as essential and this was the subject of several recommendations. Given the objective of multi-species modelling to improve management, this should also include consideration of the results in the context of a modelling framework. The Panel noted that the programme had tried to maximise the information obtained from the whales taken. It stressed the importance of archiving material collected as well as storing analytical results and data in a relational database linked to the tissue archive.

With respect to abundance, the Panel agreed that the Icelandic survey data have improved knowledge about the abundance and distribution of the common minke whale in Icelandic waters both for use in the RMP and for input to potential multispecies modelling. Despite the logistical difficulties, the spring and autumn surveys provided valuable new information, especially in the context of any future multi-species modelling.

With respect to stock structure, the Panel agreed that the data will assist in the Committee's work on this topic. With respect to feasibility component, it was of course already well-known that it is possible to collect samples to better understand stock structure from carcases (as well as from biopsy samples as the proponents' note). It welcomed the efforts to compare genetic data across the North Atlantic but recommended further effort to integrate information regarding stock structure from the variety of genetic and non-genetic sources.

With respect to biological parameters, the Panel recognised the extensive amount of field and laboratory work that had been undertaken and presented. It noted that evaluating the feasibility of collecting information on biological parameters of sufficient precision and accuracy to inform multi-species modelling requires examining the sensitivity of model results to the parameters concerned. As the modelling was not as advanced as had been originally planned, this evaluation cannot yet be conducted. One of the most important feasibility questions relates to the issue of ageing common minke whales and the Panel commended the work to examine a new approach for common minke whales, recognising that further work needs to be undertaken.

With respect to feeding ecology, a primary component of the programme, the Panel acknowledged the large amount of effort undertaken and the generally thorough analyses using a variety of techniques. The temporal changes observed as a result of the extension of the sampling period could be related to climate change or a regime shift in the waters around Iceland and this is an important issue for further research.

The general nature of the objectives made evaluation of the success of the feasibility study more complex but the Panel agreed that knowledge of the general feeding ecology of common minke whales around Iceland has been advanced. It also acknowledged the efforts to collect data in such a way as to allow a more systematic than usual examination of the results that can be obtained from lethal and non-lethal methods (see SC/65a/Rep03, table 4). Finally, the Panel strongly recommended that integrated analyses including comparison of the information from each approach be developed and submitted to the Scientific Committee.

With respect to energetics, again the Panel recognised the considerable field, laboratory and analytical effort. These provided valuable insights into aspects of the energetics of common minke whales around Iceland but further effort is required to integrate the various analyses to provide quantitative input to energetics models and multispecies modelling and allow an evaluation of the sensitivity of the results to the inevitable uncertainty.

With respect to modelling, the Panel recognised the practical difficulties explained by the proponents but concluded that this important part of the programme is as yet poorly developed. In particular, a simple preliminary model should have been developed to inform discussions of which are key parameters with respect to obtaining robust results, evaluating how sensitive results are to different levels of uncertainty and determining appropriate sample sizes. This was a major weakness in the programme. However, the Panel welcomed the modelling work presented to the Workshop as a small but valuable initial step toward the programme's overall objective.

With respect to pollutant studies, the Panel acknowledged the considerable field, laboratory and analytical work that had resulted in a number of published papers. It also appreciated the effort made to compare results across the North Atlantic and to examine relationships between concentration levels in different tissues including 'pseudo' biopsy samples. However, it agreed that the objective of assessing health status had not been fully addressed and cautioned against broad assumptions that low levels necessarily indicate no effect. The sample size of the feasibility study was insufficient to properly address any toxic-related cause-effect relationships.

With respect to parasites and pathology, the objective had been to investigate the feasibility of monitoring and evaluating the morbidity of potential pathogens. The Panel recognised the difficulty of conducting full post-mortems of animals and undertaking thorough examination for parasites and pathogens at sea. While the study of the epibiotic macro fauna has resulted in a good baseline for future analyses, overall, the Panel concluded that the approaches adopted in the feasibility study would be insufficient to achieve the objective outlined.

The Panel briefly noted that the Commission had passed several resolutions relevant to research on the ecosystem, contaminants and environmental change. It agreed that many aspects of the programme were relevant to these topics and that the information had been made available to the Scientific Committee.

With respect to the utility of lethal and non-lethal techniques the Panel referred to extensive discussions at the JARPN II review (IWC, 2010a) and the SORP conference (Baker *et al.*, 2012). The Panel welcomed the efforts of the programme to provide data to allow a more thorough and quantitative comparison of some lethal and non-lethal techniques than has previously been possible (see recommendation in IWC, 2010a). The Panel developed a simple qualitative table to summarise the situation for North Atlantic common minke whales but stressed that is not intended to represent a complete or comprehensive evaluation of lethal or non-lethal techniques, either in general or for this specific programme and drew attention to a number of caveats.

Finally the report provided a summary of its recommendations. Seventeen addressed specific issues that might be termed 'short-term' while twelve addressed 'medium to long-term' issues.

In conclusion, the Panel's Chair thanked the Panel, the proponent scientists and the observers for their constructive and patient approach to the Workshop and the Marine Research Institute for providing excellent facilities.

17.1.2 Proponents response to the Panel report

SC/65a/SP01 provides an overview of the response of scientists from the Icelandic research programme (IRP) to the report of the Panel (SC/65a/Rep03). The IRP scientists consider that in general the evaluation of the IRP by the Panel was constructive, objective and balanced.

SC/65a/SP01 also responded to the Panel's request to provide further documentation of the sampling design. The authors emphasised that the objective was to cover the Icelandic continental shelf area and not to be representative of the Central stock of common minke whales. Sampling was distributed in relation to relative abundance in nine small areas used as part of the Bormicon framework for multispecies modelling of boreal systems. In addition, sampling was stratified seasonally into five units. The purpose of such a fine-scale stratification in this feasibility study was to ensure good distribution of the sampling around Iceland and to allow for post-stratification as appropriate for the different sub-projects.

While agreeing with most of the suggestions and recommendations of the Panel, as can be seen in Table 5, the IRP scientists have not been able to fully respond to all of these within the short period determined by the review process protocol (40 days). However, the IRP plan to conclude most of these before the 2014 Annual Meeting with a particular emphasis on those considered relevant for the upcoming RMP *Implementation Review* of North Atlantic common minke whales and the joint AWMP/RMP Workshop on the stock structure of North Atlantic common minke whales (see Annex D). For example, collaboration has already been established to investigate the isotope ratios in baleen plates.

SC/65a/SP01 also noted additional collaborations and studies that were initiated during the project on subjects outside the original objectives (brain anatomy, radioactivity, climate change aspects, genetic relatedness methodology, and analysis of additional pollutants).

In conclusion, the IRP scientists noted that the Panel had acknowledged the quality and scientific relevance of the presented results to common minke whale research, while identifying areas where further work was required. IRP scientists had responded positively to the comments and recommendations of the Panel as shown in Table 1. They also noted that the guidelines for review of scientific permit programs call for special considerations of the utility of non-lethal and lethal research techniques. This comprised a special objective of the IRP and the Panel had welcomed the efforts of the IRP to provide data to allow a more thorough and quantitative comparison of some lethal and non-lethal techniques than has previously been possible. This is relevant for other populations and species. The Panel had

Table 5

IRP scientists' summary of status of progress (based on table 2 in SC/65a/SP01) in responding to the Panel's recommendations (SC/65a/Rep03), including the list of papers submitted to the Committee in response to SC/65a/Rep03 and the sub-groups at which they were presented.

Recommendations (sub-group); Item no. in SC/65a/Rep03	Status of work
Abundance (RMP)	
12.1.1.1	To be addressed in the near future. Further recommendations may be needed as to the approach to take (before the North Atlantic common minke whale *Implementation Review*).
Stock structure (RMP, SD)	
Short term recommendations	
12.1.2.1	A fully integrated stock structure paper was submitted (SC/65a/SD02).
12.1.2.2	A paper describing the genetic protocols employed during the IRP was submitted (SC/65a/SD01).
12.1.2.3	This has been dealt with in the fully integrated stock structure paper (SC/65a/SD02).
12.1.2.4	This has been partly dealt with in the fully integrated stock structure paper (SC/65a/SD02).
12.1.2.5	To be addressed in the near future.
Biological parameters (EM)	
Short term recommendations	
12.1.3.1	Addressed in SC/F13/SP15rev.
12.1.3.2	Addressed; changes in reproductive status considered in SC/F13/SP10rev and SC/F13/SP05rev.
12.1.3.3	To be addressed in the near future.
Feeding ecology (EM)	
Short term recommendations	
12.1.4.1	To be addressed in the near future.
12.1.4.2	A revised paper on the diet composition was submitted (SC/F13/SP02rev).
12.1.4.3	An update of status and response to specific recommendations is given in SC/65a/EM01 and Daníelsdóttir and Ohf (2013).
Energetics (EM)	
Short term recommendations	
12.1.5.1	A fully integrated paper was submitted (SC/65a/O02).
12.1.5.2	The revised paper was submitted (SC/F13/SP10rev).
12.1.5.3	The revised paper was submitted (SC/F13/SP05rev).
Pollution (E, EM)	
Short term recommendations	
12.1.6.1	Addressed in SC/F13/SP22rev and SP23rev.
12.1.6.2	Addressed in SC/F13/SP23rev.

also noted that the level of catches was considerably below the level that would have been allowed under the RMP. Finally the IRP scientists noted the relevance of the research programme to the work of the Scientific Committee and the RMP in particular.

17.1.3 Committee's discussion

The Committee **thanks** the Panel for its thorough review of the Icelandic programme. It also **acknowledges** the work of the IRP scientists in producing revised papers after the Workshop so that they were available 40 days prior to the Annual Meeting.

In discussion, some members noted that while the Panel had agreed that 'many aspects of the Icelandic programme were directly relevant' to a number of Commission Resolutions on the environment and climate change, they believed that it was more appropriate to say that they were 'potentially' relevant to Commission Resolutions. They also believed that the Icelandic Programme fell short of meeting the Resolution on Whaling under Special Permit (IWC, 1996a).

Some members, having taken account of the expert review, expressed some broader critical views of the Icelandic programme and these are provided in Annex P1. This was not discussed and neither was the response from the proponents given in Annex P2. Noting the previous discussions on special permit whaling, the Committee did not discuss an overall evaluation of the Icelandic program.

Without questioning the quality of the members of the Panel, the future need for increased participation from experts outside of the Scientific Committee was noted. The Steering Group explained that this was the intention but despite a long list of potential candidates developed, the availability and/or interest of outside scientists in participating in the review had proved extremely challenging.

A large number of scientific papers originated from the Icelandic programme. Several of these papers were presented to the relevant sub-committees and working groups (RMP, SD, EM and E) as shown in Table 1 of the report. However, some members of the Committee suggested that further consideration be given to how to manage the time allocated to review such papers in the future, as they felt that not enough time was available for review in some sub-groups.

17.2 Review of results from ongoing permits

As in previous years, the Committee received short cruise reports on activities undertaken but spent relatively little time on discussion of the details. For long-term programmes, the Committee has agreed that regular periodic detailed reviews (following its guidelines, IWC, 2013m) were more appropriate.

17.2.1 JARPN II

SC/65a/O03 presented the results of the 2012 JARPN II (Second Phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific) offshore component. A detailed summary is given in Annex P. There were three main research components: whale sampling survey, dedicated sighting survey and whale sighting and prey survey. A total of five research vessels were used: two sighting/sampling vessels (whale sampling survey component), one research base vessel (whale sampling survey component), three dedicated sighting vessels (dedicated sighting survey component) and one whale sighting and prey survey vessel (whale sighting and prey survey component). Catches occurred between 16 May and 3 August 2012 (74 common minke, 100 sei, 34 Bryde's and three sperm whales). Sightings surveys covered over 2,300 n.miles and eight species of large whales were seen including five blue and two North Pacific right whales. Preliminary results of biological and feeding ecology analyses are presented in this document. Data obtained during the 2012 JARPN II survey will be used in the elucidation of the role of whales in the marine ecosystem through the study of whale feeding ecology in the western North Pacific.

SC/65a/O06 presented the results of the 2012 JARPN II coastal component off Kushiro, northeastern Japan (middle part of sub-area 7CN). A more detailed summary is given in Annex P. Research occurred from 9 September to 28 October 2012, using four small sampling vessels. Catches (48 common minke whales) occurred within 50 n.miles of Kushiro port, and animals were landed at the JARPN II research station for biological examination. The frequency of whales feeding on Japanese anchovy was much lower in 2012 than in previous Kushiro surveys.

In discussion, it was clarified that search areas and vessel course were determined from weather conditions, whale distribution and information on fishing ground of coastal fisheries.

SC/65a/O07 presented results of the 2012 JARPN II coastal component off Sanriku (northeastern Japan, corresponding to a part of sub-area 7). A more detailed summary is given in Annex P. Research occurred from 12 April to 26 May 2012. Catches (60 common minke whales) occurred within 50 n.miles of Ayukawa port and all animals collected were landed at the JARPN II research station for biological examination. Information on sighting distribution, biological characteristics and prey species of whales collected during the 2012 survey was similar to that recorded before the 2011 earthquake and tsunami.

In response to a question, Sakamoto explained that samples from 32 individuals of four species from 2012 JARPN II were screened for radioactivity for the purpose of food safety. Ten of them were below the detection limit and the other 22 were well below the National Food Safety Limit set by the ministry of Health, Labor and Welfare. This information is available on the website of the Fisheries Agency of Japan[28].

17.2.2 JARPA II

SC/65a/O09 presented results of the eighth cruise of the JARPA II (Second Phase of the Japanese Whale Research Program under Special Permit in the Antarctic) survey in the 2012/13 austral summer season. A more detailed summary is given in Annex P. Research was conducted from 26 January to 14 March 2013 in Areas III East, IV, V West and part of Area V East. Four research vessels were used: three sighting/sampling vessels (SSVs) and one research base vessel. The SSVs surveyed a total of 2,103.3 n.miles in a period of 48 days. Unfortunately, the research activities were interrupted several times by members of Sea Shepherd, which directed violent sabotage activities against Japanese research vessels. A total of 103 Antarctic minke whales were caught and examined on board the research base vessel. Photo-identification, biopsy sampling and oceanographic work was also conducted. The main results of were as follows: (1) humpback whales were widely distributed in the research area with a higher density index than that of the Antarctic minke whales in all areas except in Prydz Bay; (2) the ice-free extent of the research area was substantially larger than in past seasons; (3) mature female Antarctic minke whales were observed only in Prydz Bay; and (4) all Antarctic minke whales sampled in Area IV east were immature animals.

[28]*http://www.jfa.maff.go.jp/e/inspection/.*

17.3 Planning for periodic review of results from JARPA II

JARPA II is due for a periodic review during the next intersessional period. According to the revised guidelines (IWC, 2013m), the proponents should submit a document explaining the data to be made available to the Workshop one Annual Meeting prior to the review Workshop. This information is provided in SC/65a/O08.

SC/65a/O08 summarised the data available for the next JARPA II Review Workshop to be held early in 2014. The summary was made for the six first surveys of JARPA II (2005/06-2010/11). The summary of the data followed the revised guidelines (IWC, 2013m):

(a) outline of the data that will be available;
(b) references to data collection and validation protocol;
(c) references to documents and publications of previous analyses; and
(d) contact details.

Data in SC/65a/O8 were summarised into the following sections:

(a) data for abundance estimate for several baleen and toothed whale species;
(b) ecological data;
(c) biological, feeding ecology, pollutant and stock structure data of Antarctic minke whale;
(d) biological, feeding ecology, pollutant and stock structure data of fin whale; and
(e) stock structure data of other species. Details of these data are given in Annex P5.

The next step of the review process is that the proponents make data available in electronic form one month after the end of the Annual Meeting. Then the proponents will send a document to the Secretariat describing the analytical methods to be discussed at the Workshop. This will happen nine months prior to the next Annual Meeting; i.e. the beginning of September. Based on the description of analytical methods, the Steering Group (Chair[29], Vice Chair, Head of Science and the last four Scientific Committee Chairs) will begin the process of identifying experts to participate in the Workshop. The need to try to find experts from outside the Committee was stressed. The full timetable for the process is summarised in Table 6 and details can be found in IWC (2013m).

The Committee **reaffirms** its guidelines (IWC, 2013m) that when members submit substantive analyses for a review panel, the Panel Chair, in exercising their discretion, may allow presentation of such analyses in the same manner allowed for proponents.

17.4 General comments regarding Special Permit whaling

Some members of the Committee stressed that the lack of review and comment outside the periodic reviews under the Committee's revised guidelines should not be interpreted as an indication that any of the serious scientific concerns

[29]Given his involvement in the programme, the Scientific Committee Chair, Kitakado, will not take part in the Steering Group. Palka (as immediate past Chair) will act on his behalf.

Table 6

Timetable for the periodic review of JARPA II assuming that the Annual Scientific Committee Meeting is on 1 June.

Item	Schedule	Date
Information on likely analytical methods to be used in the documents to the Workshop.	9 months before Annual Meeting	1 Sep.
Distribute documents to Vice Chair, Head of Science and Standing Steering Group (SSG).	1 week later	8 Sep.
SSG suggest names for the Specialist Workshop. Announcement of review to IWC and call for observers.	2 weeks later	22 Sep.
Chair, Vice Chair and Head of Science develop draft list of specialists and reserves.	2 weeks later	6 Oct.
Final comments from SSG.	1 week later	13 Oct.
Invitation and documents to Specialists.	1 week later	20 Oct.
Receipt and circulation of results/review documents from Special Permit research (including to IWC Scientific Committee members).	>6 months prior to Annual Meeting	1 Dec.
Observer reviews/papers due at the Secretariat.		30 Dec.
Observer's reviews sent to Specialists and Proponents.		6 Jan.
Hold Workshop.	>100 days prior to Annual Meeting	23 Feb.
Final Workshop report made available to Proponents.	>80 days prior to Annual Meeting	13 Mar.
Distribution of result documents, Workshop report and comments from Proponents to the Scientific Committee.	>40 days prior to Annual Meeting	22 Apr.
Discussion and submission of documents to the Commission.	Annual Meeting	1 Jun.

expressed about Special Permit whaling programmes have been addressed. This statement is included as Annex P3. Other members opposed this view and their statement is included as Annex P4.

17.5 Review of new or continuing proposals

17.5.1 JARPA II

Japan reported that there was no plan to change the JARPA II programme.

17.5.2 JARPN II

Japan reported that there was no plan to change the JARPN II programme.

18. WHALE SANCTUARIES

There were no new proposals for IWC Sanctuaries this year. The Committee **agrees** to keep this item on the Agenda. General matters relevant to marine protected areas were dealt with by relevant sub-groups (and see Item 4.7).

19. SOUTHERN OCEAN RESEARCH PARTNERSHIP (SORP)

SC/65a/SH25 reported on a Southern Ocean Research Partnership (SORP) meeting (31 May-2 June 2013, Jeju, South Korea). The aims of the conference were to: (1) present the scientific results from the five ongoing SORP research projects; (2) update the existing project plans and discuss new research proposals (refer to Annex 1 of SC/65a/SH25rev for details of these plans); and (3) make recommendations for the continuation and development of the SORP.

The SORP meeting made key recommendations in relation to the SORP initiative:

(1) to ensure all SORP Partners are seeking funding from all suitable sources to ensure the five existing SORP research projects are resourced adequately;
(2) to improve communication with the Commission on SORP-related outcomes to ensure that they are aware of the scientific products and to encourage financial support;
(3) to improve the dissemination of information on SORP projects and initiatives;
(4) for SORP Partners to encourage all platforms of opportunity and, where applicable, citizen science, to collect data for inclusion in SORP research projects, thereby reducing the logistic constraints of circumpolar coverage and overall expenditure;
(5) that all data and samples collected from international, collaborative research efforts such as SORP are stored and archived in recognised central repositories; and
(6) that the holders of large, long-term datasets that contain valuable information relevant to SORP, particularly acoustic data, should be strongly encouraged to analyse and publish these data as soon as possible.

The Committee **congratulates** the many scientists engaged in SORP for the significant progress and new information presented to the Scientific Committee. It **endorses** the recommendations above and notes that the scientific results were being integrated into the broader work of the Committee.

The Committee **agrees** that the preliminary objective of the Antarctic blue whale project had now been met; the identification of the most appropriate survey design method. The project has also developed a passive acoustic tracking technique that has ramifications for all future whale surveys in Antarctica. The Committee **agrees** that the data from this SORP project are key to the assessment of the Antarctic blue whale population.

The Committee also **recognises** that the acoustic trends project is extremely ambitious; it will take many years to complete but may be the only way to assess the recovery of fin whales. In time it may become the most efficient way to describe the abundance and distribution of many Antarctic whale species.

The first objectives of the Oceania humpback whale project have been completed through the collaborative analysis of biopsy and photo-identification data and those results are being used in the current assessment of Breeding Stock E humpback whales. The results of SC/65a/SH13 are also informative to this project.

The Committee **agrees** that the collection of data through platforms of opportunity may be a highly effective way to collect data in the remote Southern Ocean.

20. IWC LIST OF RECOGNISED SPECIES

The recent literature in cetacean taxonomy (SC/65a/O01) was reviewed and discussed (see Annex L) and it was agreed to add two newly recognised species to the List. *Inia geoffrensis* has been split into the Amazon river dolphin, *I. geoffrensis* and the newly recognised Bolivian bufeo, *I. boliviensis* (Ruiz-García and Shostell, 2010). *Neophocaena phocaenoides* has been split into the Indo-Pacific finless porpoise, *N. phocaenoides* and the newly recognised narrow-ridged finless porpoise, *N. asiaeorientalis* (Jefferson and Wang, 2011). New analyses based on the cytochrome b gene (SC/65a/SM03) have confirmed the split of the finless porpoises. The Burrunan dolphin *Tursiops australis* was recently described (Charlton-Robb *et al.*, 2011) but its validity is uncertain[30] and the Committee **agrees** to not add it to the List at present, pending further studies. It was noted that the extent of sympatry of the two finless porpoise species (Taiwan Strait) is thought to be small, and further sampling (molecular and morphological) to investigate possible divisions within the two recognised species is encouraged.

The Committee also recalled the open questions remaining about the taxonomy of the Bryde's whale species complex and the holotype of the common minke whale. With respect to the former, the genetic identity of the holotype specimen of *Balaenoptera edeni* remains to be identified; the Committee **reiterates** its previous recommendation that this be done.

21. CONSERVATION MANAGEMENT PLANS

Conservation Management Plans (CMPs) and their role in the IWC was first discussed by the Committee in 2008 (IWC, 2009b, p.70). A key feature of CMPs is that they provide a framework for international collaboration to address threats to populations that occur within the waters of more than one country and in offshore waters i.e. they are complementary or supplementary to individual national initiatives.

The IWC has identified some key components of CMPs (see IWC/63/CC5). These are as follows.

(1) The focus should be on practical and achievable actions (including protection for critical habitats) that have the greatest chance of resulting in improved conservation status; actions fall broadly under a number of headings (co-ordination, research, monitoring, public awareness, mitigation) all of which must be driven by the need for positive conservation outcomes.
(2) CMPs are living documents that are to be reviewed periodically against measureable milestones based on monitoring, assessment, and compliance with agreed measures.
(3) CMPs are designed to complement existing measures (e.g. national recovery plans or other national or regionally agreed measures) not to replace them; in particular they can fill identified gaps given the geographical and seasonal range of the populations involved. IWC involvement can *inter alia* bring in additional range state support, the involvement of other IGOs and scientific/technical expertise.

The approach for identifying populations for which CMPs can be developed will depend on the level of information that is available on abundance, status and threats. In addition, CMPs will only be effective where there are identified threats that are practicable to address. If management measures to address threats are already being taken by the range states involved, or if there is only one range state, then there may be little additional benefit in coordinated action through a CMP. In addition, the IWC will need to give consideration as to how CMPs might interact with other efforts such as that of the Convention on Biological Diversity for defining 'Ecologically or Biologically Significant Areas (EBSAs)' or regional agreements such as ACCOBAMS.

[30]Society for Marine Mammalogy, Committee on Taxonomy. List of marine mammal species and subspecies. *http://www.marinemammalscience.org* [16 April 2013].

The Committee noted that there were different approaches to identify whether a population that meets at least one of the following criteria (1)-(4) might be considered as a candidate:

(1) population status (i.e. knowledge of where the population is now in relation to its unexploited abundance, with an estimate of future trend) has been assessed and is of concern, and actual or likely human activities that can threaten the population have been identified;
(2) population status has not been assessed but the impacts of human activities are believed by the Committee to be substantial and thus of concern;
(3) present abundance is known and actual or likely human activities that can threaten the population have been identified; and
(4) present abundance and trend are not well known but abundance is believed by the Committee to be small such that any adverse impacts as a result of human activity may be critical.

The approach taken, for example whether the primary motivation is driven by concerns over status or the level of threat, will depend on what data are available. The Committee discussed CMPs during the work of different sub-committees, some of which considered the issue from the perspective of threats while others from the perspective of population status. The Committee **agrees** that the focus for initial discussions this year is on large whales; it is a much larger and more complex task for small cetaceans. The Committee **seeks guidance** from the Commission on whether or not it wishes the Committee to develop a priority list of populations of small cetaceans for which CMPs might be of value. The Committee **recognises** that consultation with range states is an essential first step in developing a CMP.

The Committee **agrees** that those populations with draft CMPs already in place (western gray whales – collaboratively with IUCN; southwest Atlantic population of southern right whales; and southeast Pacific population of southern right whales) remain a high priority for CMPs.

The Committee also identified the populations that could be considered for a CMP if supported by the range states. This list illustrates different examples, including agreement that populations were high priorities for a CMP, populations where their status would merit a CMP but it is difficult to identify practicable conservation measures, and populations where there were different views on whether the conservation status required a CMP.

21.1 Populations considered based on assessments by the Scientific Committee

Arabian Sea humpback whales

This population was first suggested as a possible priority candidate by the Committee in 2010. It is believed to have numbered as few as 82 individuals in 2004 (95% CI 60-111) based on dorsal fin and fluke photo identification work around Oman. No trend information is available and there are few data available from other range states (India, Pakistan, Sri Lanka, with occasional sightings for Iran and Iraq) to be sure to whether this reflects total abundance of the humpback whales in the Arabian Sea or just around Oman. Known and likely threats include entanglement in fishing gear and ship strikes but the full extent of these is unknown.

The Committee **agrees** that the Arabian Sea population remains a high priority for a CMP if support was provided by the range states.

Common minke whales in the coastal waters of China, Japan (especially the west coast) and Republic of Korea
Of the common minke whale populations in the North Pacific considered by the Committee, only common minke whales in the coastal areas of Japan, China and the Republic of Korea might satisfy the guidelines for populations which could be subject to a CMP. China, Republic of Korea, North Korea, Japan, Russian Federation are the range states. Information on the animals in these waters comes primarily from the discussions of stock structure and the modelling work undertaken as part of the RMP *Implementation Review* (Annex D1, item 10). The stock structure issue led to no agreement within the Committee: there are three hypotheses (A, B, C of increasing numbers of stocks or sub-stocks). Stock structure hypothesis C leads to most concern for the 'J-like stocks' and the 'Y-stock'; the high levels of incidental take, in particular, cause substantial projected future decline (see Annex D1). In addition to the stock structure discussions, a major information gap is the poor survey coverage, particularly the sub-areas 5 and 6W.

Despite the uncertainties, some members believed that the results from assessments underlying the *Implementation Simulation Trials* undertaken during the *Implementation Review* were sufficient to warrant consideration of the value of a CMP, given the projected impact of incidental bycatch. Other members believed that it was premature to put this proposal forward given the uncertainty regarding stock structure and the poor survey coverage in some areas.

North Atlantic right whales
The Committee reiterated its concerns over the status of North Atlantic right whales, a small population subject to high levels of human impacts from entanglement and ship strikes. However, the two range states (USA and Canada) are already taking management action and the Committee did not identify any specific ways in which a CMP would assist their conservation efforts.

North Pacific right whales
The Committee noted concern over the small size of this population, particularly in the eastern part of the species' range, and the need for more research to understand distribution, assess threats and identify actions that could be taken to reduce these. It was also noted that the range states for right whales in the North Pacific were the same as for gray whales and so there may be options for integrating North Pacific right whales with the current western gray whale CMP.

21.2 Populations considered based on knowledge of threats

Blue whales in the northern Indian Ocean
The Committee noted that there are no population estimates for blue whales in the northern Indian Ocean but there have been a number of reported ship strikes of blue whales off Sri Lanka. This highlights the urgent need for long-term monitoring of the blue whales in Sri Lankan waters and elsewhere in the northern Indian Ocean. Further assessment is needed on whether this population may benefit from a CMP.

Fin whales in the Mediterranean
This population is Red-Listed as *Vulnerable* by IUCN and is known to be subject to a high level of ship strikes. The IWC and ACCOBAMS have a joint work plan to address ship strikes in the Mediterranean. Further evaluation is required as to whether an IWC CMP would assist in the current work by IWC, ACCOBAMS and range states.

Sperm whales in the Mediterranean
This population is considered as *Endangered* by IUCN and is at risk from driftnet entanglement and ship strikes. As for fin whales in the Mediterranean, further evaluation is required to determine whether an IWC CMP would assist in the current work by IWC, ACCOBAMS and range states.

Other populations that were tentatively considered in some sub-group reports as potentially benefitting from a CMP in the future include: Antarctic blue whales; a small southeast Pacific (Isla de Chiloe) group of blue whales; and a small southeast Pacific group of 'pygmy' fin whales. However, the current information on status and/or threats in these cases was not adequate to support a recommendation at this time. In particular, in the case of these blue whale and fin whale populations, no major threats amenable to practical management action have been identified. The Committee **agrees** that other populations will be re-evaluated for priority listing as additional information becomes available.

Entanglement and ship strikes are the highest cause of non-deliberate anthropogenic mortalities for large whale populations. In addition to assessments including abundance and status, the Committee has discussed ways of estimating the numbers of entanglement and ship strike mortalities and evaluating mitigation measures. The Committee also noted that any population which is known to spend significant time in areas of high entanglement risk or high density shipping may be considered, even with a low number of reports. This is especially true if there is no local stranding network or ship strike reporting infrastructure. The Committee **agrees** that it is not currently in a position to propose any populations for CMPs based only on risk analysis where reporting is very limited.

Once a CMP is developed, the mitigation aspects of measures considered within it will need to be evaluated to assess what risk reduction is expected or being achieved. The Committee therefore **encourages** studies that fill any data gaps regarding ways that entanglement or ships strikes may be reduced, for input into CMPs. This may be in areas where CMPs have already been developed (western gray whales; southwest Atlantic population of southern right whales; and southeast Pacific right whales); are currently under consideration as candidates (Arabian Sea humpback whales) or are high on the list of priority candidates. Recognising that CMPs continue to evolve, the Committee **agrees** that it would welcome requests for further scientific input into existing CMPs.

For ship strikes, the IWC has consultative status to the International Maritime Organization (IMO) and so can assist with IMO involvement. The IMO is responsible for all measures outside of national waters that affect shipping and so an effective dialogue with IMO is critical for all measures related to ship strikes. In addition it was noted that as part of the CMP for the southwest Atlantic population of southern right whales, the range states have agreed to collect information on ship strikes with this species and report them to the IWC.

For entanglements, the IWC has established a large whale entanglement expert advisory group, with members from Australia, Canada, New Zealand, South Africa and the USA, to advise countries on the issue, and has initiated a programme to build capacity in prioritised areas, when requested (IWC, 2013a). In addition, the Committee **recommends** that the Secretariat bring the IWC's most current scientific and mitigation information to the relevant bodies within the FAO.

22. COMPILATION OF AGREED ABUNDANCE ESTIMATES

The Committee has recognised the need for consistency in evaluating abundance estimates across sub-groups, recognising that to some extent 'acceptance' depends on the use to which the estimate is being put. It is also valuable for the Commission to have an updated overview of how many whales there are by broad ocean area. This year the Committee began a process to develop such lists and summaries by placing this as an item on the agendas of the relevant sub-groups. It established an *ad hoc* working group whose report is given as Annex Q.

The Committee **agrees** with the *ad hoc* group that the most appropriate way to make progress on further development of summary tables for both its use and that of the Commission is to establish an intersessional Working Group that will consider doubtful and potentially missing estimates, compile and summarise existing estimates and report to next year's Annual Meeting (Annex R).

The membership of this Working Group should comprise members representative of the Committee's relevant sub-groups and those familiar with methods for estimating abundance. It will also produce a draft strategy for discussion at the next Annual Meeting for a process to ensure:

(a) regular updating of the tables; and
(b) a strategy to ensure consistency of the review of abundance estimates across sub-committees and Working Groups.

The objective is for this group to complete its work and circulate draft tables by the beginning of January 2014.

23. RESEARCH AND WORKSHOP PROPOSALS AND RESULTS

23.1 Review results from previously funded research proposals

Table 7 shows the progress of funded proposals from last year (IWC, 2013c).

23.2 Review Workshop proposals for 2013/14

Table 8 summarises the Workshop proposals agreed at this year's meeting. Detailed information on funding is given under Item 26.

Table 7

Progress on Research Proposals and Workshops funded last year.

Title		Status
(1)	Development of an operating model for West Greenland humpback and bowhead whales	Completed (SC/65a/Rep02)
(2)	Workshop on development of *SLA*s for Greenlandic hunts	Completed (SC/65a/Rep02)
(3)	AWMP developers funds	Used to fund work in SC/65a/AWMP02
(4)	Ship strike database coordinator	Completed (SC/65a/HIM04)
(5)	Right whale survey off South Africa	Completed (SC/65a/BRG10)
(6)	Genomic diversity and phylogenetic relationships among right whales	Not funded
(7)	Photographic matching of gray whales	Completed (SC/65a/BRG04)
(8)	Contribution to the preparation of the State of the Cetacean Environment Report (SOCER)	Completed (SC/65a/E01)
(9)	Pre-meeting Workshop on assessing the impacts of marine debris	Completed (SC/65a/Rep06)
(10)	Develop simulation of Southern Hemisphere minke line transect data	Completed (S/65a/IA15)
(11)	IWC-POWER cruise	Completed (SC/65a/Rep01 and SC/65a/IA8)
(12)	Statistical catch-at-age assessment method for Antarctic minke whales	Completed (SC/65a/IA01)
(13)	'Second' *Implementation Review* Workshop for western North Pacific common minke whales	Completed (SC/65a/Rep04)
(14)	Essential computing for RMP/NPM and AWMP	Completed (Annexes D, D1, AWMP)
(15)	MSYR review Workshop	Completed (SC/65a/Rep05)
(16)	Review and guidelines for model-based and design-based line transect abundance estimates	Postponed until this year
(17)	Modelling of Southern Hemisphere humpback whale populations	Completed (SC/65a/SH01 and SC/65a/SH07)
(18)	Antarctic humpback whale catalogue	Completed (SC/65a/SH15)
(19)	Photo matching of Antarctic blue whales	Completed (SC/65a/SH16)
(20)	Southern Hemisphere blue whale catalogue 2012/13	Completed (SC/65a/SH23)
(21)	Expert workshop for review of Iceland's Special Permit programme	Completed (SC/65a/Rep03)
(22)	Whalewatching guidelines and operator training in Oman	Completed

Table 8

Summary of proposed Workshops and pre-meetings.

Subject	Annex	Dates	Venue
IWC-POWER Technical Advisory Group meeting	Annex G	September 29-30	Tokyo, Japan
IWC-POWER planning meeting for the 2014 cruise	Annex G	October 2-3	Tokyo, Japan
Oman whalewatching Workshop	Annex M	October	Oman
IWC/IQOE soundscape Workshop	Annex K	'Winter'	The Netherlands
Workshop on developing *SLA*s for the Greenland hunts	Annex E	Early January (*)	Copenhagen, Denmark
Workshop on the North Atlantic fin whale *Implementation Review*	Annex D	Early January	Copenhagen, Denmark
International gray whale Workshop on stock structure and status	Annex F	March/April	TBD
Workshop on the problem of kelp gulls and southern right whales	Annex F	April	Puerto Madryn, Argentina
AWMP/RMP North Atlantic minke whale stock structure	Annex D, E	April	CPH (or Bergen)
JARPA II review	Annex P	Late February	Japan
North Atlantic common minke whale *Implementation Review*	Annex D	Pre-meeting (3days)	TBD
Southern Hemisphere humpback whale assessment	Annex H	Pre-meeting (2days)	TBD

24. COMMITTEE PRIORITIES AND INITIAL AGENDA FOR THE 2014 MEETING

The Committee **notes** that the Commission's decision to move to biennial meetings means that it will need to develop a two-year proposed work plan at next year's meeting. The Committee **agrees** the following priorities below based on consideration in the plenary of the recommended work plans of the sub-committees and working groups. In addition, all relevant sub-groups will continue to consider updated abundance estimates and CMPs. Given its workload, the Committee **stresses** that papers considering anything other than priority topics will not be addressed at next year's meeting. The new online system for submitting papers will be updated during the year such that Convenors will be notified directly when papers are submitted for their sub-group; they may then contact authors directly if they believe that the papers are unlikely to be discussed.

Revised Management Procedure (RMP)
The following issues are high priority topics.

General issues
(1) Finalise the approach for evaluating proposed amendments to the *CLA*;
(2) evaluate the Norwegian proposal for amending the RMP;
(3) update the requirements and guidelines for conducting surveys to reflect considerations related to model-based methods for abundance estimation;
(4) specify how to deal with imbalanced sex ratios in incidental catches under the RMP;
(5) develop guidelines for handling situations in which survey coverage in time-series of abundance estimates changes over time; and
(6) consider the use of surveys carried out in different months in the *Implementation* process and in actual implementation of the RMP.

Implementation-*related issues*
(1) Finalise work on western North Pacific common minke whales:
  (a) review results from 'hybrid' variants with respect to variants with research;
  (b) review any research proposals with respect to variants with research; and
  (c) agree estimates of abundance for use in actual applications of the RMP;
(2) complete the *Implementation Review* for the North Atlantic fin whales;
(3) begin preparations for a focused basin-wide stock structure study for North Atlantic fin whales to be completed in time to inform the next *Implementation Review*;
(4) start an *Implementation Review* for the North Atlantic minke whales beginning with a three day pre-meeting (Convenor: Walløe) including review report of the joint AWMP/RMP Workshop on the stock structure of common minke whales;
(5) review the information available for North Atlantic sei whales in the context of a *pre-Implementation assessment*; and
(6) review new information on western North Pacific Bryde's whales.

Aboriginal Whaling Management Procedure (AWMP)
The following issues are high priority topics.
(1) Participate in the North Atlantic fin whale RMP process and review the implications of this for *SLA* development for the Greenland hunt;
(2) hold joint AWMP/RMP Workshop on the stock structure of common minke whales in the North Atlantic;
(3) submit need envelopes for West Greenland fin and common minke whales;
(4) finalise the trials for the West Greenland humpback and bowhead whales (including coding) to allow developers to work intersessionally. Ensure that standard software is available to produce agreed performance statistics, as well as tabular and graphical output;
(5) present overview of photo-identification work with respect to movements to inform stock structure and human induced mortality outside West Greenland;
(6) finalise removals series including consideration of human-induced mortality outside the West Greenland area;
(7) continue initial exploration of potential *SLA*s for the Greenland humpback and bowhead whale hunts; and
(8) produce a full report on the Greenlandic conversion factor programme.

Bowhead, right and gray whales (BRG)
The following issues are high priority topics.
(1) Review report from Workshop on the rangewide review of the population structure and status of North Pacific gray whales;
(2) perform the annual review of catch information and new scientific information for the B-C-B stock of bowhead whales;
(3) perform the annual review of catch information and new scientific information for eastern gray whales;
(4) review any new information on all stocks of right whales, especially results of assessments for southern right whales and the kelp gull Workshop; and
(5) review any other new information on western North Pacific gray whales and other stocks of bowhead whales.

In-depth assessment (IA)
The following issues are high priority topics.
(1) Further investigation and application of the SCAA models;
(2) further work examining the factors which drive Antarctic minke whale distribution and abundance;
(3) complete preparations for an in-depth assessment on North Pacific sei whales, specifically:
  (a) update the IWC catch data to include new data from Canadian and Soviet catches; and
  (b) analyse available survey and genetic data from the North Pacific, including from the IWC-POWER surveys;
(4) investigate the distribution and density of baleen and toothed whales in the Antarctic relative to spatial and environmental covariates;
(5) plan and undertake the 5th IWC-POWER survey in the North Pacific; and
(6) plan the next phase of the POWER cruises in the light of the Technical Advisory Group report.

Non-deliberate human-induced mortality (HIM)
The following issues are high priority topics.
(1) Review progress in including information in National Progress Reports;
(2) entanglement;

(3) ship strikes;
(4) review of information on other sources of non-deliberate human induced mortality; and
(5) develop five year plan for suggestions for priority work by the Committee to estimate and address non-deliberate human-induced mortality; review work of intersessional group.

Stock definition (SD)
The following issues are high priority topics.
(1) Genetic analysis guidelines;
(2) stock definition terminology;
(3) statistical and genetic issues concerning stock definition;
(4) testing of spatial structure models (develop new terms of reference); and
(5) providing advice to sub-groups as appropriate.

DNA
The following issues are high priority topics.
(1) Review genetic methods for species, stocks and individual identifications;
(2) review of results of the 'amendments' work on sequences deposited in *GenBank*;
(3) examine the technical information relevant to the TORs of the Group;
(4) collection and archiving of tissue samples from catches and bycatch; and
(5) reference databases and standard for diagnostic DNA registries.

Environmental concerns (E)
The following issues are high priority topics.
(1) SOCER;
(2) pollution (including POLLUTION 2020);
(3) Cetacean Emerging and Resurging Diseases (CERD) and mortality events;
(4) effects of anthropogenic sound on cetaceans and approaches to mitigate these effects (including the results of the intersessional joint Workshop);
(5) climate change;
(6) other habitat related issues including the report of the Conservation Committee's Workshop on marine debris; and
(7) Conservation Management Plans.

Ecosystem modelling (EM)
The following issues are high priority topics.
(1) Review ecosystem modelling efforts undertaken outside the IWC (competition and environmental variability);
(2) explore how ecosystem models contribute to developing scenarios for simulation testing of the RMP (linking individual based models to the RMP); and
(3) review other issues relevant to ecosystem modelling within the Committee.

Southern Hemisphere whales other than Antarctic minke whales and right whales (SH)
The following issues are high priority topics.
(1) Complete assessment of Breeding Stocks D/E/F humpback whales - this will complete the Comprehensive Assessment of Southern Hemisphere humpback whales;
(2) review new information on Southern Hemisphere blue whales in preparation for assessment;
(3) consider the feasibility of undertaking a future assessment of sperm whales; and
(4) Arabian Sea humpback whales.

Small cetaceans (SM)
The following issues are high priority topics.
(1) Voluntary funds for small cetacean conservation research;
(2) review of small cetaceans in the eastern Mediterranean and Red Seas; and
(3) progress on previous recommendations.

Whalewatching (WW)
The following issues are high priority topics.
(1) Assess the impacts of whalewatching on the physiology, behaviour, and fitness of cetaceans (individuals and populations) and their habitats;
(2) review reports from Intersessional Working Groups;
(3) review progress on Five-Year Strategic Plan for Whalewatching;
(4) review whalewatching in the region of the next meeting;
(5) consider information from platforms of opportunity of potential value to the Scientific Committee;
(6) review whalewatching guidelines and regulations; and
(7) consider emerging whalewatching industries of concern.

Scientific Permits (SP)
The following issues are high-priority topics.
(1) Review results of specialist JARPA II meeting;
(2) review of activities under existing permits; and
(3) review of new or continuing proposals.

25. DATA PROCESSING AND COMPUTING NEEDS FOR 2013/14

Allison reported on the computing needs and requirements identified for the forthcoming year. These are summarised in Table 9.

26. FUNDING REQUIREMENTS FOR 2013/14

This year, the sub-groups of the Committee's recommended projects for funding greatly exceeded (>£180,000) the allocated funding by the Commission within the two-year budget (Table 10). Reducing the budget to within the Commission's allocation was therefore a much greater task than is usually the case. For example, last year the full budget request was less than £24,000 over the available budget. The Scientific Committee's handbook states that one of the tasks for a Convenor is:

> 'f. 'To develop with other members of the Convenors' Group a prioritised list for funding that should to be made available to the full Committee at least by 6pm on the penultimate day of the Scientific Committee Annual Meeting.'

Given the difficult situation this year, the Convenors circulated to the Committee the full budget request and the full background information on the 13 June i.e. two days before the close of the meeting, before it had managed to meet to discuss a 'prioritised list' for circulation.

After a suggested budget had been developed on the afternoon of 14 June but before a document including the suggestions and rationale could be circulated to the full Committee, it was agreed to hold a Heads of Delegation meeting in the late afternoon of 14 June; this was followed by another on the morning of 15 June. During the second meeting, it was agreed that the option for a reduced budget

Table 9

Computing tasks for the coming year.

Group	Item
RMP	
(1)	Complete final compilation of tables and plots from the *Implementation Review* of North Pacific minke whales.
(2)	Run hybrid trials (variants with research) of North Pacific minke whales as required.
(3)	Redo conditioning and rerun existing trials of North Atlantic fin whales.
(4)	Other work related to the *Implementation Review* of North Atlantic fin whales (e.g. revision of the control program; conditioning and running of final trials to be specified by the intersessional Workshop (Annex D, Appendix 2).
(5)	Run a full set of trials for western North Pacific Bryde's whales and North Atlantic minke whales using the Norwegian version of the *CLA* and place the results on the IWC website.
(6)	Work with the Norwegian Computing Centre to standardise the Norwegian catch limit program code (Annex D, item 2.4).
(7)	Work to specify and run additional trials for testing amendments to the *CLA* (Annex D, item 2.2).
AWMP	
(1)	Finalise the catch and other removals series for use in trials including ship strikes and other human induced mortality outside West Greenland and data from Canada (see Annex E, item 3.2 and 3.3).
(2)	Work on the control program for the West Greenland humpback and bowhead whales (see Annex E, item 3.2 and 3.3).
IN-DEPTH ASSESSMENT	
(1)	Prepare catch series for North Pacific sei whales including inclusion of revised Canadian catch data and new analysis of Soviet North Pacific catch records to extent possible in time available, noting any discrepancies (see Annex G, item 5.1).
(2)	Validation of the POWER cruise data and work towards standard IDCR/SOWER dataset (see Annex G, item 5.3).
(3)	Complete validation of the 1995-97 blue whale cruise data and incorporate into the DESS database (carried over).
(4)	Eliminate discrepancies between the IWC individual catch data for Antarctic minke whales and the Japanese special permit data held by scientists.
BRG	
(1)	Update the catch series for North Pacific gray whales (Annex F).

developed by the Convenors should be submitted to the full Committee, noting that it had been seen by the Heads of Delegations but that there had been insufficient time for them to fully review it. In doing so, it was recognised that the Convenors had given full consideration to the reduced budget; the revised budget discussion document was annotated with comments made by individual Heads of Delegations.

The Committee **agrees** that it is important to consider possible new systems for future budget allocations; it will add this topic to its agenda next year. In this regard it also noted the need to develop a two-year budget request next year. The Heads of Delegations **requested** that the Secretary review the governance rules, procedures and practices of the Scientific Committees of the other intergovernmental organisations and report back to the Scientific Committee in 2014 in order to assist discussions of the working methods of the Committee. They also requested a more substantial role in Committee governance. Recognising that these are funds provided by the Commission, the Committee **agrees** that *inter alia* Heads of Delegations should play a substantial role in discussions of how the budget should be allocated in future. Convenors should continue to play an important role since they are familiar with the research needs and priorities of each sub-group. The advice of the Commission will also be sought on both the process and its priorities.

As noted above, trying to balance the budget this year was an extremely difficult task. The approach taken by the Convenors for the discussion document is summarised below.

Check the feasibility of voluntary reductions

Each budget line was examined to see if any proposal could be lowered (based on the knowledge of single projects, discussions with proposers where possible or discussions within the sub-committee itself) e.g. by reducing the number of participants to workshops/meetings, finding external funders (for research, workshops or participants), removing part of the research programme, etc.

Checking the feasibility of projects' postponement, in the light of the sub-group priorities

In some cases the amount was either lowered or cut, according to the feasibility to defer some work by one year.

Final cuts based on the strength of recommendations in sub-group reports and an assessment by all Convenors of overall Committee priorities

This was by far the most difficult part of the process, given a remaining overrun of more £100,000.

Table 10 summarises the complete list of recommendations for funding made by the Committee as well as the reduced budget developed in light of the known available funding. The Committee **recommends** all of these proposals to the Commission. In **recommending** its reduced budget, the Committee **stresses** that projects for which it has had to suggest reduced or no funding are still important and valuable.

(1) AWMP-1 INTERSESSIONAL WORKSHOP ON DEVELOPING *SLA*S FOR THE GREENLAND HUNTS

The Committee has identified completion of the development of long-term *SLA*s for these hunts as high priority work. In order to meet the proposed timeframe, an intersessional Workshop is required. The focus of the proposed Workshop is to: (1) to review the results of the developers of *SLA*s for humpback whales and bowhead whales; (2) finalise the modelling framework/trial structure for these hunts; (3) develop a workplan to try to enable completion of work on *SLA*s for these two hunts at the 2014 Annual Meeting; and (4) consider possible input (e.g. using AWMP/RMP-lite) for the joint AWMP/RMP Workshop on North Atlantic common minke whale stock structure. The Workshop will be held in early 2014 in Copenhagen, Denmark. It is intended to hold this back-to-back with the RMP Workshop on fin whales to save travel costs given some common participants.

(2) AWMP-2 AWMP DEVELOPERS' FUND

The developers fund has been invaluable in the work of *SLA* development and related essential tasks of the SWG. It has been agreed as a standing fund by the Commission.

Table 10

Budget requests (see text). Note that the Committee's agreement on the Small Cetacean Conservation Research Fund is given under Item 14.2. Asterisks indicate alternative funding has been found.

Number	Summary of item	Plenary Agenda Item, Annex item	Full cost (£)	Reduced budget (£)
AWMP-1	AWMP Intersessional Workshop on developing *SLA*s for the Greenlandic hunts	Item 8.3. Annex E, item 9.2	8,000	8,000
AWMP-2	AWMP developers fund	Item 8.3. Annex E, item 9.2	7,000	7,000
BRG/AWMP/SD-1	Gray whale rangewide Workshop	Items 8.1.2, 9.2.1, 10.5.3, 11. Annexes E, F and I	15,000	10,000
BRG-1	Southern right whale kelp gull Workshop	Item 10.6.2. Annex F, item 4.4	6,000	6,000
BRG-2	Southern Ocean right whale survey	Item 10.6. Annex F, item 4.1	23,000	*
E-1	State of the Cetacean Environment Report (SOCER)	Item 12.1. Annex K, item 6	5,000	4,000
E-2	POLLUTION 2020	Item 12.2.1. Annex K, item 7.1	27,000	20,000
E-3	Complete implementation of the CERD website	Item 12.3.2. Annex K, item 8.2	5,000	4,000
E-4	Joint IWC/IQOE Workshop predicting soundfields-global soundscape modelling	Item 12.4.2. Annex K, item 9.2	26,900	19,700
E-5	2nd phase Workshop on marine debris	Item 7.5.1. Annex K, item 11.2	5,000	*
HIM-1	Ship strike data coordinator	Item 7.4. Annex J, item 8.1	10,000	8,000
HIM-2	Bryde's whale abundance, distribution and risk of ship strike in the Hauraki Gulf	Item 7.4.3. Annex J, item 8.3	27,1	0,000
IA-1	Satellite tagging of Antarctic minke whales to provide information on breeding grounds, habitat utilisation and availability bias	Item 10.1.2. Annex G, item 8	69,500	0,000
IA-2	Statistical catch-at-age issues for further investigation	Item 10.1.3. Annex G, item 2.1	12,500	12,500
IA-3	2014 IWC-POWER North Pacific survey	Item 10.12.1 Annex G, item 3.3	62,600	58,600
RMP-1	Intersessional Workshop on North Atlantic fin whales	Items 6.2.1, 8.3.1. Annex D, item 5	4,000	4,000
RMP-2	Pre-meeting on North Atlantic minke *Implementation Review*	Item 6.3.2. Annex D, item 3.2	2,000	2,000
RMP/AWMP/SD	Simulations to evaluate power and precision of genetic clustering at critical [demographic] dispersal rates	Items 6.3.2, 8.3.1. Annex D, Appendix 3, adjunct 2	15,000	15,000
RMP/AWMP-1	Joint AWMP-RMP Workshop on stock structure hypotheses for North Atlantic minke whales	Items 6.3.2, 8.3.1. Annex D, item 3.2	10,000	10,000
RMP/AWMP-2	Computing support for RMP and AWMP	Item 22. Annexes D and E	8,000	4,000
SH-1	Minimum abundance estimates of Breeding Stock D humpback whales from Western Australian aerial surveys	Item 10.2.1.2. Annex H, item 3.1	4,000	4,000
SH-2	Modelling work to complete assessments of Breeding Stocks D, E and F	Item 10.2.1.1. Annex H, item 3.1	3,000	3,000
SH-3	Antarctic Humpback Whale Catalogue	Item 10.2.4. Annex H, item 3.4	15,000	10,000
SH-4	Comparison of photographs from JARPA II to the Antarctic Blue Whale Catalogue	Item 10.3.1.4. Annex H, item 5.1.4	7,500	5,000
SH-5	Southern Hemisphere Blue Whale Catalogue 2012/13	Item 10.3.1.4. Annex H, item 5.1.4	15,000	5,000
SH-6	Pre-meeting Workshop to complete the assessment of humpback whale Breeding Stocks D/E/F	Item 10.2.1. Annex H, item 3.1	7,000	7,000
SP-1	Expert Workshop to review JARPA II	Item 17.3. Annex P, item 7.3	30,000	25,000
IPs	IPs	All	64,000	64,000
Total			**498,000**	**315,800**

The primary development tasks facing the SWG are for the Greenlandic fisheries. These tasks are of high priority to the Committee and the Commission. The fund is essential to allow developers to work and thus allow progress to be made.

(3) BRG/AWMP/SD RANGEWIDE GRAY WHALE WORKSHOP ON STOCK STRUCTURE AND STATUS

Recent information has led to the need for a reappraisal of the population structure and movements of North Pacific gray whales. Sufficient new information exists to justify an international Workshop dedicated to developing new models to evaluate the question of North Pacific gray whale stock structure, and to better assess the potential impact of human activities on the status and develop appropriate strategies and mitigation measures. It will also suggested revisions to the background information sections of CMP. The issue has been an important part of discussions in AWMP, BRG, SD and is also relevant to CMPs and it is hoped the results will inform discussions at the 2014 Commission Meeting. The funding is for eight Invited Participants.

(4) BRG-1 SOUTHERN RIGHT WHALE KELP GULL WORKSHOP

The mass mortality of southern right whale calves has been an important issue for the Committee. This year, the Committee expressed concern and recommended that investigation of the causes of this mortality, and actions to reduce the risk of gull attacks on southern right whales at Península Valdés should be further developed and implemented. This is also a high priority action for the CMP.

(5) BRG-2 SOUTHERN RIGHT WHALE SURVEY

After consultation with the proposer this was reduced to zero as outside funding is expected.

(6) E-1 SOCER REPORT

SOCER is a long-standing effort to provide information to Commissioners and Committee members on environmental matters that affect cetaceans in response to several Commission resolutions. Funds are for salaries, library services, and printing.

(7) E-2 POLLUTION 2020

POLLUTION 2000+ has been a flagship programme of the Committee and the Commission has supported it and continued work on pollution in several Resolutions. POLLUTION 2020 is in effect Phase III of POLLUTON 2000+ and has two main priority areas of research; the toxicity of microplastics and the impact of polyaromatic hydrocarbons on cetaceans.

(8) E-3 COMPLETE IMPLEMENTATION OF CERD WEBSITE

The CERD website is being developed in two phases. The first phase focuses on large cetacean species and relies on a 'consultation and sharing' approach. The second phase is intended to include all cetacean species and incorporate a potential 'reporting' role. This website will have 'public' and 'registered user' levels. The public level will provide basic information on diseases in cetaceans, as well as access to selected discussion forum content. Registered users will have full access to the site, including in-depth information on cetacean disease, as well as to discussion forums and posting ability. Links will be provided for quick access to discussion boards that can be shared with groups focused on other topics such as pollution, ship strikes and marine debris.

(9) E-4 JOINT IWC/IQOE ACOUSTIC WORKSHOP

This is a co-sponsored Workshop dealing with global soundscape modeling to inform management of cetaceans and anthropogenic noise. Noise has been an important topic for the Committee since a 2004 Workshop. An increasing number of scientific efforts (International Quiet Ocean Experiment (IQOE), US's National Oceanic and Atmospheric Administration CetSound effort) directed at this topic reflect this broader scope. In September 2011, the IQOE held an open science planning meeting where research into soundscape characterisation and modelling were identified as one of the four key themes to be contained in the IQOE's draft Science Plan. This proposal for a joint IWC/IQOE Workshop will work to expand these tools and their application to a more global scale where they can be used to inform management of potential impacts on cetaceans.

(10) E-5 FUNDING FOR INVITED PARTICIPANTS FOR THE 2ND PHASE WORKSHOP ON MARINE DEBRIS

The Committee is working on this issue with the Conservation Committee. The first Workshop has taken place and the second is due. This is a high priority issue. The money (£5,000) was for two SC participants at the 2nd Workshop. The funds are available from an alternative source.

(11) HIM-1 SHIP STRIKE DATA COORDINATOR

The ongoing development of the IWC ship strike database requires data gathering, communication with potential data providers and data management. Co-ordinators were appointed last year and HIM agreed this should continue and a list of tasks was developed. It relates directly to the Commission's Conservation Committee Working Group on the topic.

(12) HIM-2 BRYDE'S WHALE ABUNDANCE, DISTRIBUTION AND RISK OF SHIP-STRIKE IN THE HAURAKI GULF

This money was requested to partially fund an aerial survey to estimate abundance of a small stock of Bryde's whales around New Zealand where the number of ship strikes has been giving cause for possible conservation concern.

(13) IA-1 DETERMINATION OF BREEDING GROUNDS, HABITAT UTILISATION AND AVAILABILITY BIAS IN ANTARCTIC MINKE WHALES

Habitat utilisation, location of breeding grounds and diving behaviour of Antarctic minke whales represent major data gaps in the Committee's knowledge in relation to four major issues. Research reported in SC/65a/IA12 has demonstrated that the deployment of these types of tags is practical and efficient and can provide a great deal of valuable data. Tags are intended to be deployed in the Ross Sea in December 2013/January 2014. One researcher has a pending research proposal with the US NSF that would provide ship time for tag deployment later in 2014-15 in the Ross Sea. The cost is for 15 Splash MK10A Satellite-linked time-depth recording LIMPET tags (location and dive data) 10 Spot 5 Satellite-linked LIMPET Tags (location only data).

(14) IA-2 DISTRIBUTION OF BALEEN AND TOOTHED WHALES RELATIVE TO SPATIAL AND ENVIRONMENTAL COVARIATES

This was reduced to zero as alternative funding was found.

(15) IA-3 STATISTICAL CATCH-AT-AGE (SCAA) ISSUES FOR FURTHER INVESTIGATION

This approach is one that has been guided and funded by the Committee for several years. The SCAA can be used to evaluate various hypotheses regarding the dynamics of Antarctic minke whales, such as whether growth and carrying capacity have changed. The Committee has identified where further work might solidify some of the conclusions, and a number of detailed technical suggestions were made by the Committee. This proposal addresses the main remaining suggestions made. The Committee also suggested that work be made available for the JARPA II review. The funds will allow the recommended analytical work to be completed.

(16) IA-4 2014 IWC-POWER NORTH PACIFIC SURVEY

The Committee has strongly advocated the development of an international medium- to long-term research programme involving sighting surveys to provide information for assessment, conservation and management of cetaceans in the North Pacific, including areas that have not been surveyed for decades. The Committee developed objectives for the overall plan and this will fund the final leg of the initial phase. The money is for: (1) IWC researchers and equipment as the vessel is provided free by Japan; (2) to allow the Committee's Technical Advisory Group to meet to review the multi-year results thus far and develop the plans for the next phase of POWER based on the results obtained from Phase I; and (3) to enable analyses to completed price to the 2014 Annual Meeting.

(17) RMP-1 INTERSESSIONAL RMP WORKSHOP ON NORTH ATLANTIC FIN WHALES

The objective of this short Workshop is to review the results of conditioning and trials for North Atlantic fin whales, modify these if necessary and determine an intersessional workplan to ensure that the *Implementation Review* can be completed at the 2014 Annual Meeting. It is also relevant to developing *SLA*s for the Greenland hunt. It will be held back-to-back with the AWMP Workshop to save costs. Costs are for five IPs. This work should allow the *Implementation Review* to be completed in 2014 and greatly assist the work on the AWMP.

(18) RMP-2 PRE-MEETING NORTH ATLANTIC MINKE *IMPLEMENTATION REVIEW*

The Committee has agreed to undertake a full *Implementation Review* of common minke whales in the North Atlantic. This is a large exercise that will build upon discussions at the joint AWMP/RMP Workshop on stock structure. A pre-meeting will maintain progress such that it should be able to be completed within two years.

(19) RMP/AWMP/SD SIMULATIONS TO EVALUATE POWER AND PRECISION OF GENETIC CLUSTERING AT CRITICAL [DEMOGRAPHIC] DISPERSAL RATES

On many occasions the Committee has found that identifying stocks from genetic analyses often yielded ambiguous results because the values of key parameters at which management recommendations change are not defined. Realising that such 'tipping points' are likely to be case specific it has been agreed to use the North Atlantic minke whale as a case study. This study will: (1) conduct demographic simulations under reasonable range of stock hypotheses and management scenarios to determine the dispersal rates such that management performance is acceptable from a conservation point; and (2) the second step is to conduct genetic simulations to assess the ability of genetic clustering methods to robustly determine the number of breeding populations and assign individuals to a breeding population. It will enable similar work to be undertaken for other large whale species of conservation and management concern.

(20) AWMP/RMP-1INTERSESSIONAL JOINT AWMP-RMP MEETING ON STOCK STRUCTURE HYPOTHESES FOR NORTH ATLANTIC MINKE WHALES

This Workshop addresses common issues for AWMP/ RMP and will use the work of proposal 19 above. It was discussed and agreed last year. The costs are for eight invited participants.

(21) AWMP/RMP-2 ESSENTIAL COMPUTING FOR RMP AND AWMP

This is to provide assistance to the Secretariat with the large computing tasks it is facing in the coming year.

(22) SH-1 OBTAINING MINIMUM ABUNDANCE ESTIMATES OF BREEDING STOCK D HUMPBACK WHALES FROM WESTERN AUSTRALIAN AERIAL SURVEYS

This work was identified as of great importance if the Assessment of Breeding Stock D is to be completed. The cost is for new analyses of data from western Australian aerial surveys, 1999, 2005 and 2008. The observers' search pattern during these aerial surveys had not followed conventional protocols for conducting aerial surveys. The effect of such search patterns on the estimates is unknown, but sufficient concerns about their effect reduces confidence in the use of the resulting abundance estimates as absolute (rather than relative) estimates within the modelling exercise being undertaken (see next project).

(23) SH-2 MODELLING OF SOUTHERN HEMISPHERE HUMPBACK WHALE POPULATIONS

The project will focus on a combined assessment of humpback breeding stocks D, E1 and Oceania using a three-stock model which allows for mixing on the feeding grounds. Methods used will be based upon the Bayesian methodology as developed and presented for BSC and BSB Comprehensive Assessments recently completed. Exploration of alternative models which may be able to explain the observed data will be explored. These will include models that address anomalies identified regarding the population model fit to data for breeding stock D, and approaches suggested there to account for them, such as use of an environmental variation model and changes in carrying capacity over time.

(24) SH-3 ANTACTIC HUMPBACK WHALE CATALOGUE

The Antarctic Humpback Whale Catalogue collates photo-identification information from Southern Hemisphere humpback whales. Increasing awareness of the project among research organisations, tour operators and other potential contributors has widened the scope of the collection; research efforts in areas that had not previously been sampled have extended the geographic coverage. This catalogue has grown by 25% in the last two years, adding 1,127 new individuals, and increasing the time required to analyse photographs. In addition to these requested IWC funds, additional funds from other sources will be sought.

(25) SH-4 COMPARISON OF ANTARCTIC BLUE WHALE IDENTIFICATION PHOTOGRAPHS FROM JARPA II TO THE ANTARCTIC BW CATALOGUE

This work follows on from previous recommendations and work by the Committee on the assessment of Southern Hemisphere blue whales. It is also be of relevance to the SORP blue whale project. The sighting histories of individual Antarctic blue whales from photo-id provide data for a mark-recapture estimate of abundance as well as information on the movement of individual blue whales within the Antarctic region. The addition of more samples to the collection of Antarctic blue whale identification photographs would be extremely useful for these analyses. A total 380 blue whale identification photographs were collected during JARPA II cruises but need to be compared to the Antarctic Blue Whale Catalogue (305 individuals) and the associated sighting data added to the sighting history database.

(26) SH-5 SOUTHERN HEMISPHERE BLUE WHALE CATALOGUE 2012/13

The Southern Hemisphere Blue Whale Catalogue (SHBWC) is an international collaborative effort to facilitate cross-regional comparison of blue whale photo-identifications catalogues. In 2006, the Committee of the agreed to initiate an in-depth assessment of Southern Hemisphere blue whales and in 2008, it endorsed a proposal to establish the SHBWC. Currently the SHBWC holds photo-identification catalogues of researchers from major areas off Antarctica, Australia, Eastern South Pacific and the Eastern Tropical Pacific. A total of 884 blue whales are catalogued. Results of comparisons among different regions in Southern Hemisphere will improve the understanding of population boundaries, migratory routes and model abundance estimates. In addition, assessment of blue whales and estimates abundance of populations will require improving software capabilities to access encounter histories of individuals.

(27) PRE-MEETING WORKSHOP TO COMPLETE THE ASSESSMENT OF HUMPBACK WHALE BREEDING STOCKS D/E/F

This pre-meeting is required to facilitate the timely completion of the assessment of humpback whales breeding stocks D, E and F (Item 3.1.2). These are the last stocks remaining in the in-depth assessment of Southern Hemisphere humpback whales. The Committee has agreed that this assessment should be completed in SC/65b, as a matter of high priority. The meeting will evaluate the results of intersessional modelling efforts. Costs are for eight Invited Participants.

(28) EXPERT WORKSHOP TO REVIEW JARPA II

The Committee has agreed a procedure for periodic and final reviews of results from Special Permit research (IWC, 2013m). This procedure outlines an intersessional review meeting by an expert panel. The report from the intersessional expert meeting will be reviewed and discussed at the 2014 Scientific Committee Annual Meeting, SC/65b. The experts to the review Workshop will be identified by September 2013 and the expert Workshop will be convened during four days in February/March 2014. The requested funds are for travel for the invited experts. The Committee noted that after discussion at the Commission Meeting last year, a budget for the review of the Icelandic permit was approved.

27. WORKING METHODS OF THE COMMITTEE

27.1 Annual Meetings

Last year (IWC, 2013c, pp.78-9), after considerable discussion of the balance between cost savings and the efficiency of the Committee, it was agreed that primary documents would be distributed only electronically at Scientific Committee meetings thereby making significant cost savings in terms of freight (paper and pigeon holes) and copying (paper, Xeroxing and staff).

This year, the Committee continued to review its procedures both in terms of efficiency and cost savings. As part of this, careful consideration was given as to whether it might be possible to reduce the number of days of the Committee's meetings (e.g. removing the initial reading day from the start of the meeting, removing the rest day, reducing the length of Plenary, reducing the number of sub-committees, reducing sub-committee agendas or having some sub-committees meet only biennially). With its present workload and agenda, the Committee **agrees** that changing the number of days in an already full schedule was not practical at this time. However, it **agrees** to keep this item on its Agenda. In particular, it **agrees** to a trial period of introducing an earlier deadline for paper submission.

At present, authors are requested to submit at least preliminary titles, authors and ideally an abstract about six weeks before the meeting using an online system. Whilst authors are strongly encouraged to submit papers as early as possible, the final deadline is that primary papers must be submitted by the end of the first day of the Annual Meeting. This procedure recognises that participants voluntarily submit papers and most have other responsibilities than the IWC; some papers are also the result of recommendations made by the Committee or intersessional Workshops and are essential to the Committee's progress in a timely fashion. After considerable discussion, the Committee **agrees** to establish a deadline for primary papers as a trial for the 2014 Annual Meeting of seven days before the start of the meeting. In doing so it **agrees** that this has the potential to improve the Committee's efficiency in a number of ways; however, at least as a measure on its own, it will not result in cost savings but will provide information to inform discussions of cost savings next year.

The Committee will review the trial next year in the light of information to be provided on a number of factors to be finalised by the Convenors intersessionally including: improvements to efficiency of Convenors in terms of developing annotated agendas; number of papers available by the deadline; timing of overall submission in the weeks leading up to the meeting; download data; questionnaire to the Committee.

The Committee also agreed to improvements with the National Progress Reports database as discussed under Item 3.2 and Annex O.

27.2 Increasing the support of the Scientific Committee on conservation related issues

The Committee welcomed information that a number of scientists (Galletti Vernazzani, Iñíguez, Luna, Marzari, Peres and Rodríguez-Fonseca) will present next year a review of the Committee's reports, IWC Resolutions and information on population status since 1986. The review will highlight *inter alia* when the Committee has commented/recommended on as scientific matters (when a comment/conclusion is aimed to continue gathering scientific information), whaling management matters (when a comment/conclusion is aimed towards whaling management) and conservation matters (when a comment/conclusion is aimed to call the attention on threats and/or status, or improve the conservation of a species/subspecies/population). The objective of this work is to stimulate discussion within the Committee as to how best to improve communications on conservation matters to the Conservation Committee and Commission, in order to better contribute to the long term survival of cetacean species, sub-species and populations.

The Committee **agrees** that this item will be placed on its Agenda next year.

28. ELECTION OF OFFICERS

This is the first year for both the Chair and the Vice-Chair and so no elections were necessary.

29. PUBLICATIONS

The Committee was pleased to hear that the *Journal of Cetacean Research and Management* was now to become open access and freely available. It **agrees** that the *Supplement* should continue to be available in hard copy for participants given its central role at the meeting. The Committee **re-emphasises** the importance of the *Journal* to its work and **thanks** the Secretariat and the Editorial Board for its work.

30. OTHER BUSINESS

There was no other business.

31. ADOPTION OF REPORT

The completed parts of the report were adopted at 17:10hrs on 15 June 2013. As is customary, those parts that were only discussed on the final afternoon were agreed by the Chair, rapporteur and Convenors. The Chair thanked all of the participants for their co-operative attitude on this his first meeting, the rapporteurs, Secretariat and especially the host government and the hotel for their provision of excellent facilities. The meeting thanked the Chair for his expert and fair handling of the meeting.

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Annex A

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Annex B

Agenda

1. Introductory items
    - 1.1 Chair’s welcome and opening remarks
    - 1.2 Appointment of rapporteurs
    - 1.3 Meeting procedures and time schedule
    - 1.4 Establishment of sub-committees and working groups
    - 1.5 Computing arrangements

2. Adoption of Agenda

3. Review of available data, documents and reports
    - 3.1 Documents submitted
    - 3.2 National Progress Reports on research
    - 3.3 Data collection, storage and manipulation
        - 3.3.1 Catch data and other statistical material
        - 3.3.2 Progress of data coding projects
        - 3.3.3 Progress on program verification projects

4. Cooperation with other organisations
    - 4.1 Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR)
    - 4.2 Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES)
    - 4.3 Convention on the Conservation of Migratory Species (CMS)
        - 4.3.1 Scientific Council
        - 4.3.2 Conference of Parties (COP)
        - 4.3.3 Agreement on Small Cetaceans of the Baltic and North Seas (ASCOBANS)
        - 4.3.4 Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)
        - 4.3.5 Other
    - 4.4 Food and Agriculture Organisation of the United Nations (FAO)
    - 4.5 Inter-American Tropical Tuna Commission (IATTC)
    - 4.6 Agreement on the International Dolphin Conservation Program (AIDCP)
    - 4.7 International Committee on Marine Protected Areas (ICMMPA)
    - 4.8 International Council for the Exploration of the Sea (ICES)
    - 4.9 International Maritime Organization (IMO)
    - 4.10 International Union for the Conservation of Nature (IUCN)
    - 4.11 North Atlantic Marine Mammal Commission (NAMMCO)
    - 4.12 North Pacific Marine Science Organisation (PICES)
    - 4.13 Protocol on Specially Protected Areas and Wildlife of the Cartagena Convention for the Wider Caribbean (SPAW)
    - 4.14 Other organisations

5. Revised Management Procedure (RMP) – general issues
    - 5.1 Complete the MSY rates review
    - 5.2 Finalise the approach for evaluating proposed amendments to the *CLA*
    - 5.3 Evaluate the Norwegian proposal for amending the *CLA*
    - 5.4 Modify the ‘Catch Limit’ program to allow variance-covariance matrices
    - 5.5 Update ‘Requirements and Guidelines for Conducting Surveys and *Implementations*’
    - 5.6 Work plan

6. RMP – *Implementation*-related matters
    - 6.1 North Pacific common minke whales
        - 6.1.1 Review report of Intersessional Workshop
        - 6.1.2 Complete *Implementation*
        - 6.1.3 Recommendations
    - 6.2 North Atlantic fin whales
        - 6.2.1 *Implementation Review*
        - 6.2.2 Recommendations
    - 6.3 North Atlantic minke whales
        - 6.3.1 Review new information
        - 6.3.2 Prepare for 2014 *Implementation Review*
        - 6.3.3 Recommendations
    - 6.4 North Atlantic sei whales
        - 6.4.1 Begin *pre-Implementation assessment*
        - 6.4.2 Recommendations
    - 6.5 Western North Pacific Bryde’s whales
        - 6.5.1 Prepare for the 2016 *Implementation Review*
        - 6.5.2 Recommendations
    - 6.6 Work plan

7. Non-deliberate human-induced mortality of large whales
    - 7.1 Determination of cause of death from strandings
    - 7.2 Reporting to National Progress Reports
    - 7.3 Entanglement of large whales
        - 7.3.1 Estimation of rates of entanglement, risks of entanglement and mortality
        - 7.3.2 Methods to estimate time-series of bycatches

- 7.3.3 Collaboration with FAO and FIRMS
- 7.3.4 Collaboration with Commission's Humane Killing and Animal Welfare Methods Working Group including consideration of mitigation measures
- 7.3.5 Provision of information to RMP and AWMP including estimation of time series for trials

7.4 Ship strikes
- 7.4.1 Progress on the global database
- 7.4.2 Estimating rates of ship strikes, risk of ship strikes and mortality
- 7.4.3 Collaboration with the Commission's ship strikes working group including consideration of mitigation measures
- 7.4.4 Provision of information to RMP and AWMP

7.5 Marine debris
- 7.5.1 Consideration of report from Workshop on marine debris
- 7.5.2 Recommendations

7.6 Other issues including mortality from acoustic sources

7.7 Work plan

8. Aboriginal Subsistence Whaling Management Procedure (AWMP)
   - 8.1 Matters arising out of the *Implementation Review* for eastern North Pacific gray whales
   - 8.2 Guidelines for *SLA* development and evaluation
   - 8.3 Progress on *SLA* development for the Greenlandic hunts
   - 8.4 New information related to conversion factors for edible products for Greenland fisheries
   - 8.5 Work plan

9. Aboriginal Subsistence Whaling management advice
   - 9.1 Eastern Canada and West Greenland bowhead whales
     - 9.1.1 Assess stock structure/abundance of Eastern Canada and West Greenland bowhead whales
     - 9.1.2 Review recent catch information
     - 9.1.3 Management advice
   - 9.2 Eastern North Pacific gray whales
     - 9.2.1 Provide information to the SWG on AWMP for *Implementation Review*
     - 9.2.2 Review of recent catch information
     - 9.2.3 Management advice
   - 9.3 Bering-Chukchi-Beaufort Seas bowhead whale
     - 9.3.1 New information
     - 9.3.2 Management advice
   - 9.4 Common minke whale stocks off Greenland
     - 9.4.1 New information
     - 9.4.2 Management advice
   - 9.5 Fin whales off West Greenland
     - 9.5.1 New information
     - 9.5.2 Management advice
   - 9.6 Humpback whales off West Greenland
     - 9.6.1 New information
     - 9.6.2 Management advice
   - 9.7 Humpback whales off St. Vincent and The Grenadines
     - 9.7.1 New information
     - 9.7.2 Management advice
   - 9.8 Work plan

10. Whale stocks
    - 10.1 Antarctic minke whales
      - 10.1.1 Consideration of technical aspects of the agreed abundance estimates for CPII and CPIII
      - 10.1.2 Continue to examine reasons for the difference between abundance estimates from CPII and CPIII
      - 10.1.3 Apply statistical catch-at-age models
      - 10.1.4 Work plan
    - 10.2 Southern Hemisphere humpback whales
      - 10.2.1 Review results of assessment of Breeding Stocks D, E and F
      - 10.2.2 Review new information on other breeding stocks
      - 10.2.3 Work plan
    - 10.3 Southern Hemisphere blue whales
      - 10.3.1 Review new information
      - 10.3.2 Work plan
    - 10.4 North Pacific sei whale in-depth assessment
      - 10.4.1 Review intersessional progress
      - 10.4.2 Assessment
      - 10.4.3 Work plan
    - 10.5 North Pacific gray whales
      - 10.5.1 Review new information
      - 10.5.2 Conservation advice
      - 10.5.3 Work plan
    - 10.6 Southern Hemisphere right whales
      - 10.6.1 Review new information
      - 10.6.2 Complete assessment
      - 10.6.3 Work plan
    - 10.7 North Atlantic right whales
      - 10.7.1 Review any new information
      - 10.7.2 Work plan
    - 10.8 North Pacific right whales
      - 10.8.1 Review any new information
      - 10.8.2 Work plan
    - 10.9 North Atlantic bowhead whales
      - 10.9.1 Review any new information
      - 10.9.2 Work plan
    - 10.10 Okhotsk Sea bowhead whales
      - 10.10.1 Review any new information
      - 10.10.2 Work plan
    - 10.11 Arabian Sea humpback whales
      - 10.11.1 Review new information
      - 10.11.2 Progress toward the development of a Conservation Management Plan
      - 10.11.3 Work plan
    - 10.12 International cruises

10.12.1 IWC-POWER cruises in the North Pacific
10.12.2 Review of 2012 IWC-POWER sighting survey
10.12.3 Review planning meeting report for 2013 cruise
10.12.4 Recommendations for 2014 cruise
10.12.5 IWC-SOWER cruises (progress on website, publications, analyses)
10.12.6 Other cruises
10.13 Other

11. Stock definition
11.1 Guidelines for genetic studies and DNA data quality
11.2 Statistical and genetic issues related to stock structure matters faced by the Committee
11.3 Terminology and unit-to-conserve
11.4 Work plan

12. Environmental concerns
12.1 State of the Cetacean Environment Report, SOCER
12.2 Pollution
12.3 Cetacean Emerging and Resurging Diseases (CERD) and mortality events
12.4 Effects of anthropogenic sound on cetaceans and approaches to mitigate these effects
12.5 Effects of climate change on cetaceans
12.6 Habitat related issues
12.7 Work plan

13. Ecosystem modelling
13.1 Review ecosystem modelling efforts undertaken outside the IWC
13.2 Explore how ecosystem models contribute to developing scenarios for simulation testing of the RMP
13.3 Antarctic minke whale body condition analyses
13.4 Review other issues relevant to ecosystem modelling within the Committee
13.5 Work plan

14. Small cetaceans
14.1 Review of selected small cetacean populations in East Asian Waters (China (including Taiwan), Korea, Japan and Russia (only white whales)
14.2 Report on the Voluntary Fund for Small Cetacean Conservation Research
14.3 Review progress on previous recommendations
14.4 Review takes of small cetaceans
14.5 Update on proposed joint Workshop on monodontids
14.6 Work plan

15. Whalewatching
15.1 Assess the impact of whalewatching on cetaceans
15.2 Review whalewatching in southern and central eastern Asia
15.3 Progress on Commission's five-year strategic plan including guidelines and regulations
15.4 Other issues
15.4.1 Consider information from platforms of opportunity of potential value to the Scientific Committee
15.5 Work plan

16. DNA testing
16.1 Review genetic methods for species, stock and individual identification
16.2 Review results of the 'amendments' of sequences deposited in GenBank
16.3 Collection and archiving of tissue samples from catches and bycatches
16.4 Reference databases and standards for diagnostic DNA registries
16.5 Work plan

17. Scientific permits
17.1 Review report of the Workshop for Icelandic Scientific Permit whaling
17.2 Review of results from ongoing permits
17.2.1 JARPN II
17.2.2 JARPA II
17.2.3 Planning for a periodic review of results from JARPA II beginning September 2013
17.3 Review of new or continuing proposals
17.3.1 JARPA II
17.3.2 JARPN II
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03. Scordino, J.J., Akmajian, A.M., Gearin, P.J., Gosho, M. and Calambokidis, J. Availability of Pacific Coast Feeding Group gray whales during the gray whale migratory season in the Makah Usual and Accustomed Fishing Grounds. 5pp.
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23. Shpak, O. and Glazov, D. Review of the recent scientific data on the Okhotsk Sea white whale (*Delphinapterus leucas*) population structure and its application to management. 19pp.
24. Aizu, M., Nishida, S., Kusumi, J., Tajima, Y., Yamada, T.K., Amano, M. and Araya, K. Genetic population structure of finless porpoise in Japanese coastal waters. 12pp.
25. Mullié, W.C., Wagne, M.M., Elmamy, C.A.A., Jan Veen, F.M.Y. and Van Waerebeek, K. Large number of stranded harbour porpoises *Phocoena phocoena* as by-catch victims in Mauritania. 5pp.
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01. Scarpaci, C. and Parsons, E.C.M. Recent advances in whale-watching research: 2012-2013. 18pp.
02. No Paper.
03. Carlson, C., Kaufman, G., Ritter, F. and Rose, N.A. Report of the Intersessional Working Group on Guiding Principles Development. 4pp.
04. Stack, S.H., Currie, J.J., Davidson, E.H., Frey, D., Maldini, D., Martinez, E. and Kaufman, G.D. Preliminary results from line transect surveys utilizing surprise encounters and near-missed as proxies of vessels collisions with humpback whales (*Megaptera novaeangliae*) in Maui County waters, Hawai'i, USA. 20pp.
05. Kaufman, G.D. and Kaufman, P.M. Summary results of a survey conducted during the 2012 whalewatching season in Hervey Bay, Australia. 18pp.

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01. Perrin, W.F. and Brownell, R.L., Jr. Proposed 2013 updates to the IWC List of Recognised Species of Cetaceans. 4pp.
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03. Bando, T., Mogoe, T., Isoda, T., Wada, A., Mori, M., Tsunekawa, M., Tamahashi, K., Moriyama, R., Miyakawa, N., Kadowaki, I., Watanabe, H. and Ogawa, T. Cruise report of the second phase of the Japanese Whale Research Program under Special Permit in the Western North Pacific (JARPN II) in 2012 (part I) - offshore component. 33pp.

04. Matsuoka, K., Yoshimura, I. and Miyashita, T. Cruise report of the Japanese cetacean sighting survey in the western North Pacific in 2012. 8pp.

05. Kato, H., Matsuoka, K., Miyashita, T., Murase, H. and Pastene, L. Proposal for the 2014 IWC-Pacific Ocean Whale and Ecosystem Research (POWER). 9pp.

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08. Institute of Cetacean Research. Data available for the JARPA II Review Workshop (JARPA II surveys 2005/06-2010/11). 7pp.

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11rev. Bell, E.M. Annual Report of the Southern Ocean Research Partnership (SORP) 2012/13. 49pp.

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12. Vázquez, J.A., Martínez-Cedeira, J., López, A., Cañadas, A., Marcos, E., Maestre, I., Ruano, A., Laria, L., Llanova, A., Macleod, K. and Evans, P. Abundance estimates for fin whale (*Balaenoptera physalus*) and sperm whale (*Physeter macrocephalus*) in the North Atlantic Marine Demarcation and adjacent waters of the Bay of Biscay (2003-2011). 9pp.

REPORTS OF INTERSESSIONAL MEETINGS

SC/65a/Rep

01. Report of the Planning Meeting for the 2013 IWC-POWER Cruise, 25-26 October 2012, Tokyo, Japan. 18pp.

02. Report of the Fourth AWMP Workshop on the Development of *SLA*s for the Greenlandic Hunts, 15-18 December 2012, Copenhagen, Denmark. 33pp.

03. Report of the Expert Workshop to Review the Icelandic Special Permit Research Programme, 18-22 February 2013, Reykjavik, Iceland. 47pp.

04. Report of the 'Second' Intersessional Workshop on the *Implementation Review* for Western North Pacific Common Minke Whales, 19-23 March 2013, La Jolla, California, USA. 21pp.

05. Report of the Fourth Intersessional Workshop on the Review of Maximum Sustainable Yield Rates (MSYR) in Baleen Whales, 26-28 March 2013, La Jolla, California, USA. 14pp.

06. Report of the 2013 IWC Scientific Committee Workshop on Marine Debris, 13-17 May 2013, Woods Hole, USA. 39pp.

COMMISSION DOCUMENTS

IWC/65/

04(2013). Cooperation with other organisations. 22pp.

Annex D

Report of the Sub-Committee on the Revised Management Procedure

Members: Bannister (Convenor), Allison, An, Baulch, Bjørge, Brandão, Brownell, Butterworth, Childerhouse, Chilvers, Cipriano, Collins, Cooke, Currey, De la Mare, De Moor, Diallo, Donovan, Double, Elvarsson, Fortuna, Funahashi, Goodman, Gunnlaugsson, Hakamada, Hammond, Hoelzel, Holloway, Iñíguez, Kanaji, Kanda, Kato, Kelly, Kim, H., Kishiro, Kitakado, Lang, Legorreta-Jaramillo, Marzari, Miyashita, Morishita, Murase, Nelson, Øien, Palacios, Palsbøll, Pampoulie, Park, J., Park, K., Pastene, Punt, Roel, Sakamoto, Santos, Simmonds, Skaug, Solvang, Víkingsson, Walløe, Williams, Witting, Yasokawa, Yoshida.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks
As Convenor, Bannister welcomed the participants.

1.2 Election of Chair and appointment of rapporteurs
Bannister was elected Chair. Punt acted as rapporteur.

1.3 Adoption of Agenda
The adopted Agenda is shown in Appendix 1.

1.4 Available documents
The documents considered by the sub-committee were SC/65a/RMP01-10, SC/65a/Rep05, SC/F13/SP06, SC/F13/SP17-19, SC/F13/SP20rev, and relevant extracts from past reports of the Committee.

2. REVISED MANAGEMENT PROCEDURE (RMP) – GENERAL ISSUES

2.1 Complete the MSY rates review
2.1.1 Report of the intersessional Workshop
Donovan introduced SC/65a/Rep05, the report of the fourth intersessional Workshop on the review of maximum sustainable yield rates (MSYR) in baleen whales. The Workshop was kindly hosted by the Southwest Fisheries Science Center in La Jolla, USA, from 26-28 March 2013.

Since 2007, the Committee has been discussing maximum sustainable yield rates (MSYR) in the context of a general reconsideration of the plausible range to be used in population models used for testing the *Catch Limit Algorithm* (*CLA*) of the RMP (IWC, 2008; 2009a; 2009b; 2010a; 2010b; 2010c; 2011a; 2011b; 2012a). The current range is 1% to 7%, in terms of the mature component of the population. At the 2012 Annual Meeting, the Committee had agreed that one more year be allocated for the MSYR review, but that if it could not be completed at the 2013 meeting, the current range of MSYR rates would be retained (IWC, 2013b; 2013c).

Donovan noted that the Workshop was primarily technical, and thus only a brief summary is provided here. Those interested in the details are referred to SC/65a/Rep05. He reported that the first part of the Workshop comprised a review of the present methods. In short, the approach agreed last year (IWC, 2013b) involves developing a posterior distribution for the quantity r_0/r_{max}, i.e. the ratio of the increase rate in the limit of zero population size to the maximum rate of increase of a whale stock which is demographically possible. Punt (2012) describes the model used to determine the extent of process error in r_0/r_{max} ('process error' is the variation in the true value for r_0/r_{max} caused by environmental variation). Considerably more detail is given in SC/65a/Rep05, including agreement to change the hyperpriors previously agreed such that they were in effect non-informative as was desired. The Workshop also received information on and endorsed intersessional refinements and additions: (1) to the population dynamics model used to calculate the extent of variation and temporal autocorrelation in the annual rate of increase; and (2) to update the software to allow for variation in natural mortality rather than fecundity.

The Workshop briefly reviewed the estimates of rates of increase to be used in the meta-analysis. These had been developed and refined over a number of years and are summarised in Table 1. Changes from previous agreements primarily centred around the need to limit the stocks included in the meta-analysis to those that had been depleted to 'low' levels (at least at the start of the data series) to approximate r_0 and to remove datasets that only referred to feeding aggregations given concerns about their relationship to the remainder of the stock.

The Workshop also agreed that following on from discussions in 2012 (IWC, 2013c), it would agree single estimates of demographic parameters for each species (Table 2). Table 3 summarises the input values for the reference case, where $\tilde{\sigma}_f$ and $\tilde{\rho}_f$ represent the standard deviation and temporal autocorrelation in fecundity (Brandon and Kitakado, 2011; Cooke, 2011).

Following on from discussions of Cooke (2011) last year, the Workshop focused on the question of correlation between variability in reproductive rates and in survival rates. It agreed that positive correlation between survival rate and reproduction was the most likely case, but agreed to include the cases of negative, zero and positive correlation in the meta-analysis as sensitivity checks, consistent with the view of the Scientific Committee (IWC, 2013c). Some potential additional work was specified to help determine the plausible range of variability in survival as summarised later. The Workshop agreed that if this was not successful, conclusions will continue to be based on sensitivity tests which assume that mortality and reproduction contribute in equal measure to the variation in the net recruitment rate.

The Workshop then discussed de la Mare (2013), which provided initial results from an individual-based model for a generic baleen whale population based on standard energetic relationships. It provided examples of relationships between the values of the annual births, which were subject to variation due to stochastic prey availability (as characterised here by $\tilde{\sigma}_f$), and additional deaths due to shortages of prey. Initial results also suggested a positive correlation between survival rate and birth-rate due to stochastic variability in prey abundance. In welcoming this new approach

Table 1

Estimates of rates of increase used as r_0 and the associated time periods over which they were estimated based upon the review provided in IWC (2010a) apart from for southern right whales which was based upon IWC (2013a). The main reference is given for each population but a fuller discussion of depletion and reliability can be found in the two reports. L=low; M=medium; H=high.

	Population level	Reliability of data	r_0 (%) (95% CI)	SE	Time period	Year span	References
Blue whale							
Central N Atlantic	L	H	9.0 (2.0, 17.0)	3.83	1987-2001	15	Pike *et al.* (2007)
Southern Hemisphere	L	H	8.2 (1.6, 14.8)	3.37	1978/79-2003/04	26	Branch (2007)
EN Pacific	L	H	3.2	1.4	1991-2005	16	Calambokidis *et al.* (2007)
Fin whale							
N Norway	L	H	5 (-13, 26)	9.95	1988-98	11	Víkingsson *et al.* (2007)
EN Pacific	L	H	4.8 (-1.6, 11.1)	3.24	1987-2003	15	Zerbini *et al.* (2006)
Humpback whale							
W Australia	L	H	10.1 (0.9, 19.3)	4.69	1982-94	13	Bannister and Hedley (2001)
E Australia	L	H	10.9 (10.5, 11.4)	0.23	1984-2007	24	Noad *et al.* (2008)
EN Pacific	L	H	6.4	0.9	1992-2003	12	Calambokidis and Barlow (2004)
Hawaii	L	H	10 (3-16)	3.32	1993-2000	18	Mizroch *et al.* (2004)
Bowhead whale							
B-C-B	M	H	3.9 (2.2, 5.5)	0.84	1978-2001	24	Zeh and Punt (2005)
Southern right whale							
SE Atlantic (S Africa)	L	H	6.8 (6.4, 7.2)	0.2	1979-2010	32	Brandão *et al.* (2011)
SW Atlantic (Argentina)	L	H	6.0 (5.5, 6.6)	0.28	1971-2010	40	Cooke *et al.* (2001)
SE Indian (Australia)	L	H	6.6 (3.8, 9.3)	1.40	1993-2010	18	Bannister (2011)

Table 2

Values of demographic parameters used to calculate r_{max} on a per-species basis. S is the annual adult survival rate, assumed to apply from age 1 and above; S_J is the survival rate for the first year of life which is assumed to equal S^2, a_{fp} is the age at first parturition, f is the highest fecundity considered possible, and r_{max} is the corresponding exponential growth rate in steady unexploited conditions.

	S	S_J	a_{fp}	f	r_{max}
Blue whale	0.98	0.96	5	0.5	0.114
Fin whale	0.98	0.96	5	0.5	0.114
Humpback whale	0.97	0.941	5	0.5	0.103
Bowhead whale	0.99	0.98	22	0.33	0.043
Southern right whale	0.99	0.98	8	0.33	0.076

the Workshop identified two approaches to using it to provide estimates that could be used in examining the effects on the meta-analysis arising from combined variability in births and deaths. This formed part of the proposed intersessional research discussed further below.

Given the absence of data to allow direct estimation of the extent of variability in survival, the Workshop **agreed** that analyses including such variability should be seen as providing robustness tests for the results of analyses taking account variability in reproduction alone.

The Workshop then considered estimates of the r_0/r_{max} distribution for the reference case based on the rate of increase data for the stocks in Table 3. The results are discussed fully in SC/65a/Rep05. They are not summarised here as these and the final analyses presented at the present meeting are discussed under Item 2.1.2 below and summarised in Table 4.

The Workshop considered a number of sensitivity analyses relating to:

(1) application of the environment model;
(2) data sets included in the meta-analysis;
(3) allowing for variation in natural mortality as well as fecundity; and
(4) higher and lower specifications for the values of r_{max}.

The results of the meta-analysis were generally insensitive to changing the assumptions upon which it is based, with a few exceptions (SC/65a/Rep05, fig. 3; Table 4). In particular, increasing the extent of variation and autocorrelation of fecundity leads to a posterior distribution for r_0/r_{max} which emphasises higher values for r_0/r_{max}. This is because higher environmental variation leads to higher overall variation (process and observation) for stocks with lower r_0/r_{max}. Consequently, the relative weight given to stocks for which the rate of increase is close to r_0 (especially the right whale stocks) becomes greater. The rates of increase for the right whale stocks are generally close to r_{max}).

The Workshop then focussed on the key matter of approaches to relate the r_0/r_{max} distribution to an appropriate MSYR range, the ultimate goal. The last discussion of this took place during the 2009 intersessional workshop on MSYR for baleen whales (IWC, 2010a), at which two views emerged. In the light of those discussions, and discussions at the Workshop, two proposals were put forward at the workshop: (1) $MSYR_{1+}=r_0/2$ (Butterworth and Best, 1990); $MSYR_{1+}= r_0/1.619$ as follows from the age-aggregated Pella-Tomlinson population model with MSYL=0.6*K*, which is used frequently in the Scientific Committee. However, the basis for these inferences was questioned on the grounds that they failed to take account of more recent work (Cooke, 2007; de la Mare, 2011) on the impacts on the shape of yield curves resulting from environmental stochasticity and predator-prey effects. As an interim approach, the Workshop had agreed to list results based on both assumptions and to revisit the matter at the Annual Meeting in the light of proposed intersessional work by Cooke (see below).

The Workshop agreed that while it had made considerable progress, it was not in a position to develop recommendations for the Scientific Committee on the appropriate range of MSYR rates. In the time available, the Workshop summarised the issues that must be explored more fully during the 2013 Scientific Committee meeting. In summary, these related to three major areas:

(1) the limitations of the modelling approach itself;
(2) the limitations within the approach (e.g. paucity of data); and
(3) the interpretation of the results in the context of the RMP.

Possible areas for further discussion at the Scientific Committee meeting included:

(a) the validity of the assumption that the distribution of r_0/r_{max} is independent of r_{max};
(b) the validity of extrapolating to species with a higher r_{max} than those included in the meta-analysis and how this should be done;
(c) the effect of the r_{max} constraint, uncertainty in r_0 and the variability in fecundity;
(d) sample size limitations;
(e) use within the RMP; and
(f) reference component of the population to which MSYR applies.

The Workshop finally noted four areas of work that, if able to be completed, would assist discussions at the 2013 Annual Meeting.

(1) Cooke agreed to explore further the plausible parameter space for the model in Cooke (2011), with a view to determining the plausible range of variability in survival.
(2) de la Mare agreed to investigate use of his individual based model (de la Mare, 2013) to examine the relationship between variability in reproduction and survivorship further.

Table 3

Summary of the values for the reference case to be used in the meta-analysis. The values in bold-underline typeface are taken from estimates pertain to the stock in question; other values are assigned from stocks of the same species listed in Table 2.

	r_0 (%) (SE)	Year-span	r_{max}	$\tilde{\sigma}_f$	$\tilde{\rho}_f$
Blue whale					
Central N Atlantic	9.0 (3.83)	15	0.114	0.380	-0.181
Southern Hemisphere	8.2 (3.37)	26	0.114	0.380	-0.181
EN Pacific	3.2 (1.4)	16	0.114	**0.380**	**-0.181**
Fin whale					
N Norway	5 (9.95)	11	0.114	0.765	0.636
EN Pacific	4.8 (3.24)	15	0.114	0.765	0.636
Humpback whale					
W Australia	10.1 (4.69)	13	0.103	0.135	0.320
E Australia	10.9 (0.23)	24	0.103	0.135	0.320
EN Pacific	6.4 (0.9)	12	0.103	**0.135**	**0.320**
Hawaii	10 (3.32)	18	0.103	0.135	0.320
Bowhead whale					
B-C-B	3.9 (0.84)	24	0.043	**0.995**	**0.065**
Southern right whale					
SE Atlantic (S African)	6.8 (0.2)	32	0.076	**0.042**	**0.169**
SW Atlantic (Argentinian)	6.0 (0.28)	40	0.076	**0.308**	**-0.074**
SE Indian (Australian)	6.6 (1.40)	18	0.076	0.042	0.169

Table 4

Outputs from the Bayesian meta-analysis.
Results are shown for the lower 5th and 10th percentiles of the posterior for r_0/r_{max}. For each percentile, results are shown are: (a) r_0/r_{max}, $r_0/r_{max}/2$; and (b) the product of r_{max} and $r_0/r_{max}/2$, for two choices for r_{max}. See SC/65a/Rep05 for the definitions of the sensitivity tests.

	Lower 5th percentile			Lower 10th percentage		
	r_0/r_{max}	$MSYR_{1+} \sim r_0/2$		r_0/r_{max}	$MSYR_{1+} \sim r_0/2$	
r_{max}		0.0426	0.114		0.0426	0.114
Reference	0.396	0.008	0.022	0.490	0.01	0.028
Case						
(a) Sensitivity tests to assumptions						
No environmental effects	0.386	0.008	0.022	0.481	0.010	0.027
common median $\tilde{\sigma}_f$ and $\tilde{\rho}_f$	0.395	0.008	0.022	0.488	0.010	0.028
75% $\tilde{\sigma}_f$ and $\tilde{\rho}_f$	0.431	0.009	0.024	0.524	0.011	0.03
95% $\tilde{\sigma}_f$ and $\tilde{\rho}_f$	0.621	0.013	0.035	0.688	0.015	0.039
No bowhead whale data	0.370	0.008	0.021	0.464	0.010	0.026
No fin whale data	0.412	0.009	0.023	0.506	0.011	0.029
Right whale data only	0.579	0.012	0.033	0.651	0.014	0.037
Independent *M* and *F*	0.414	0.009	0.024	0.508	0.011	0.029
Positive correlation *M* and *F*	0.391	0.008	0.022	0.485	0.010	0.028
Negative correlation *M* and *F**	0.406	0.009	0.023	0.500	0.011	0.028
Based on SC/65a/RMP09&	0.419	0.009	0.024	0.512	0.011	0.029
(b) Sensitivity to specifications for r_{max}						
20% higher fecundity	0.595	0.013	0.034	0.679	0.014	0.039
20% lower fecundity	0.335	0.007	0.019	0.42	0.009	0.024

*Ignoring the data for fin and bowhead whales because the populations do not persist given the assumed levels of variation of natural mortality and fecundity. &New sensitivity test for this meeting.

(3) Cooke agreed to examine the relationship between $MSYR_{1+}$ and $MSYR_{mat}$ in the context of variability in net recruitment.
(4) Punt agreed to conduct a meta-analysis of r_0 values.

The sub-committee thanked Donovan for chairing the intersessional Workshop and the participants for their work during the Workshop and subsequently, without which it would not have been possible to conclude the MSYR review at this meeting.

2.1.2 Progress on intersessional work

As noted above, the Workshop had identified a number of areas of work that would assist discussions at the present meeting. However, given the short time between the Workshop and the present meeting, it was not possible for Cooke to explore further the plausible parameter space using the model of Cooke (2011) or to examine the relationship between $MSYR_{1+}$ and $MSYR_{mat}$ given variability in net recruitment.

SC/65a/RMP09 presented results from the energetic model presented to the MSYR Workshop in SC/F13/MSYR2. The model was used to predict variability in the realised rate of increase (r_0) in a generic depleted whale population given estimates of the variability and autocorrelation in birth-rates. The variability in the model's realised rates of increase is subject to the variability in death rates because the model links deathrates to birth-rates through the energetic requirements of the animals. The results are provided in the form used in the meta-analysis of (MSYR) according to the methods described in Punt (2012). Variability in births and deaths in a population is modelled as a consequence of a variable food supply. The realised rates of increase depend both on the average amount of food available and its variability. A wide range of variations in the food supply was modelled so as to produce a range of variations in birth-rates, deathrates and r_0. The results of the simulations are used in a linear model to predict the variability in r_0 conditioned on given values of variability in birth-rate (σ_f) and its autocorrelation (ρ_f). The procedure for the calculations starts with setting a number of scenarios for the prey population and running a single realisation of the population model for 1,500 years to stabilise the composition of the population so that it is at carrying capacity (*K*) and adapted to each particular prey scenario. The population is then reduced to about 1% of *K* over a 50 year period with a constant harvest rate. This provides a starting point from which the population is allowed to recover from a low level, but only a 10 year period is used so that the results remain consistent with the recovery rate of the stock at low abundance. The numbers of animals alive in each year is used to calculate the rate of increase and its inter-annual variability. The recovery period is repeated 200 times thus giving a total simulated time series of 2,000 years.

The sub-committee thanked de la Mare for conducting these analyses. It noted that the individual-based population dynamics model will be reviewed by the EM group. In discussion, de la Mare noted that variability in demographic rates tended to lead to lower values of MSYL than the 0.6 conventionally assumed in the Scientific Committee.

The sub-committee observed that none of the model runs conducted in SC/65a/RMP09 led to estimates of MSYL that were 0.6 or larger. In addition, Cooke (2007) showed that MSYL was closer to 0.5 than to 0.6 based on simulations in the context of a model with environmental effects for a wide range of parameter values. The Workshop had identified two scenarios for consideration with respect to the relationship between $MSYR_{1+}$ and r_0: $MSYR_{1+}=r_0/2$ and $MSYR_{1+}=r_0/1.619$. The latter scenario corresponds to $MSYL_{1+}$=0.6. Given the results in SC/65a/RMP09 and in Cooke (2007), the sub-committee **agreed** that $MSYR_{1+}= r_0/2$ was more appropriate for drawing inferences regarding the range of MSY rates for use in trials.

A key component of the work over the period of the review had been directed at a meta-analysis of observed rates of increase at low population size. SC/65a/RMP08 provided the results of a final sensitivity test for the Bayesian hierarchical meta-analysis using the data for rates of increase for the 13 baleen whale stocks selected in SC/65a/Rep05. The extent of environmental variation in r_0 as a function of r_0/r_{max} in SC/65a/RMP08 was determined from Equation 2 in SC/65a/RMP09. The lower 5% and 10% points of the posterior predictive distribution for r_0/r_{max} for an unknown stock for this sensitivity test were 0.419 and 0.512 respectively. SC/65a/RMP02 constructed a posterior predictive distribution for an unknown stock for r_0 rather than r_0/r_{max}. The lower 5% and 10% points of this posterior predictive distribution were 0.029 and 0.037 respectively.

2.1.3 Discussion and recommendations

The sub-committee recognised the considerable additional work that had been undertaken since the current range for MSYR of 1% to 7% in terms of the mature component of the population was selected in 1993 (IWC, 1994). In particular, since 2007, the Committee had *inter alia:*

(1) assembled and evaluated information on rates of increase for stocks at low population size;
(2) explored some of the impacts of environmental effects on r_0 relative to r_{max} and the shape of the yield curve for exploited baleen whales; and
(3) developed a meta-analysis framework to integrate this information, along with information on demographics to derive a probability distribution for r_0 and r_0/r_{max}.

Given the available information and knowledge, the Workshop had explored the sensitivity of the distribution for r_0/r_{max} to a number of factors, including choices of stocks from amongst those for which suitable data were available and to the potential effects of environmental variation on rates of increase (see Table 4). The sub-committee recognised that while the meta-analysis was an important advance, it was inevitably limited for a number of unavoidable reasons and uncertainty over a number of factors including:

(1) the assumption that the distribution of r_0/r_{max} is independent of r_{max};
(2) the effect of the r_{max} constraint;
(3) uncertainty about environmental impacts on r_0;
(4) sample size considerations, including the dependence of the results on estimated rates of increase for well-studied right whale populations and the over-representation of populations recovering in regions where most other large whale populations are also depleted and/or where there are limited, if any, effects from forage fisheries; and
(5) the lack of stocks from species of current interest for the RMP (e.g. minke, sei or Bryde's whales) apart from two fin whale stocks, which hardly contributed to the results because of the high variance of their trend estimates - the analysis thus relied almost exclusively on data from bowhead, right, blue and humpback whales.

In conclusion, despite these uncertainties, the sub-committee **agreed** that it had a better basis to select the range for MSYR for use in trials than when the 1% to 7%

choice had been made in 1993. In deciding to complete the review this year it recognised that this did not mean that additional work should not continue and be periodically reviewed by the Committee, both in a general sense and as part of *Implementations* and *Implementation Reviews*.

Given its importance in terms of meeting conservation objectives, the sub-committee then focused on the lower bound for MSYR for use in trials, based on the assumption MSYR~r_0/2. A number of options was considered when examining the results of the meta-analysis relating to choice of percentile (5% or 10%), the value for r_{max}, and whether the meta-analysis should be based on r_0 or r_0/r_{max}. A broad consideration of the full set of sensitivity tests in SC/65a/Rep05, SC/65a/RMP02 and SC/65a/RMP08, suggests a range of 1% to 2.5% for the lower bound for MSY rate expressed in terms of the age 1+ component of the population (during the RMP development process and to date, MSYR has been expressed in terms of the mature component of the population; the AWMP development process by contrast expresses MSYR in terms of the 1+ component).

Recognising the uncertainties in the meta-analysis and the need for precaution, the sub-committee **recommended** that $MSYR_{1+}$=1% be adopted as a pragmatic and precautionary lower bound for use in trials. The value corresponds to the lower of the two percentiles in table 5 of SC/65a/Rep05, and the lowest of the r_{max} values; all of the point estimates of r_0 used in the meta-analysis correspond to $MSYR_{1+}$ values larger than 1% under $MSYR_{1+}$~r_0/2. In essence, $MSYR_{1+}$=1% is roughly the equivalent of 1.5% $MSYR_{mat}$. This recommendation has the additional practical advantage of unifying the MSYR 'currencies' of the RMP and AWMP processes.

In making this practical recommendation, the sub-committee **recognised** that much remains to be learned regarding MSYR for baleen whales and that the issue of the appropriate range for MSYR should continue to be reviewed as new information becomes available. In particular, should data become available for more species and populations, the meta-analysis should be revisited with a view to making it more representative. The sub-committee **emphasised** in particular the need for information relating to stocks of species of interest for the RMP, including fin, sei, Bryde's and minke whales (although of course information on MSYR is important in assessing the status of all species within the Committee's work). Work should also continue to better understand the impact of environmental variation on MSYR and the biological and ecological processes leading to density-dependence, together with the shape of yield curves and hence the relationship between r_0 and $MSYR_{1+}$. As is already the case, consideration of MSYR for particular species and stocks should also occur during *Implementations* and *Implementation Reviews,* particularly where other information for the stock or species concerned suggests alternative plausible values to those discussed above.

The sub-committee **recommended** that the '*Requirements and Guidelines for Implementations under the RMP*' (IWC, 2012c) be updated as follows.

'2. FIRST INTERSESSIONAL WORKSHOP

Under the list of 6 items under 'Workshop discussions will include the items listed below' add a new number (2) and renumber the subsequent items.

(2) A review of any information relating to MSYR for the particular species and/or *Region* that might cause trials to be developed for $MSYR_{1+}$ outside the general range of $MSYR_{1+}$ 1% to 4% agreed at the 2013 Annual Meeting of the Committee (IWC, 2014 when published). In considering this, the Workshop will take into account the discussions and limitations noted in IWC (2014, pp. will be inserted when known) when this range was agreed, the full text of which will be part of the information supplied to the Workshop."

The sub-committee thanked Brandon, Butterworth, Cooke, de la Mare, Donovan, Kitakado and Punt, as well as other participants of the many intersessional meetings without whom it would not have been possible to complete the MSYR review. Above all, the sub-committee would like to acknowledge the contribution and dedication of the field researchers, whose data, particularly on bowhead, blue, right and humpback whales, collected over periods of up to 40 years, formed the backbone of the meta-analysis and the MSYR review.

2.2 Finalise the approach for evaluating proposed amendments to the *CLA*

The Committee agreed in 2006 that two steps needed to be completed. The first of these was the review of MSY rates, which was completed this year (see Item 2.1) and the second was specification of additional trials for testing the *CLA* and amendments to it. The latter related to modelling the effects of possible environmental degradation in addition to, or possibly replacing, the trials in which *K*, perhaps with MSYR, varies over time. This is because the current changing *K* trials have questionable behaviour when modelling population sizes above *K*. Last year, the sub-committee re-established a working group under Allison (members: Allison, Butterworth, Cooke, Donovan, Punt, Walløe) to develop and run such trials for consideration at this year's meeting. However, Allison reported that there had been insufficient time during the intersessional period to conduct the work.

The sub-committee noted that the EM Working Group had identified a set of possible issues to be addressed using individual-based simulation and other models (see Annex K1, item 3). These issues could form the basis for additional trials to further explore the behaviour of the RMP. The sub-committee re-established the working group under Allison (members: Allison, Butterworth, Cooke, de la Mare, Donovan, Punt, Walløe) to formulate and run trials related to environmental degradation, taking account of the discussions in EM, and report the results to the 2014 Annual Meeting.

2.3 Evaluate the Norwegian proposal for amending the *CLA*

The sub-committee noted that evaluation of this proposal required: (a) completion of the MSYR review; (b) review of the trials conducted in Aldrin and Huseby (2007); and (c) review of additional trials which explore the performance of the RMP given environmental degradation. This year, the sub-committee completed the MSYR review (see Item 2.1), but did not complete the trials related to environmental degradation. In addition, the sub-committee did not have time to review Cooke *et al.* (2007). The sub-committee **agreed** that: (a) Aldrin and Huseby (2007) should be a primary document for SC/65b; and (b) it would not be necessary to have all of the trials related to environmental degradation completed before a decision on amending the *CLA* could be made given the time required to parameterise trials based on individual-based models. It also **agreed** that the *Implementation Review* for North Atlantic minke whales could take place even though a decision had yet to be made regarding the Norwegian proposal to amend the *CLA*.

2.4 Modify the 'CatchLimit' program to allow for variance-covariance matrices

Last year it was noted that the Norwegian 'CatchLimit' program allows variance-covariance matrices for the abundance estimates to be specified. Allison was tasked last year to work with the Norwegian Computing Center during the interessional period to develop a final version of the program for use in trials and for actual application of the *CLA*. Allison reported that the Norwegian version of the *CLA* was used in the trials for western North Pacific minke whales. Some coding issues remain with the Norwegian version of the program. The sub-committee **recommended** that Allison contact the Norwegian Computing Center to attempt to resolve those issues.

2.5 Update requirements and guidelines for conducting surveys and *Implementations*

The RMP's *'Requirements and Guidelines for Conducting Surveys'* (IWC, 2012b) were written when the only realistic paradigm for planning and analysing good sighting surveys was the design-based approach. However, there is now potentially a legitimate alternative to design-based estimates: model-based estimates using spatial modelling (smoothers), which, unlike design-based approaches, also give some basis for limited spatial extrapolation. In addition, many surveys closely resemble design-based surveys, but do not strictly meet the design-based criterion. Last year, the sub-committee recommended that a review covering model-based abundance estimation in theory and practice, and its relation to the design-based approach, be conducted. The review was to provide draft text for inclusion in the *'Requirements and Guidelines for Conducting Surveys'* document. Hedley was contracted to conduct the review, but was unable to complete it on time. The sub-committee looks forward to receiving the review at the 2014 Annual Meeting.

2.6 Update the list of accepted abundance estimates to include western North Pacific common minke whales

The sub-committee **recommended** that the list of accepted abundance estimates be updated using the values provided by the western North Pacific minke whale Working Group (see Annex D1, item 10). However, that working group had been unable to finalise the estimates of abundance; final decisions are to be made at next year's meeting.

2.7 Other business

A number of issues arose during the 'second' western North Pacific common minke whale *Implementation Review* workshop that were of general relevance to the RMP process and require the attention of the Scientific Committee and the sub-committee on the RMP, as follows.

Imbalanced sex ratio in incidental catches

The Workshop confirmed that the RMP specification 3.5, which reduces the catch limit in a *Small Area* to the extent required to ensure that the intended catch of females is not exceeded, was only applicable to the commercial catch for the present trials (IWC, 2012a). However, the generic issue of how to deal with imbalanced sex ratios in incidental catches under the RMP needs to be examined by the Committee. The sub-committee **agreed** to consider this matter at the 2014 Annual Meeting and **encouraged** papers on this topic.

Review of abundance estimates in an RMP context

To avoid difficulties faced in reviewing estimates in the future, the Workshop recommended that the Scientific Committee consider including in its Requirements and Guidelines for *Implementations* and *Implementation Reviews*, a specified set of associated information to be provided along with abundance estimates:

(1) plots showing survey transects (excluding transit legs) with primary sighting positions, together with survey block boundaries, sub-area boundaries, and those parts of the area surveyed that are included when calculating the abundance estimates; and
(2) a table summarising: the number of primary sightings made; the distance searched on primary effort; the size of the open-ocean area included in the survey design; the mean school size and the effective search half-width inputs, together with population estimates output on a block-by-block basis for these surveys.

The sub-committee **endorsed** this recommendation.

Changing survey coverage in time-series of abundance estimates

It is conceivable that proportional coverage might increase in some future surveys. The Workshop agreed that such circumstances would trigger an *Implementation Review*, as it would not be acceptable to input such estimates automatically into the RMP because they would give the *CLA* a false impression of resource productivity that was too large. The sub-committee **agreed** to consider this matter at the 2014 Annual Meeting and **encouraged** papers on this topic.

Use of surveys carried out in different months in the Implementation *process and in actual implementation of the RMP*

The Workshop agreed to include surveys that occurred in different months in simulated applications of the candidate RMP variants (this is conservative in that if a variant is acceptable with these surveys included, it would be acceptable had they been excluded, and the purpose of the trials is purely to determine whether or not different variants are acceptable). The Workshop emphasised that this decision did not imply that such survey results would be acceptable for input in an actual application of the RMP, and recommended that the generic aspects of this matter be discussed by the Scientific Committee. The sub-committee **agreed** to consider this matter at the 2014 Annual Meeting and **encouraged** papers on this topic.

2.8 Work plan

The sub-committee **agreed** that its work plan before the 2014 Annual Meeting would be as follows:

(1) specify and run additional trials for testing the *CLA* and amendments to it (Item 2.2); and
(2) review issues related to model-based methods for abundance estimation (Item 2.5).

The sub-committee **agreed** that its work plan during the 2014 Annual Meeting would be as follows:

(1) finalise the approach for evaluating proposed amendments to the *CLA* (Item 2.2);
(2) evaluate the Norwegian proposal for amending the RMP (Item 2.3);
(3) update the requirements and guidelines for conducting surveys to reflect considerations related to model-based methods for abundance estimation (Item 2.5);
(4) specify how to deal with imbalanced sex ratios in incidental catches under the RMP (Item 2.7);
(5) develop guidelines for handling situations in which survey coverage in time-series of abundance estimates changes over time (Item 2.7); and
(6) consider the use of surveys carried out in different months in the *Implementation* process and in actual implementation of the RMP (Item 2.7).

3. RMP – *IMPLEMENTATION*-RELATED MATTERS

3.1 North Atlantic fin whales

3.1.1 Implementation Review

Appendix 2 provides the report of the pre-meeting to initiate the *Implementation Review*. The sub-committee reviewed the report and **endorsed** its conclusions, recommendations, and work plan. It established an intersessional group convened by Elvarsson (Allison, Butterworth, Donovan, Elvarsson, Gunnlaugsson, Punt, and Witting) to develop revised specifications for the trials.

3.2 North Atlantic minke whales

3.2.1 Review new information

The sub-committee received five papers which had been either been presented to the Special Permit Review or were revised versions of papers which were presented to the Review.

SC/F13/SP17 was first presented to the IWC Scientific Committee in 2008 (Pampoulie *et al.*, 2008). It presents genetic analyses based on samples collected during the Special Permit programme (2003-07) and historical samples (1981-85) collected in Icelandic waters, as well as samples collected off Greenland, in the Norwegian coastal region, in the Barents Sea, in the North Sea and off Spitsbergen, to allow comparisons with other geographical areas and IWC stock boundaries. None of the analyses revealed any pattern of genetic structure among feeding grounds. SC/F13/SP17 also compared geographical regions by pooling samples because Andersen *et al.* (2003) reported genetic differentiation at microsatellite loci for samples collected in four geographical-ecological regions (Iceland, West Greenland, Norway and the North Sea). A hierarchical analysis of molecular variance was performed and no genetic differentiation could be found, which contradicted the results of Andersen *et al.* (2003). Although the results for nuclear DNA markers in SC/F13/SP17 suggested no genetic structure among feeding grounds, two groups of mtDNA haplotypes were detected, but there was no geographical pattern to the groups. These results might suggest the existence of two putative breeding populations on the feeding grounds.

SC/F13/SP20rev used samples presented in SC/F13/SP17 and samples from Norway (2002-04) to perform relatedness analyses. SC/F13/SP20rev demonstrated a high rate of relatedness across the North Atlantic using relatedness analysis based on the likelihood odds score (LOD) and false discovery rate (FDR) methods, suggesting a high dispersal rate, and confirming the conclusion in SC/F13/SP17. The FDR procedure was calibrated to detect most mother-foetus pairs (where relationships were known), while at the same time limiting the number of false-positive determinations (calling two individuals related when they are actually unrelated). Although the combination of several datasets (Norway and Iceland), and the development of relatedness analyses seemed to be promising, SC/F13/SP20rev also reported on the value of access to additional biological information (such as age data) to understand the type of relationship observed, and to correct for false positives. However, additional analyses are needed as only parent-offspring LOD scores have been computed in SC/F13/SP20rev. The half-sibling and first-cousin relationships will be investigated in the current year.

The sub-committee welcomed the information in SC/F13/SP17 and SC/F13/SP20rev. It should be useful for the upcoming *Implementation Review,* and, in particular, the work of the joint AWMP/RMP Working Group on stock structure chaired by Palsbøll.

SC/F13/SP19 is an extension of Christensen *et al.* (1990) using morphometric data from 2003-09. Results from principal component analyses, multivariate analyses of variance, linear discriminant analyses and cluster analyses, suggest that morphometric data from five North Atlantic geographical areas ranging from West Greenland to Norway cannot be regarded as random samples drawn from one uniform distribution. However, the overlap between groups was too substantial to allow a firm conclusion to be drawn concerning the question of isolated breeding stocks versus a large common breeding pool. The Review Panel made several recommendations for revisions to these analyses and suggestions for new analyses. While there has not been time to complete these yet, the authors aim to present a revised paper during the 2014 *Implementation Review*.

SC/F13/SP18 reported that experiments were conducted to instrument and track the movements of common minke whales on their feeding grounds in Icelandic waters during 2001-10. Most of these constituted a part of the Icelandic research programme on minke whales (SC/65a/SP01). These experiments have led to the monitoring of the movements of six whales, of which three moved out of Icelandic waters during autumn. The start of the autumn migration occured over at least a month, somewhat later than previously assumed. The southbound migration appears to take place in the middle of the North Atlantic far from coastal areas. Signals were received from one minke whale off the west coast of Africa in early December 2004, 101 days after tagging and 3,700km from the tagging site off southwest Iceland. This study provides the first documentation of the autumn migration route and destination of common minke whales in the North Atlantic. It is noteworthy that none of the nearly 400 positions from eight whales received was outside the North Atlantic Central stock area.

The sub-committee recognised the value of the satellite tracking of minke whales for the development of *Implementation Simulation Trials*. It reiterated the recommendations of the the Special Permit Review that such tagging should continue, as much information as possible should be collected from each tagged individual, and that the results from the various stock definition methods should be integrated. Víkingsson and Pampoulie noted that attempts are made, and will continue to be made, to take biopsies from tagged animals, and that work is already underway to integrate multiple sources of information to resolve stock structure questions (SC/65a/SD02).

The sub-committee **agreed** that data from satellite tracking could be used in *Implementation Simulation Trials* both qualitatively (e.g. identification of breeding grounds and broad migration patterns) as well as quantitatively (e.g. estimation of movement and dispersal rates). The sub-committee noted there would be benefits to identifying the analysis methods to apply to data from satellite-tagged animals to determine the minimum number of animals needed for meaningful quanitative estimates and the point at which tagging additional animals leads to minimal additional information. If such analyses methods are developed, they should be reviewed by the Stock Definition group.

SC/F13/SP06 noted that the main objective of the aerial survey component of the Research program was to obtain a seasonal profile of relative abundance in coastal Icelandic waters with off-season survey effort. Mid-summer surveys in this area have been used to obtain absolute abundance estimates. Observers have to concentrate on the area closest to the plane during mid-summer surveys, but in some cases observer detection functions did not confirm that, or there were too few duplicates with the independent observer. This could result in large differences in the estimated abundance by observer. The number of sightings can be very low in the off-season surveys, and fitting a detection function to these sightings is not an option. Therefore, the consistency of the left and right observers and consistency in repeated coverage of the same area was first checked. It was found that the number of minke whales sighted was fairly consistent between repeats and observers. The detections of the smallest whales are more variable by observer, and inversely related to sightings of large whales. Consequently, an encounter rate with covariates for sightability was used for estimating relative abundance. Sightings in April-May were very few, but sightings in the autumn are still at about half the level of mid-summer surveys. Surveying later in the season was not considered feasible, and it was anticipated that trackings would provide more valuable information then. Surveys conducted after the off-season surveys have shown much greater variability in the encounter rate of minke whales in different areas and in the area as a whole than the earlier surveys. These recent surveys show a northward shift in the distribution of both minke whales and dolphins. This is in line with observed changes in the area and in the condition of the animals sampled. As the Panel mentions, these data will be revisited when it comes to application of a multispecies model. The recommendation of the Panel 'to model the detection function' does not have a clear benefit, because applying a detection function from a mid-summer survey to a spring survey is in effect just a function of the encounter rate.

3.2.1.1 NEW SURVEYS

SC/65a/RMP10 presented Norway's plans to conduct a new series of annual partial surveys over the period 2014-19 to collect data for a new estimate of minke whale abundance in the northeast Atlantic to be in accordance with the RMP requirements for the provision of abundance estimates at regular intervals. The survey and analytical methods will follow the same procedures as used in the previous survey cycles.

The sub-committee noted that the upcoming *Implementation Review* could lead to changes to the definitions of the *Small Areas*. Øien noted that the boundaries of the original *Small Areas* changed as a result of the 2003 *Implementation Review*, and that the survey strata had been modified to be in accord with the revised *Small Area* boundaries. The sub-committee noted the desire to achieve agreement between survey and *Small Area* boundaries, but **agreed** that an approach has been applied which can address changes in *Small Area* boundaries.

3.2.2 Prepare for 2014 Implementation Review

The sub-committee was informed that the joint AWMP/RMP group chaired by Palsbøll is coordinating discussions and analyses related to using genetics to examine stock structure for the North Atlantic minke whales. The sub-committee reviewed the report of the group (Appendix 3) and **endorsed** its recommendations. It reiterated its recommendation from last year that the work plan for the group (Donovan *et al.*, 2013) be completed, and supported holding an intersessional Workshop to consider stock structure hypotheses for North Atlantic minke whales. The sub-committee received and **supported** a proposal to conduct analyses to support the deliberations of the intersessional Workshop (Appendix 4).

3.2.3 Recommendations

The sub-committee **recommended** that a Steering Group (Walløe [Convenor], Butterworth, Donovan, Palsbøll, Punt, Víkingsson and Witting) be established to co-ordinate planning for the 2014 *Implementation Review*. It **recommended** that a three day pre-meeting be held prior to the 2014 Annual Meeting to ensure that sufficient progress is made on the *Implementation Review*, noting that this *Implementation Review* could be more complicated than previous *Implementation Reviews* because the original *Implementation* was not conducted under the current *'Requirements and Guidelines for Implementations'*.

3.3 North Atlantic sei whales

The decision whether to initiate an implementation is made by the Commission. However, last year the sub-committee established an intersessional group (Víkingsson [Convenor], Hammond, Øien, Palka, Palsbøll, Donovan) with Terms of Reference to review the available data for North Atlantic sei whales in the context of a *pre-Implementation assessment* and provide a report to the 2013 Annual Meeting. Unfortunately, insufficient progress was made during the intersessional period to warrant starting the *pre-Implementation assessment* at this year's meeting. The sub-committee therefore **recommended** that the intersessional group be re-established and progress evaluated at the 2014 Annual Meeting.

3.4 Western North Pacific's Bryde's whales

3.4.1 Prepare for 2016 Implementation Review

Miyashita provided the sub-committee with an update on progress and plans for the 2016 *Implementation Review*. A sighting survey was conducted between 30°N-40°N, 130°E-170°E (a part of sub-area 1 for the western North Pacific Bryde's whales) during 2012. 132 primary sightings of Bryde's whales were recorded and 42 Bryde's whales were biopsied. A sighting survey will be conducted in sub-areas 7 and 8 for the western North Pacific minke whales in 2013, and sightings of Bryde's whales will be recorded and biopsies obtained. POWER cruises will take place in 30°N-40°N, 160°W-135°W in 2013 and in 30°N-40°N, 170°W-160°W in 2014. Sightings data will be collected during these surveys and attempts will be made to biopsy Bryde's whales. Thirty-four genetic samples of Bryde's whales were collected during JARPN II cruises in 2012 and additional genetic samples will be collected during the 2013 JARPN II cruises.

3.5 Work plan

The sub-committee **agreed** that its work plan before the 2014 Annual Meeting would be as follows.

(1) Determine the final trial specifications for the northern Atlantic fin whales including framework and developing new trials (Item 3.1).
(2) Condition and run all the North Atlantic fin whale trials specified by the Steering Group, including all remaining original trials as well as new trials using the Norwegian version of the *CLA* (Item 3.1).
(3) Hold an intersessional meeting with objectives to review the results of conditioning and trials for the North Atlantic fin whales specified by the Steering Group, to modify the trial specifications if necessary, and determine an intersessional work plan to ensure that the *Implementation Review* can be completed at the 2014 Annual Meeting. There will be costs involved for travel and subsistence, estimated at £4,000 (Item 3.1).
(4) Evaluate the extent of dispersal needed to achieve management goals for North Atlantic minke whales given uncertainty in stock structure and relate this genetic sample sizes (Item 3.2).

(5) Hold an intersessional joint AWMP-RMP meeting on stock structure hypotheses for North Atlantic minke whales (see also IWC, 2013c, p.108). There will be costs involved for travel and subsistence, estimated at £10,000 (Item 3.2).

The sub-committee **agreed** that its work plan during the 2014 Annual Meeting would be as follows.

(1) Continue the *Implementation Review* for North Atlantic fin whales (Item 3.1).
(2) Begin preparations for a focused basin-wide stock structure study for North Atlantic fin whales to be completed in time to inform the next *Implementation Review* (Item 3.1).
(3) Start an *Implementation Review* for North Atlantic minke whales (Item 3.2) starting with a three day pre-meeting before SC/65b (Convenor: Walløe) (Item 3.2).
(4) Review the information available for North Atlantic sei whales in the context of a *pre-Implementation assessment* (Item 3.3).
(5) Review new information on western North Pacific Bryde's whales (Item 3.4).

4. CONSIDERATION OF CANDIDATES FOR CMP (CONSERVATION MANAGEMENT PLANS)

The sub-committee had no candidates for Conservation Management Plans.

5. ADOPTION OF REPORT

The Report was adopted at 14:01 on 11 June 2013. The sub-committee thanked Punt for his customarily indefatigable rapporteuring and Bannister for his excellent Chairmanship.

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Appendix 1

AGENDA

1. Introductory items
    - 1.1 Convenor's opening remarks
    - 1.2 Election of Chair and appointment of rapporteurs
    - 1.3 Adoption of Agenda
    - 1.4 Available documents
2. Revised Management Procedure (RMP) – general issues
    - 2.1 Complete the MSY rates review
        - 2.1.1 Report of the intersessional Workshop
        - 2.1.2 Progress on intersessional work
        - 2.1.3 Discussion and recommendation
    - 2.2 Finalise the approach for evaluating proposed amendments to the *CLA*
    - 2.3 Evaluate the Norwegian proposal for amending the *CLA*
    - 2.4 Modify the 'CatchLimit' program to allow for variance-covariance matrices
    - 2.5 Update the 'Requirements and Guidelines for Conducting Surveys and *Implementations*'
    - 2.6 Update the list of accepted abundance estimates to include western North Pacific common minke whales
    - 2.7 Other business
    - 2.8 Work plan
3. RMP – *Implementation*-related matters
    - 3.1 North Atlantic fin whales
        - 3.1.1 *Implementation Review*
    - 3.2 North Atlantic minke whales
        - 3.2.1 Review new information
            - 3.2.1.1 New surveys
        - 3.2.2 Prepare for 2014 *Implementation Review*
        - 3.2.3 Recommendations
    - 3.3 North Atlantic sei whales
    - 3.4 Western North Pacific's Bryde's whales
        - 3.4.1 Prepare for 2016 *Implementation Review*
    - 3.5 Work plan
4. Consideration of candidates for CMP (Conservation Management Plans)
5. Adoption of Report

Appendix 2

REPORT OF THE PRE-MEETING ON THE *IMPLEMENTATION REVIEW* FOR THE NORTH ATLANTIC FIN WHALES

1. INTRODUCTION

1.1 Opening remarks
Donovan welcomed the participants to Jeju and thanked the Government of Korea for providing excellent facilities. He noted that the purpose of the pre-meeting was to begin work on the *Implementation Review* for North Atlantic fin whales. The RMP states that:

> 'An *Implementation Review* for a species and *Region* should normally be scheduled no later than six years since the completion of the previous *Implementation (Review)*. In some cases an *Implementation (Review)* may require the specification and running of further *Implementation Simulation Trials*, especially when major changes to *Management Area* boundaries or the selection of different options for *Catch-capping* and/or *Catch-cascading* than those currently used is contemplated. In such cases the *Implementation Review* would probably not be completed at a single meeting.'

The purpose of such a review is therefore to examine any new information available (including catch and abundance) and determine whether the existing trials (and by extension hypotheses) are adequate, whether further trials are necessary or whether some existing trials are no longer required. The pre-meeting began on 1 June 2013 and continued into 2 June. The list of participants is given as Adjunct 1.

1.2 Election of Chair and appointment of rapporteurs
Donovan was elected Chair. Butterworth, Punt and Witting acted as rapporteurs, with assistance from the Chair.

1.3 Adoption of Agenda
The adopted agenda is given as Adjunct 2.

1.4 Documents available
The documents available to the meeting were SC/65a/RMP01, SC/65a/RMP03-05, together with relevant documents and extracts of the reports from past meetings.

2. SUMMARY OF THE RESULTS OF THE INITIAL *IMPLEMENTATION*

The original *Implementation* began in 2007 and was completed in 2009. Details of the final trials specifications can be found in IWC (2010). The final conclusions were developed at the 2009 Annual Meeting.

In summary, the Committee concluded that several variants (1, 3, 4, 5, 6) were all 'acceptable without research', but variant 2 had 'unacceptable' performance for some of the trials, all related to stock structure Hypothesis IV. In terms of catch-related performance, the Committee noted that variant 2 gave, by an appreciable margin, the best catch-related performance over the trials as a whole. Iceland indicated that they wished to pursue the option of presenting a research programme to the Committee that would allow variant 2 to be classified as 'acceptable with research'. Subsequent simulation runs had shown that this was acceptable in principle.

In 2010 however, comparison of results from different versions of the *CLA* revealed that variant 3 (which had the next best catch performance) did not have 'acceptable' performance for some of the trials and could no longer be considered to be acceptable without research, but was rather 'acceptable with research', when the 'Norwegian version' of the *CLA* code was used. The Committee had recommended that in future only the Norwegian version of the *CLA* should be used when conducting future trials; it had also been recommended that the existing trials should all be rerun using that version.

Subsequent to those discussions, Icelandic scientists worked simultaneously on developing a research programme and on examining existing marking data to investigate the validity of Hypothesis IV, including the running of additional trials. Discussion of this can be found in recent Committee reports and forms an important component of discussions under Item 3.3 below.

3. REVIEW OF NEW INFORMATION

3.1 Stock structure and movements
3.1.1 Existing hypotheses
The 2009 *Implementation* considered seven stock structure hypotheses and seven sub-areas (see Fig. 1). One of these (Hypothesis VII) was considered to be low plausibility, and trials based on this hypothesis were not used to select among RMP variants. The final stock structure hypotheses on which recommendations for RMP variants were based were:

(I) *Four stocks with separate feeding areas*. There are four stocks with the central 'C' stock divided into 3 sub-stocks. The 'W' stock feeds in the EC and WG sub-areas, sub-stock 'C1' in the EG sub-area, sub-stock 'C2' in the WI sub-area, sub-stock 'C3' in the EI/F sub-area, stock 'E' in the N sub-area, and stock 'S' in the Sp sub-area.

(II) *Four stocks with 'W' and 'E' feeding in the central sub-areas.* There are four stocks with the central stock divided into 3 sub-stocks. The 'W' stock feeds in sub-areas EC, WG, EG and WI, sub-stock 'C1' in sub-area EG, sub-stock 'C2' in sub-area WI, sub-stock 'C3' in sub-areas EI/F, stock 'E' in sub-areas WI, EI/F and N, and stock 'S' in sub-area Sp.

(III) *Four stocks with 'C' feeding in adjacent sub-areas*. There are four stocks with the central stock divided into 3 sub-stocks. The 'W' stock feeds in sub-areas EC and WG, sub-stock 'C1' in sub-areas EC, WG and EG, sub-stock 'C2' in sub-area WI, sub-stock 'C3' in sub-areas EI/F and N, stock 'E' stock in sub-area N, and stock 'S' in sub-area Sp.

(IV) *Four stocks without sub-stock interchange*. There are four stocks with the central stock divided into 3 sub-stocks, but there is no interchange between the sub-stocks. The 'W' stock feeds in sub-areas EC and WG; sub-stock 'C1' feeds in sub-areas EC, WG, EG and WI, sub-stock 'C2' in sub-areas EG, WI and EI/F, sub-stock 'C3' in sub-areas WI, EI/F and N, stock 'E' in sub-area N, and stock 'S' in sub-area Sp.

(V) *Four stocks with 'S' feeding in adjacent sub-areas*. There are four stocks with the central 'C' stock divided into 3 sub-stocks. The stocks/sub-stocks feed as in hypothesis I except that stock 'S' feeds in sub-areas N and EI/F in addition to sub-area Sp.

(VI) *Three stocks*. There are three stocks with the central 'C' stock divided into 3 sub-stocks. The 'W', 'C1', 'C2' and 'S' stock/sub-stocks feed as in Hypothesis II. Sub-stock 'C3' feeds in sub-areas EI/F and N.

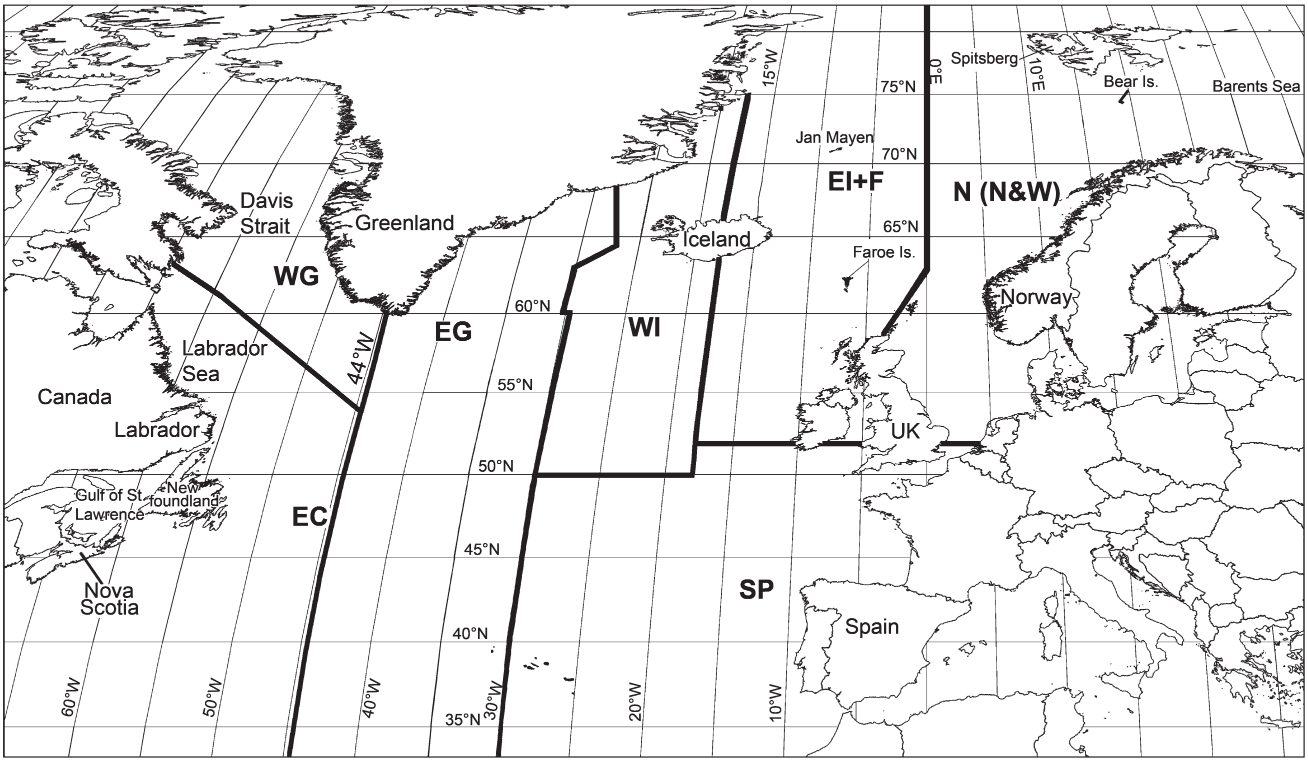


Fig. 1. Map of the North Atlantic showing the sub-areas defined for the North Atlantic fin whales.

Five of these stock structure hypotheses (I, II, III, V, and VI) included dispersal among the sub-stocks which mix in the EG, WI, and EI+F sub-areas (hypothesised sub-stocks[1] 'C1', 'C2' and 'C3'), while Hypothesis IV was based on the assumption that whales from the 'C1', 'C2', and 'C3' sub-stocks mix across the North Atlantic (except the Sp sub-area), but there is no dispersal among sub-stocks. Mixing, in the context of these trials, involves a fixed proportion of a stock (or sub-stock) feeding in a sub-area. While the proportion of a stock feeding in an area is assumed to be constant over time, the specific animals which feed in each sub-area are random from one year to the next. Dispersal between two stocks (or sub-stocks) involves permanent movement from one stock (or sub-stock) to another. It should be noted that dispersal is not the same as gene flow; it is possible for there to be gene flow between two stocks but with no animals moving permanently between the stocks. Dispersal can lead to a 'rescue effect' whereby a 'sub-stock' can be harvested in excess of its natural production, but sustained owing to dispersal into that sub-stock from other sub-stocks.

The extent of mixing had been pre-specified for Hypothesis IV during the *Implementation* primarily for the purposes of exploring behaviour, and the meeting **agreed** that the mixing rates should be estimated rather than being pre-specified if trials based on Hypothesis IV remain (see discussion below). Last year, Gunnlaugsson *et al.* (2012) compared Hypotheses III and IV using likelihood ratio tests and found that Hypothesis III was better supported by the data. However, Gunnlaugsson *et al.* (2012) fitted the operating model under the assumption of a Poisson distribution, rather than a negative binomial distribution, and the estimate of the tag reporting rate was larger than 1 when it was estimated for Hypothesis IV. Gunnlaugsson *et al.* (2012) proposed that their results were sufficient to reject Hypothesis IV and the Committee had referred further examination of this to the present *Implementation Review.* This matter is discussed further below.

3.1.2 New information

SC/65a/RMP01 presented a new method for genetic relatedness analysis based on a three-step procedure. First, LOD scores are computed for three kinds of relationships (half-siblings, parent-offspring, first cousins), *p*-values are then estimated, and finally a False Discovery Rate (FDR) procedure is applied. SC/65a/RMP01 applied this procedure and found relationships among 15 individuals caught during 2009 and 2010 in Icelandic waters (out of the 34,959 pair comparisons), exhibiting various relationships, from grandparent to grandchild, to parent and offspring and half-sibling. One female was found to be related to two other animals. This female was the mother of a male and half-sibling with another female. SC/65a/RMP01 suggested that this new three-step procedure supported by *p*-values should be applicable to additional stock structure issues, in terms of different levels of relationships observed among IWC 'stock boundaries'.

The meeting welcomed this new method and other close kin approaches. The paper was also discussed by the Working Group on Stock Definition and this is reported in Annex I. The meeting noted that parent-offspring relationships change over time and **recommended** further development and application of the method. The value of the method increases with sample size, and the meeting **recommended** that future analyses be based on data for the whole North Atlantic (see recommendation below).

SC/65a/RMP03 summarised the existing genetic stock structure studies performed on the North Atlantic fin whale using a table of information on structure based on allozymes, microsatellite loci and mtDNA. It emphasised the generally low levels of differentiation observed except at some

[1]Note that these sub-stocks are not based on observed genetic differences, but are rather a modelling device to approximate a genetic cline *in extremis*.

allozyme loci. However, Olsen *et al.* (In press) suggested that allozyme patterns at the two most informative loci (MPI and MDH-1) are not detected using DNA, which suggests that the observed patterns at these loci may not reflect genetic drift, migration or even selection. The results based on allozyme studies consequently should be interpreted with caution. SC/65a/RMP03 also summarised estimates of the number of migrants (gene flow) and LOD score, and emphasised the need to further develop these methods in the absence of large genetic differentiation. The authors of SC/65a/RMP03 also emphasised the need for more cooperative work and more effort to combine all available data/samples to better characterise the stock structure of the North Atlantic fin whales.

The meeting noted that in the longer term, new collaborative genetics studies could be used to refine understanding of population structure within the North Atlantic. It **recommended** that focused genetics studies take place based on samples from the entire North Atlantic. Recognising that this was a considerable task it **recommended** that a Steering Group be established (Convenor: Pampoulie, members to include at least Witting, Palsbøll, Skaug) to ensure that this work is developed and completed before the next *Implementation Review.* To improve sample size and geographical spread, it also **recommended** that:

(1) the possibility of obtaining historical samples (e.g. from Norway) should be explored;
(2) existing West Greenland samples should be analysed and samples should be collected from whales harvested off West Greenland wherever possible; and
(3) biopsy samples should be taken during sightings surveys throughout the North Atlantic whenever possible.

The meeting also noted that data on genetic relatedness could be used to estimate abundance. Gunnlaugsson advised that the estimate of abundance which can be inferred from the 11 parent-offspring pairs from the 1980s: 5,600; CV 0.37 (Gunnlaugsson, 2012) is comparable with estimates of abundance from shipboard surveys (although the estimate based on close-kin is less precise).

The meeting **agreed** that the genetics information alone did not warrant changing the existing stock structure hypotheses. It then went on to discuss a broader range of information with a focus on the plausibility of Hypothesis IV.

3.1.3 Stock Structure Hypothesis IV

The meeting noted that all of the stock structure hypotheses were necessarily caricatures of reality. In particular, Hypothesis IV can be considered to be the limit of low dispersal among sub-stocks. Genetic studies performed with microsatellite loci and mtDNA have not revealed any genetic structure among samples collected at several feeding grounds over a period of 20 years (Pampoulie *et al.*, 2008; SC/65a/RMP03). Genetic differences among samples would be expected if there were multiple independent stocks which mix on the feeding grounds in different proportions. However, it was noted that lack of genetic differences among areas would not be inconsistent with lack of permanent movement among stocks if gene flow, but not exchange of individuals, occurs between the stocks.

The breeding areas for fin whales in the North Atlantic are unknown. Hypothesis IV does not suggest where the breeding areas are, but assumes that there are three isolated breeding stocks (‘C1’, ‘C2’ and ‘C3’). Gunnlaugsson commented that: (a) there were no observations indicating separation; and (b) the whales must be breeding in the deep waters of the open ocean with no geographic barriers and there are no suggestions of different breeding times for these ‘sub-stocks’. In addition, he noted that there are no references or data to support a fixed proportional site fidelity in whales and he could not see how this could genetically arise and be maintained in this situation. Although calves are likely to follow their mothers it remains to be explained how they would learn such proportional preferences.

One consequence of a mixing rather than a dispersal hypothesis is that there is no ‘rescue’ effect whereby if, for example, sub-stock ‘C2’ was exterminated, there would be no density-dependent response in the proportion of whales moving to the feeding grounds of sub-stock ‘C2’. The meeting **agreed** that it would be expected that areas which are depleted will eventually be rebuilt through changes in movement behaviour, but that the timescale over which that would take place, though unknown, would be large in the context of Hypothesis IV.

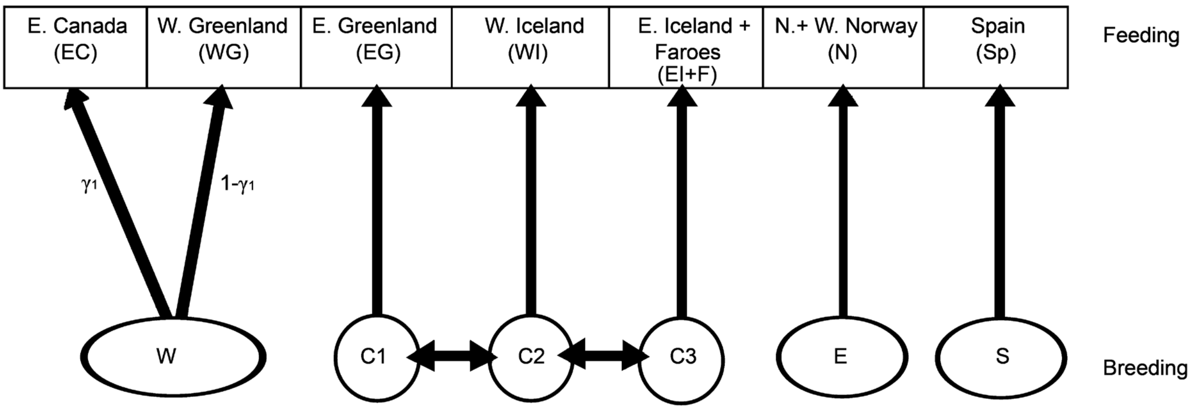
Whales are likely to be found close to where they were the previous year, but over time they would move randomly and gradually into other areas. Temporary site fidelity has been shown for whales in the WI sub-area (Víkingsson and Gunnlaugsson, 2006), consistent with generally gradual dispersal. It was noted that both Hypotheses III and IV relate the dynamics of populations, and neither are explicit about the behaviour of individuals at spatial scales smaller than sub-area. While of interest scientifically, there are likely too few data to enable a model at a fine spatial scale to be developed and parameterised. Gunnlaugsson commented that that by definition Hypothesis IV has no site fidelity across block boundaries and therefore site fidelity within a block would call for animal behaviour to obey arbitrarily drawn blocks.

Tag recoveries in sub-areas EG and WI, as well as in the Canadian marking areas show signs of gradual spatial dispersal (Gunnlaugsson *et al.*, 2012). Gunnlaugsson (2011) presented data on the time trend in the Discovery marking data. The Committee agreed in 2011 that while the patterns in the Discovery marking data were suggestive that Hypothesis IV could be rejected, and recommended further analysis based on *Implementation Simulation Trials*. Gunnlaugsson *et al.* (2012) subsequently showed that the fit of Hypothesis IV was significantly worse than that of Hypothesis III, even then mixing rate parameter in Hypothesis IV was estimated rather than being assumed to be 5%.

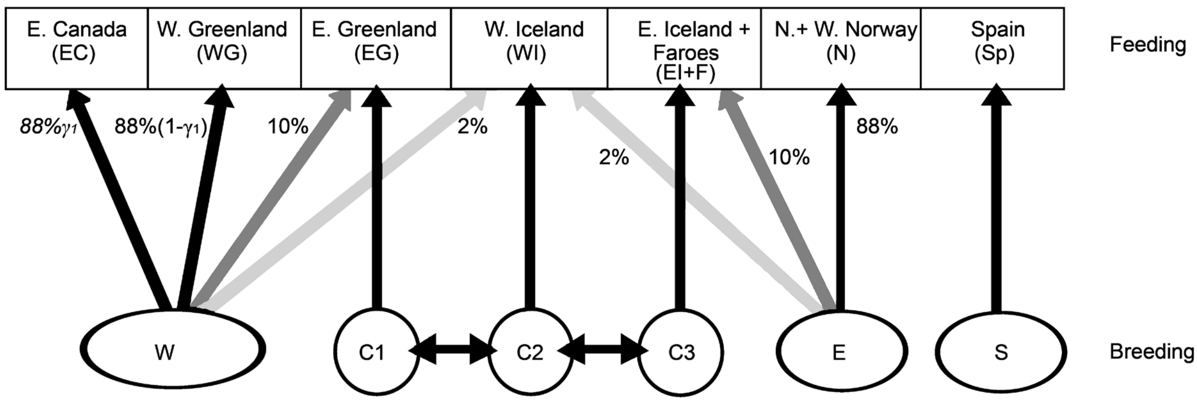
The meeting explored how well Hypotheses III and IV fit the abundance and tagging data when $MSYR_{mat}$ is set to 1%. In contrast to Gunnlaugsson *et al.* (2012), the analysis was based on the assumption of a negative binomial rather than a Poisson recapture process to match the structure of the existing trials. The deviance for Hypothesis III is 10.46 units lower than that for Hypothesis IV, which is statistically significant given that the Hypothesis III model has only one more parameter than the Hypothesis IV model. The mixing proportion for Hypothesis IV is estimated to be 8.4%. Figs. 2 and 3 show the fits to the abundance and tagging data. Although the fits of Hypothesis III are nominally statistically significant better than those of Hypothesis IV at p=0.05, the probable lack of independence of the data means that this is not sufficient to allow Hypothesis IV to be rejected. Hypothesis III fits the data for releases and recaptures in sub-area WI better than Hypothesis III. The reporting rate would be higher than 1 for Hypothesis IV if it was estimated.

Although the results in Figs 2 and 3 indicate a preference for Hypothesis III over Hypothesis IV, most members **agreed** that they are not sufficient alone to reject Hypothesis IV. It was

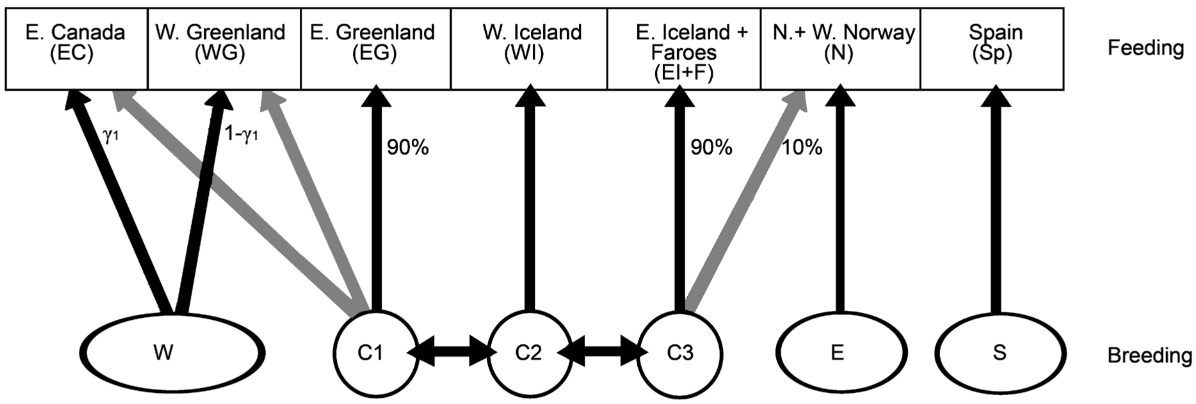
Hypothesis (I). Base case: 4 breeding stocks with separate feeding sub-areas



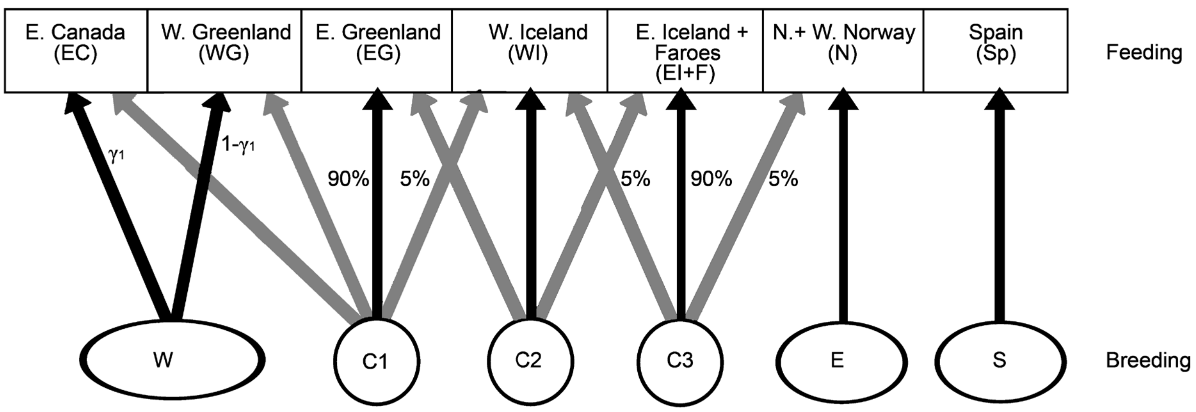
Hypothesis (II). 4 breeding stocks with the W and E stocks also feeding in the central sub-area



Hypothesis (III). 4 breeding stocks with the C stock feeding in adjacent sub-areas



Hypothesis (IV). 4 breeding stocks but without interchange between the C sub-stocks



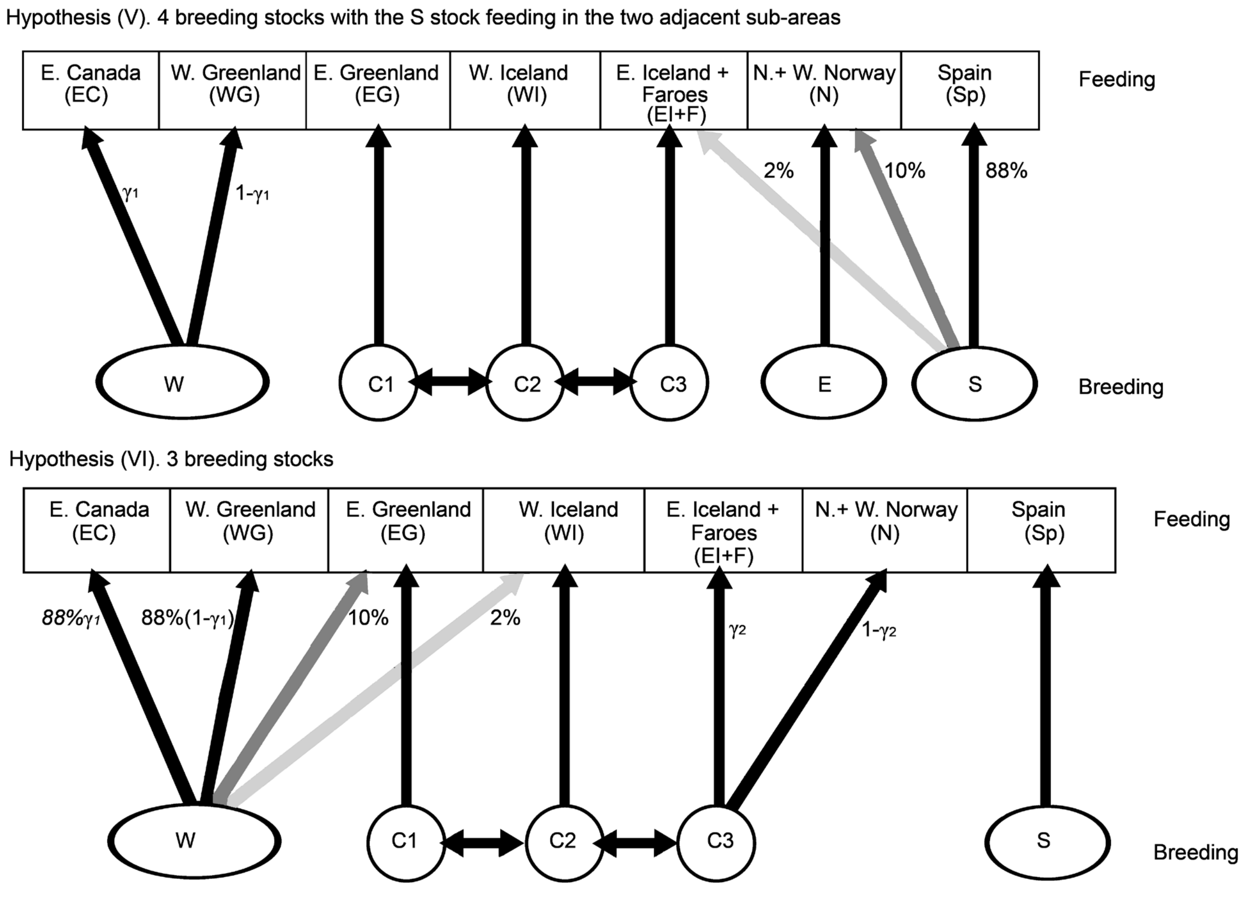


Fig. 2. Stock structure hypotheses for North Atlantic fin whales.

Table 1

Agreed North Atlantic fin whale abundance estimates.

	Variant 6								Variant 2	
	EG+WI+EI/F		WI		EG		EI/F		EG+WI	
Year	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV
1988	14,773	0.1424	4,243	0.229	5,269	0.221	5,261	0.277	9,512	0.1594
1995	21,859	0.1567	6,800	0.218	8,412	0.288	6,647	0.288	15,212	0.1867
2001	25,761	0.1253	6,565	0.194	11,706	0.194	7,490	0.255	18,271	0.1425
2007	21,946	0.1483	8,118	0.260	12,215	0.20	1,613	0.260	20,333	0.1588

noted that during the *Implementation,* all stock hypotheses had been considered 'high' (apart from one hypothesis). The meeting **agreed** that this discussion showed that 'medium' plausibility for Hypotheses IV was appropriate, compared to 'high' for Hypothesis III. However, it noted that in practice this would not change the overall overview of trial results since all trials with $MSYR_{mat}$=1% had been assigned 'medium' plausibility.

3.2 Abundance

The agreed North Atlantic fin whale abundance estimates were compiled in Annex D last year and are summarised in Table 1.

The most recent survey had been carried out in 2007. Regarding future surveys, Víkingsson advised that Iceland's intention was to maintain a six-year cycle as assumed in the *Implementation.* Nevertheless, a decision had been made to conduct the next set of surveys in 2015 rather than 2013. This had been a compromise to fit in with the availability of survey vessels to other states in the North Atlantic so as to be able to carry out a synoptic survey of the whole region.

The meeting recognised the advantage of synoptic surveys. However, it noted that this means that a new abundance estimate (time-stamped 2015) would not be available until 2016. In addition to the phase-out rule implications for catch limits set under the RMP, it was noted that similar circumstances might result in delays in the future. The implications of this for the specification of future *IST*s is discussed under Item 4.

3.3 Catches

Table 2 lists the catches by sub-area and sex from 1864 to 2012.

3.4 Other

SC/65a/RMP04 considered data that had become available following the resumption of whaling on fin whales west of Iceland, which provided an opportunity to compare estimated biological parameters of the stock after three decades without whaling on the stock that followed continuous whaling for over four decades which had ended in four years of extensively studied scientific permit catches.

The comparison showed some large changes. As expected there were more large whales after the pause in whaling, but these whales had a lower pregnancy rate and a higher age at maturity. The predominant sex in the catch had changed from female to male, and there were few young whales in the recent catch together with indications of stunted growth. This implied that there had already been a density-dependant response in the stock. The authors concluded that this would not be expected if the stock was severely depleted with a low MSYR, as assumed in some *IST* scenarios.

The meeting noted that it was important to examine whether the estimated changes were real or perhaps the result of operational changes (e.g. selectivity) or the tempero-geographical differences in the hunt or the animals. Adjunct 3 summarises information on abundance and distribution over recent decades, which Víkingsson developed at the meeting's request. This information points to an expansion of the fin whale distribution west of Iceland into deeper waters over the most recent years, and also to the different estimated rates of increase in different areas, with a higher rate in the West Iceland/East Greenland region compared to the East Iceland/Faroes and Norwegian areas. The Icelandic scientists noted that it was unlikely that operational changes could explain the differences since the operational strategies were largely the same even for the period of special permit whaling.

As an initial basis to assist in the interpretation of the recent estimated changes, particularly with respect to the catch-at-length distributions, reported in SC/65a/RMP04, the meeting requested certain data extractions. The spatial distributions of catches by month over various periods of harvest are shown in Fig. 3. The meeting considered that these did not give evidence of any major changes.

Inspection of the data revealed no indication of differential age-readability by length. The age distributions (see Fig. 4) showed a distinct difference for the most recent period, reflecting a comparatively lower proportion of smaller whales. The meeting agreed that the interpretation of this needed to await the provision of statistics on the implied age distributions of catches from trials under the existing stock structure hypotheses, but also recognised that refinement of the trials might be necessary to be able to reflect these recent estimated changes.

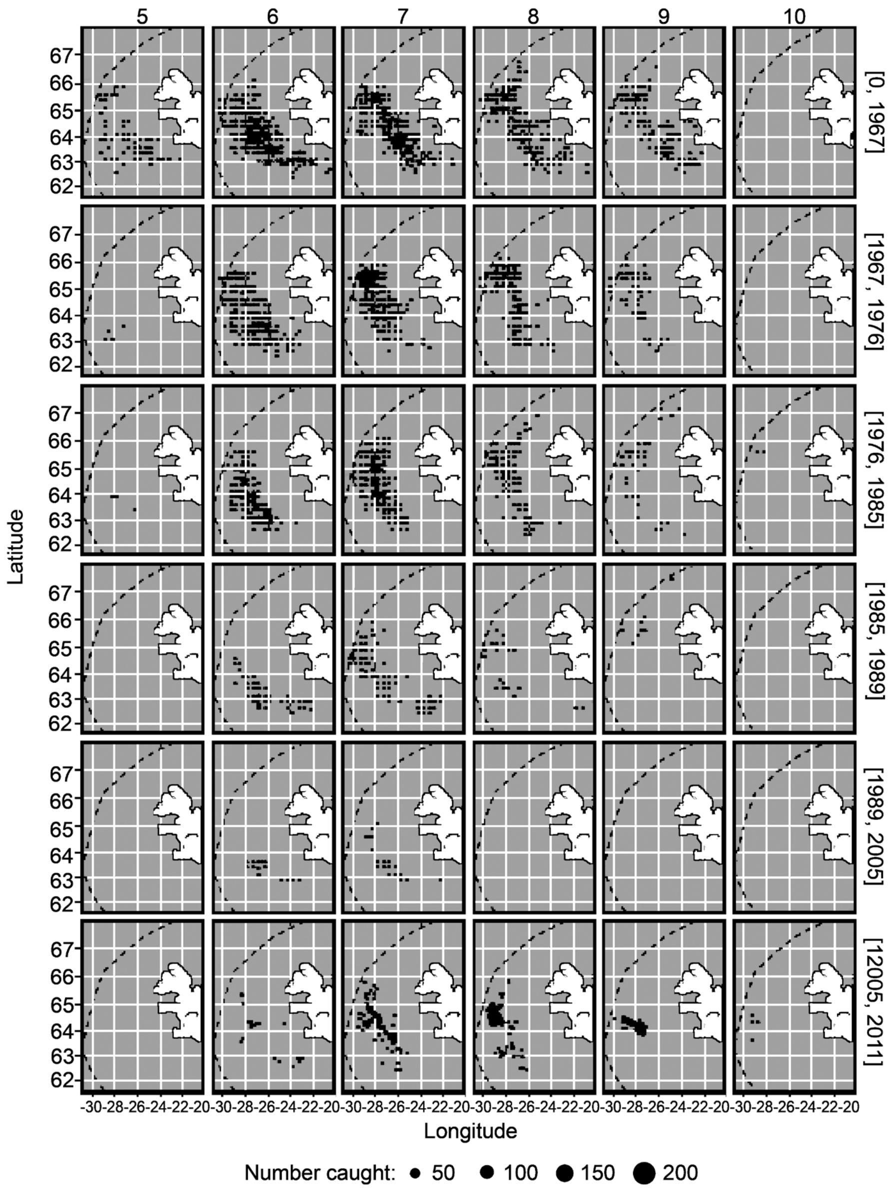


Fig. 3 Spatial distribution of the catch by period.

Table 2

Catches of North Atlantic fin whales by sex and sub-area (the 'Best' series). A ratio of 50:50 males:females is assumed for catches of unknown sex.

Subarea:	EC	EC	EC	WG	WG	WG	EG	EG	EG	WI	WI	WI	EI/F	EI/F	EI/F	N	N	N	Sp	Sp	Sp
Year	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?
1864	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
1865	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
1866	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0
1867	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	0	0	1	0	0	0
1868	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	10	0	0	0
1869	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0
1870	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	0
1871	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	20	0	0	0
1872	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0
1873	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0
1874	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0
1875	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0
1876	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
1877	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0
1878	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0
1879	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52	0	0	0
1880	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	0	0
1881	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68	0	0	0
1882	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	366	0	0	0
1883	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	316	0	0	0
1884	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	338	0	0	0
1885	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	12	8	592	0	0	0
1886	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0	15	22	830	0	0	0
1887	0	0	0	0	0	0	0	0	0	0	0	28	0	0	0	6	14	607	0	0	0
1888	0	0	0	0	0	0	0	0	0	0	0	47	0	0	0	11	10	488	0	0	0
1889	0	0	0	0	0	0	0	0	0	0	0	86	0	0	0	10	7	492	0	0	0
1890	0	0	0	0	0	0	0	0	0	0	0	105	0	0	0	17	19	449	0	0	0
1891	0	0	0	0	0	0	0	0	0	0	0	119	0	0	0	9	21	365	0	0	0
1892	0	0	0	0	0	0	0	0	0	0	0	164	0	0	5	22	22	486	0	0	0
1893	0	0	0	0	0	0	0	0	0	0	0	403	0	0	4	20	9	706	0	0	0
1894	0	0	0	0	0	0	0	0	0	0	0	273	0	0	18	10	12	688	0	0	0
1895	0	0	0	0	0	0	0	0	0	0	0	372	0	0	10	1	4	587	0	0	0
1896	0	0	0	0	0	0	0	0	0	0	0	235	0	0	26	20	16	1015	0	0	0
1897	0	0	0	0	0	0	0	0	0	0	0	329	0	0	33	8	5	595	0	0	0
1898	0	0	103	0	0	0	0	0	0	0	0	249	0	0	49	10	11	649	0	0	0
1899	0	0	116	0	0	0	0	0	0	0	0	389	0	0	61	4	4	371	0	0	0
1900	0	0	99	0	0	0	0	0	0	0	0	425	0	0	86	1	2	385	0	0	0
1901	0	0	135	0	0	0	0	0	0	0	0	532	0	0	204	13	10	474	0	0	0
1902	0	0	235	0	0	0	0	0	0	0	0	485	0	0	295	13	7	620	0	0	0
1903	0	0	449	0	0	0	0	0	0	0	0	322	0	0	835	10	10	217	0	0	0
1904	0	0	897	0	0	0	0	0	0	6	15	234	238	210	770	0	0	318	0	0	0
1905	0	0	598	0	0	0	0	0	0	0	0	202	291	262	930	0	0	329	0	0	0
1906	0	0	354	0	0	0	0	0	0	0	0	151	101	121	743	0	0	132	0	0	0
1907	0	0	466	0	0	0	0	0	0	0	0	131	91	93	1404	0	0	170	0	0	0
1908	0	0	449	0	0	0	0	0	0	0	0	138	428	416	552	0	0	76	0	0	0
1909	0	0	524	0	0	0	0	0	0	0	0	261	528	601	538	0	0	58	0	0	0
1910	0	0	384	0	0	0	0	0	0	10	11	177	474	507	377	0	0	149	0	0	0
1911	0	0	371	0	0	0	0	0	0	10	10	133	410	437	444	0	0	131	0	0	0
1912	0	0	336	0	0	0	0	0	0	0	0	97	209	225	241	0	0	81	0	0	0
1913	0	0	293	0	0	0	0	0	0	0	0	49	237	225	190	0	0	42	0	0	0
1914	0	0	252	0	0	0	0	0	0	10	10	6	283	231	154	0	0	0	0	0	0
1915	0	0	171	0	0	0	0	0	0	20	24	15	131	101	114	0	0	0	0	0	0
1916	0	0	50	0	0	0	0	0	0	0	0	0	48	39	121	0	0	0	0	0	0
1917	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1918	0	0	84	0	0	0	0	0	0	0	0	0	0	0	0	11	10	586	0	0	0
1919	0	0	34	0	0	0	0	0	0	0	0	22	0	0	0	0	0	477	0	0	0
1920	0	0	0	0	0	0	0	0	0	0	0	36	46	68	567	0	0	165	0	0	0
1921	0	0	0	0	0	0	0	0	0	0	0	0	0	0	174	0	0	37	0	0	323
1922	0	0	0	0	0	14	0	0	0	0	0	0	23	21	393	0	0	117	0	0	571
1923	0	0	66	0	0	20	0	0	0	0	0	0	55	41	409	32	29	86	0	0	1,080
1924	0	0	144	34	32	28	0	0	0	0	0	0	59	63	624	0	0	272	0	0	1,218
1925	0	0	270	0	0	30	0	0	0	0	0	0	114	110	316	165	167	0	16	8	1,568
1926	0	0	329	0	0	24	0	0	0	0	0	0	17	21	518	160	136	104	103	129	1,080
1927	92	96	61	0	6	16	0	0	0	0	0	0	168	163	103	190	143	44	83	89	197
1928	134	135	89	0	0	24	0	0	0	0	0	0	166	166	87	230	197	0	0	0	0
1929	164	169	0	0	4	20	0	0	0	0	0	0	89	144	0	137	143	60	0	0	0
1930	153	128	0	0	3	24	0	0	0	91	76	0	102	130	6	246	247	18	0	0	0
1931	0	0	0	154	132	15	0	0	0	1	7	0	0	0	0	130	103	0	0	0	0
1932	0	0	0	32	34	0	1	2	0	101	90	0	0	0	0	205	191	2	0	0	0
1933	0	0	0	13	11	0	25	23	9	159	130	1	52	43	0	211	181	4	0	0	0
1934	0	0	0	0	0	23	0	0	0	48	50	0	34	40	0	70	94	0	41	25	0
1935	44	53	59	9	14	0	0	0	0	0	0	25	36	38	1	45	58	3	0	0	0
1936	78	68	0	6	9	0	0	0	0	26	46	0	40	42	0	72	75	0	0	0	0
1937	0	0	439	2	7	0	6	2	0	185	160	1	91	83	0	173	182	0	0	0	0
1938	0	0	0	4	3	0	0	0	0	55	58	0	108	74	1	139	122	0	0	0	0
1939	62	56	0	1	2	0	0	0	0	66	43	0	73	80	0	134	148	0	0	0	0

Cont.

Subarea:	EC	EC	EC	WG	WG	WG	EG	EG	EG	WI	WI	WI	EI/F	EI/F	EI/F	N	N	N	Sp	Sp	Sp
Year	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?	M	F	?
1940	0	0	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1941	26	39	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0	0	0	0
1942	30	32	0	0	0	0	0	0	0	0	0	0	0	0	0	33	25	0	0	0	0
1943	65	76	0	0	0	0	0	0	0	0	0	0	0	0	0	67	43	0	0	0	0
1944	115	116	0	0	0	0	0	0	0	0	0	0	0	0	0	55	57	0	0	0	38
1945	139	207	0	0	0	0	0	0	0	0	0	0	0	0	30	80	79	0	0	0	36
1946	280	222	0	26	21	0	0	0	0	0	0	0	53	39	2	207	185	0	0	0	42
1947	224	189	0	29	22	0	0	0	0	0	0	0	107	89	0	138	147	0	0	0	111
1948	374	295	1	10	11	0	0	0	0	92	103	0	112	111	0	133	127	0	21	25	132
1949	210	215	0	5	16	0	0	0	0	108	141	0	101	121	0	191	151	0	0	0	69
1950	195	213	0	18	18	0	0	0	0	96	130	0	228	179	2	185	156	1	45	37	0
1951	217	266	0	8	7	0	0	0	0	123	189	0	81	87	1	174	147	0	23	22	27
1952	0	1	0	4	12	0	0	0	0	100	124	0	15	5	0	193	181	0	6	6	129
1953	0	1	0	6	9	0	0	0	0	101	106	0	43	44	0	125	150	0	4	5	49
1954	0	0	0	17	5	0	0	0	0	70	107	0	6	11	0	137	132	1	6	6	114
1955	0	2	0	14	8	0	0	0	0	119	117	0	46	34	0	118	92	0	0	0	134
1956	3	4	0	17	11	0	0	0	0	114	151	0	22	21	0	62	70	0	0	0	34
1957	12	10	1	11	10	0	0	0	0	152	196	0	71	70	0	68	71	0	12	12	39
1958	37	18	0	2	6	0	0	0	0	141	148	0	7	9	0	58	65	0	10	15	12
1959	6	8	0	0	0	0	0	0	0	96	82	0	0	0	0	94	86	0	17	19	18
1960	1	0	0	0	0	0	0	0	0	82	78	0	0	0	0	62	66	0	22	17	85
1961	0	0	0	0	0	0	0	0	0	65	77	0	0	0	0	83	79	0	19	20	120
1962	0	0	0	0	0	0	0	0	0	164	139	0	5	1	0	80	65	0	1	2	47
1963	0	0	0	0	0	0	0	0	0	151	132	0	0	3	0	23	19	0	1	3	15
1964	20	36	1	0	0	1	0	0	0	111	106	0	4	9	0	18	20	0	30	11	18
1965	69	69	3	0	0	1	0	0	0	157	131	0	5	5	0	63	43	0	37	28	90
1966	188	235	4	0	0	0	0	0	0	161	149	0	2	1	1	23	31	0	58	49	0
1967	303	438	4	0	0	0	0	0	0	111	128	0	0	0	0	17	17	0	54	45	0
1968	312	388	0	0	0	3	0	0	0	101	101	0	4	2	0	39	37	0	60	46	0
1969	216	316	1	0	0	0	0	0	0	117	134	0	0	0	0	8	8	0	73	43	0
1970	288	288	2	0	0	0	14	5	0	140	132	0	0	0	0	17	27	0	97	84	0
1971	190	227	1	0	0	0	0	0	0	97	111	0	0	0	0	18	19	0	57	41	0
1972	177	183	0	0	0	1	0	0	0	122	116	0	0	0	0	0	0	0	41	56	0
1973	0	0	0	0	0	2	0	0	0	135	132	0	0	0	0	0	0	0	57	54	1
1974	0	0	0	0	0	5	0	0	0	142	143	0	0	0	0	0	0	0	65	55	0
1975	0	0	0	0	0	1	0	0	0	127	118	0	0	0	0	0	0	0	77	60	0
1976	0	0	0	0	0	9	0	0	0	132	143	0	0	0	0	0	0	0	113	121	0
1977	0	0	0	0	0	13	0	0	0	64	80	0	0	0	0	0	0	0	81	70	0
1978	0	0	0	1	0	7	0	0	0	104	132	0	5	2	0	0	0	0	253	207	208
1979	0	0	0	0	0	7	0	0	0	127	133	0	4	7	0	0	0	0	255	197	110
1980	0	0	0	0	0	13	0	0	0	117	119	1	0	0	0	0	0	0	113	105	0
1981	0	0	0	0	0	7	0	0	0	121	132	1	2	1	0	0	0	0	78	68	0
1982	0	0	0	0	0	9	0	0	0	96	98	0	1	2	0	0	0	0	58	91	1
1983	0	0	0	0	0	8	0	0	0	70	74	0	1	4	0	0	0	0	62	58	0
1984	0	0	0	0	0	10	0	0	0	66	100	1	2	0	0	0	0	0	33	69	0
1985	0	0	0	1	2	6	0	0	0	74	87	0	0	0	0	0	0	0	18	30	0
1986	0	0	0	2	1	6	0	0	0	27	49	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	1	2	6	0	0	0	38	42	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	4	5	0	0	0	0	31	37	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	3	3	8	0	0	0	23	45	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	9	6	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	5	6	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	4	9	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	2	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	10	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	8	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	5	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	1	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	3	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	3	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	5	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	2	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	5	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	1	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	2	6	2	0	0	1	3	4	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	6	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	8	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	1	7	2	0	0	0	67	58	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	5	1	0	0	0	74	68	6	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	0	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

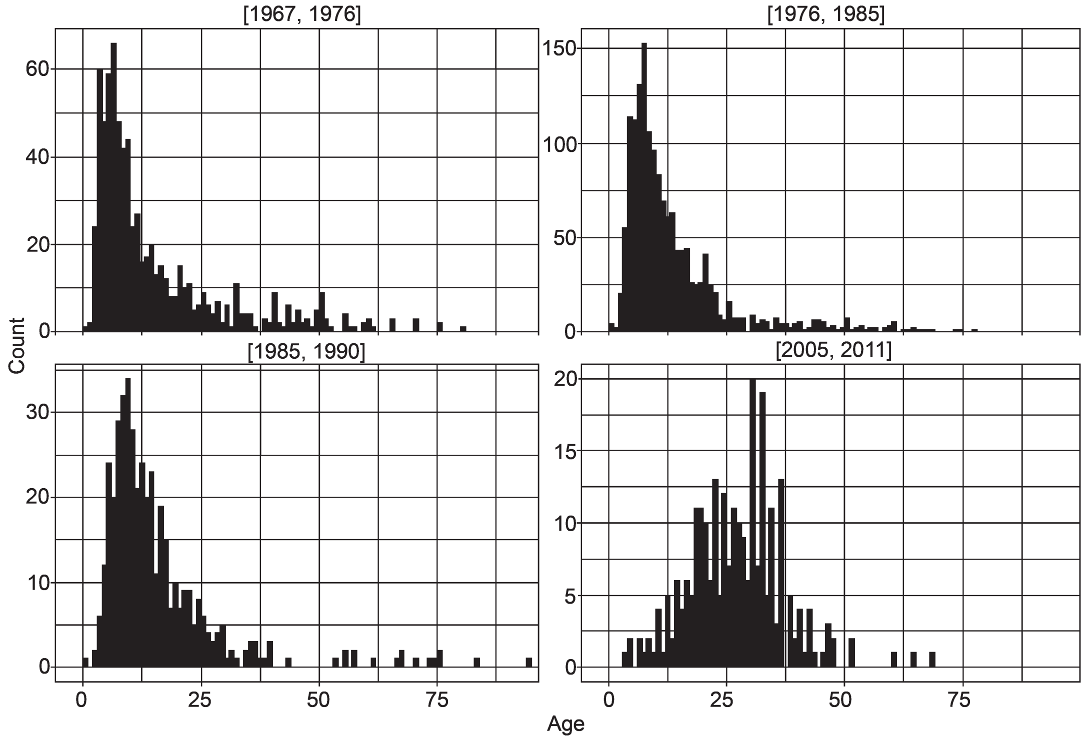


Fig. 4. Age distributions by period.

4. CONSIDERATION OF THE NEED FOR NEW TRIALS (AND THE NEED TO RERUN EXISTING TRIALS)

SC/65a/RMP05 provides the specifications for the most recent version of RMP/AWMP-lite. RMP/AWMP-lite is a platform written in R which implements a framework for evaluating the performance of catch and strike limit algorithms. This framework can be used to evaluate management schemes where multiple stocks of whales are exploited by a combination of commercial and aboriginal whaling operations. The operating models can be conditioned to the actual data to allow an evaluation of whether stock structure assumptions and other hypotheses are comparable with the available data. SC/65a/RMP05 applies the framework for illustrative purposes to data for fin whales in the North Atlantic.

The meeting **agreed** that the set of trials need to be refined as follows.

(1) The mixing rates in trials based on stock structure Hypothesis IV should be estimated rather than being assumed to be 5%.
(2) The operating model should be initialised in a year other than 1864 with a non-equilibrium age-structure.
(3) Allowance should be made for time-dependent movement among sub-areas to better fit the abundance estimates for sub-areas WG and EG (see Fig. 5 of SC/65a/RMP05).
(4) The catch age-composition from the operating model should be output and compared with the observed data. This comparison may suggest that some stock structure hypotheses or choices for $MSYR_{mat}$ are implausible.
(5) Trials should be developed which condition the operating model on the catch age-composition data.
(6) Trials should be developed in which sub-areas EG and WI are combined into a single sub-area given the continuous distribution of sightings between Iceland and East Greenland (see Adjunct 3). Operating models which pool these sub-areas may also fit the recent abundance data better.
(7) Trials which relate to an 8-year survey period.

The meeting established a small group under Elvarsson to begin to develop revised specifications based on the above factors. Progress was made but it was agreed that this work has an iterative component and would need to continue. An intersessional group convened by Elvarsson (Allison, Butterworth, Donovan, Elvarsson, Gunnlaugsson, Punt, and Witting) to develop revised specifications for the trials. The meeting also **agreed** that the trials would need to be reconditioned given that the control program which implemented the earlier trials has been shown to converge to local minima (Elvarsson, 2011). The RMP variants should be implemented using the Norwegian version of the *CLA* code in future trials as previously recommended by the Committee.

The meeting noted that it did not address several issues which are relevant to developing and running trials: (1) the values for $MSYR_{mat}$ – these may be refined as a consequence of the MSYR review; and (2) the need envelope and candidate strike limit algorithms for West Greenland – these will be specified by the SWG on the AWMP.

5. CONCLUSIONS AND WORK PLAN

The meeting **agreed** that the progress made during this meeting should allow the *Implementation Review* to be completed at the next Annual Meeting provided an intersessional Workshop is held. The meeting noted that cost savings could be made if the Workshop was held in conjunction with a proposed intersessional Workshop of the AWMP (see Annex E), given the overlap in some key personnel.

The Workshop proposed the following timetable:

Item	Task	Responsible persons	Date
4	Finalise trial specifications including framework and developing new trials.	Steering Group via email and Skype	Mid-Jul. 2013
2, 4	Condition and run all trials specified by the Steering Group including remaining original trials as well as new trials using Norwegian code.	Allison with assistance from Steering Group	Mid Dec. 2013
4	Review results of conditioning and trials specified by the Steering Group, modify if necessary and determine intersessional work plan to ensure that the *Implementation Review* can be completed at the 2014 Annual Meeting.	2-day intersessional Workshop	Early Jan.
3.1.2	Begin preparations for a focused basin-wide stock structure study to be completed in time to inform the next *Implementation Review* expected around 2020.	Steering Group	2014 Annual Meeting

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Adjunct 1

Participants

Iceland
Bjarki Elvarsson
Thorvaldur Gunnlaugsson
Christophe Pampoulie
Gisli Víkingsson

Denmark
Lars Witting

Secretariat
Cherry Allison
Greg Donovan

Invited Participants
Doug Butterworth
André Punt

Japan
Toshihide Kitakado
Naohisa Kanda

Adjunct 2

Agenda

1. Introduction
   - 1.1 Opening remarks
   - 1.2 Election of Chair and appointment of rapporteurs
   - 1.3 Adoption of Agenda
   - 1.4 Documents available
2. Summary of the results of the initial *Implementation*
3. Review of new information
   - 3.1 Stock structure and movements
   - 3.2 Abundance
   - 3.3 Catches
   - 3.4 Other
     - 3.1.1 Existing hypotheses
     - 3.1.2 New information
     - 3.1.3 Stock structure Hypothesis IV
4. Consideration of the need for new trials (and the need to rerun existing trials)
5. Conclusions and work plan

Adjunct 3

Distribution and abundance of fin whales in the Irminger Sea and adjacent areas 1987-2007

Gísli A. Víkingsson

Fin whale distribution and abundance in Icelandic and adjacent waters has been monitored since 1987 throughout the NASS surveys. During 1987-2001 abundance has increased by 4% p.a. in the EGI area as a whole (see Table 1). Most of this increase has been in the Irminger Sea between Iceland and E-Greenland (the whaling grounds and adjacent areas) where the rate of increase has been 10% (Table 1). The distribution of fin whales in this area has also changed during this period. During 1987 and 1989 distribution was largely confined to the continental shelf areas off W Iceland and E Greenland with low densities in the deep waters between. However, fin whale densities have increased markedly in this deep water area from 1995, so that in the 2001 and 2007 surveys, the area between Iceland and Greenland has been characterised by uniformly high densities (Figs. 1 and 2). Concomitantly sea temperature has increased in this area (Fig. 1) which may have triggered the increase and distribution changes of fin whales (e.g. through increased krill production?).

The abundance estimate from 2007 (TNASS) was slightly lower than the 2001 estimate, albeit not significantly different (Pike *et al.*, 2008). This might indicate that the population expansion/increase has come to an end, perhaps as the stock approached carrying capacity although further monitoring is obviously necessary to confirm that. The observed decrease in APR (Apparent Pregnancy Rates) (SC/65a/RMP04) would be consistent with such a theory.

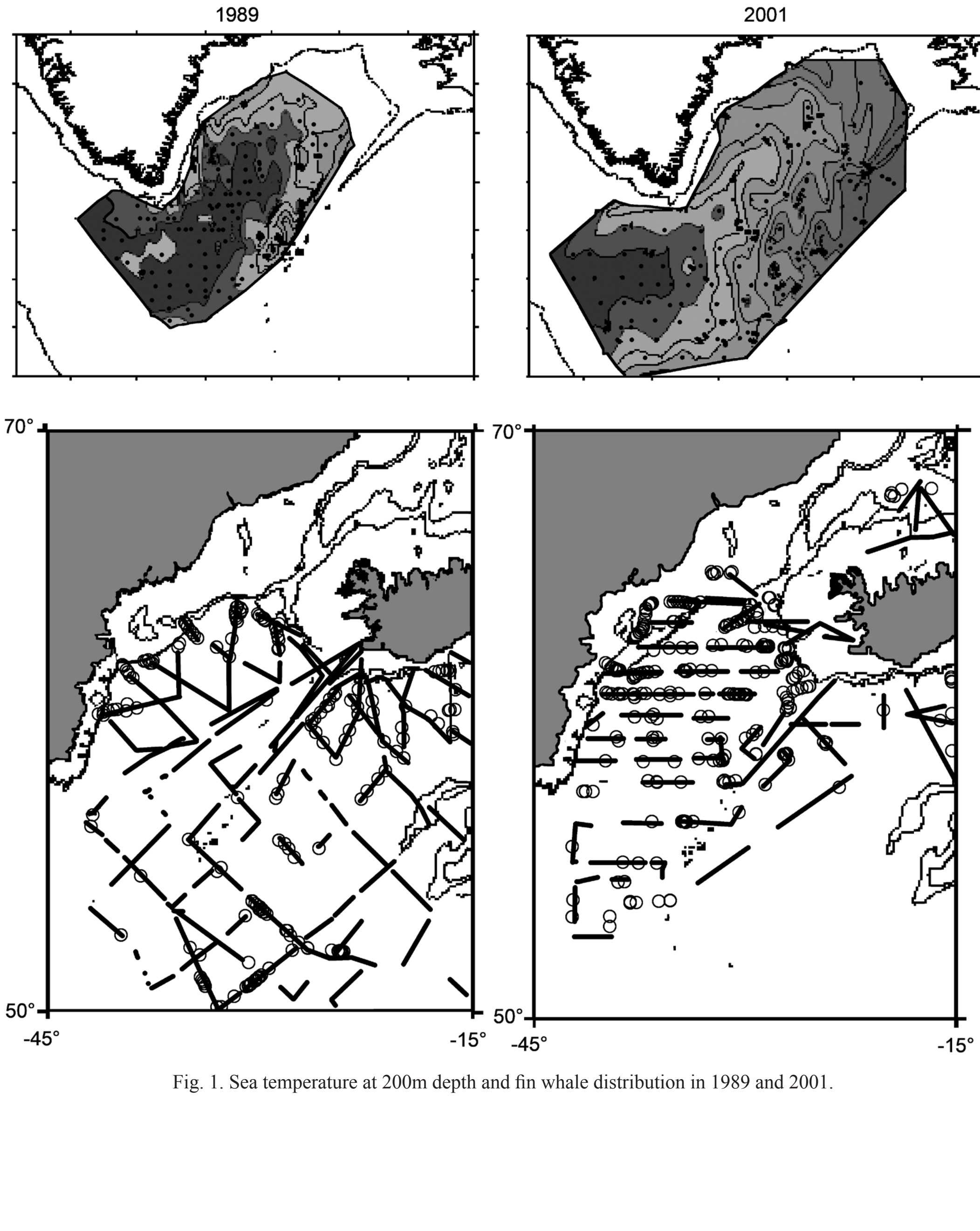

Fig. 1. Sea temperature at 200m depth and fin whale distribution in 1989 and 2001.

Table 1

Abundance estimates and rates of increase for fin whales 1987-2001 (from Víkingsson *et al.*, 2009). *A*=surface area (n.mile^2); *N*=abundance; *D*=density (no./n.mile^2); CV=coefficient of variation for *N* and *D*; *L*, *U*=lower and upper 95% confidence intervals for *N*.

Year	Region	*A*	*N*	*D*	CV	*L*	*U*	Comments
1987	West	192,302	3,607	0.0188	0.18	2,537	5,132	
1989	West	175,185	6,006	0.0343	0.25	3,468	10,401	
1995	West	178,763	13,726	0.0768	0.23	8,667	21,740	
2001	West	191,434	14,021	0.0732	0.18	9,550	20,586	
Growth rate			0.1			0.06	0.14	
1988	EGI	908,077	15,237	0.0168	0.22	9,990	23,239	Includes components of 1987 and 1989 surveys
1995	EGI	623,605	20,262	0.0325	0.21	13,464	30,492	Norwegian – Øien (2003)
2001	EGI	659,192	23,676	0.0359	0.13	18,024	31,101	
Growth rate			0.03			-0.01	0.07	
1988	NOR	231,195	1,242	0.0054	0.38	512	3,009	Øien and Bøthun (2005)
1989	NOR	231,195	1,106	0.0048	0.43	464	2,637	Øien and Bøthun (2005)
1995	NOR	231,195	1,806	0.0078	0.51	576	5,668	Øien and Bøthun (2005)
1998	NOR	231,195	1,723	0.0075	1.09	201	14,734	Øien and Bøthun (2005)
Growth rate			0.05			-0.13	0.26	
1988	Total	1,982,281	17,482	0.0088	0.19	11,981	25,508	Includes components of 1987 and 1989 surveys
1995	Total	1,768,393	26,343	0.0149	0.17	18,754	37,004	Norwegian – Øien (2003)
2001	Total	1,703,020	29,891	0.0176	0.11	24,040	37,167	Norwegian – Øien (2004)
Growth rate			0.04			0.01	0.08	

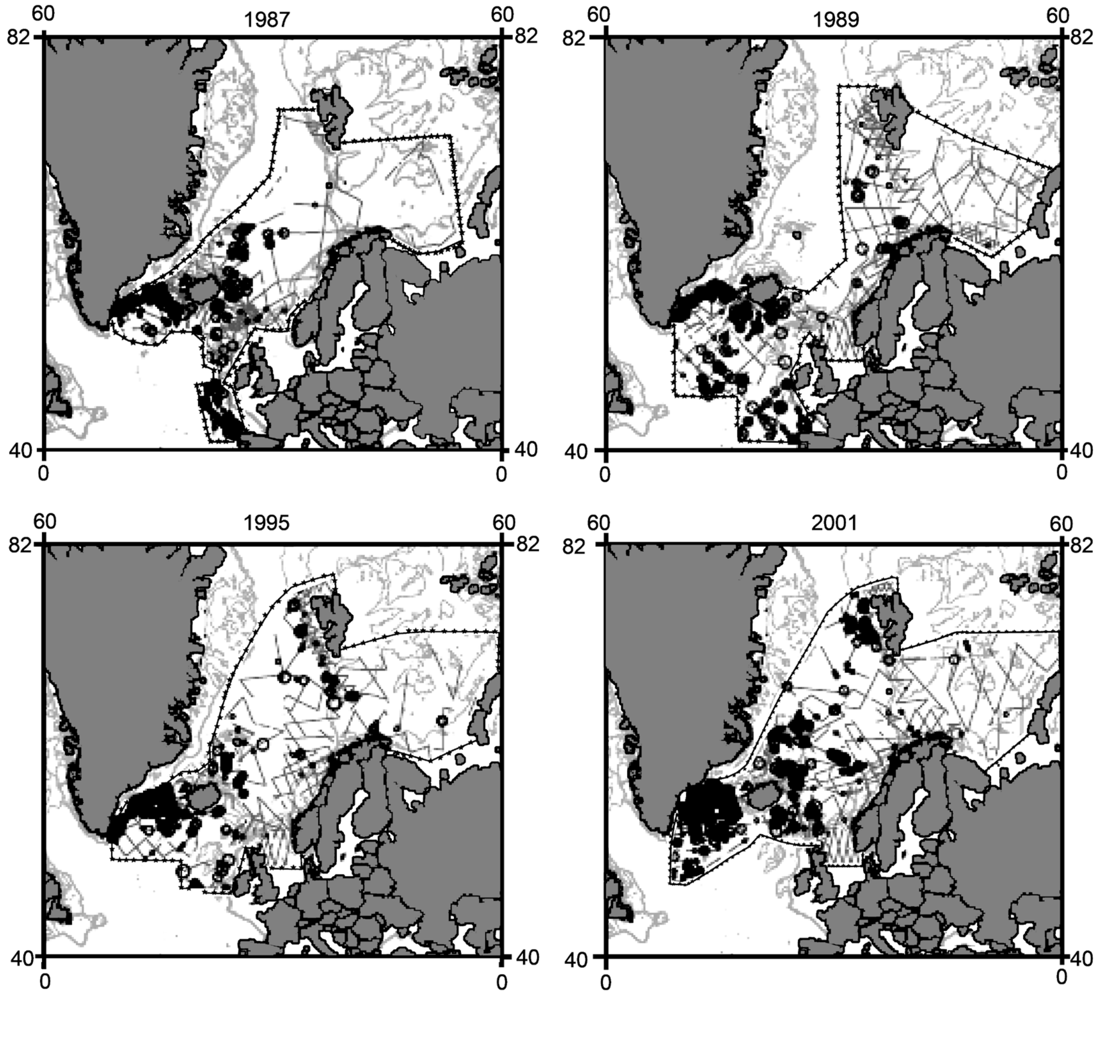

Fig.2. Realised survey effort and sightings of fin whales in NASS ship surveys, 1987 to 2001. Symbol size is proportional to group size from 1 to 4+. The Norwegian sector of the 2001 survey was surveyed from 1996-2001.

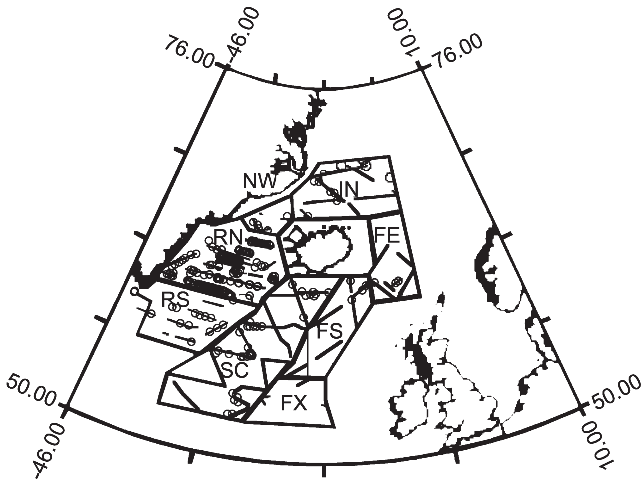

Fig. 3. Sightings of fin whales (High-Medium confidence identification) in the T-NASS Faroese and Icelandic ship surveys. Symbol size is proportinal to group size is proportional to group size in the range 1 to 5.

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Appendix 3

REPORT OF THE NORTH ATLANTIC MINKE WHALE STOCK DEFINITION SMALL WORKING GROUP

Members: Donovan, Gaggiotti, Hoelzel, Pampoulie, Palsbøll, Punt, Skaug, Solvang, Tiedemann, Øien, Víkingsson, Waples and Witting.

The small working group met twice during SC/65a to draft an overall plan to organise and direct the stock structure analyses for the North Atlantic minke whale *Implementation Review*. Four specific items were discussed: (i) designing a simulation experiment to assess data needs for genetic stock identification analyses; (ii) coordinating the generation of new genetic data; (iii) deciding on possible additional non-genetic data generation; and (iv) setting a timetable for simulation experiment, data inventory and generation of genetic data.

1. Simulation experiment to assess expected level of resolution and corresponding data needs for genetic stock analyses

Over the years it has been brought up at multiple occasions during Scientific Committee meetings and inter-sessional workshop and reviews, that identifying stocks from genetic analyses often yield ambiguous results because the values of key parameters at which management recommendations change are not defined. Realising that such 'tipping points' are likely to be case specific it was suggested to use the North Atlantic minke whale as a case study. Such an *in silico* pre-assessment will help the IWC Scientific Committee in two ways; (a) determine which stock hypothesis may be resolved by feasible genetic analyses; and (b) provide an approximate estimate of the amount of genetic data necessary to achieve the required precision. The process consists of two steps.

(1) Conduct demographic simulations for a reasonable range of stock hypotheses and management scenarios to determine the dispersal rates such that management performance is acceptable from a conservation point. After a general discussion a small group (Punt, Skaug, Witting and Pampoulie) outlined the demographic simulations (Appendix I). This first step is anticipated to be completed by the beginning of October, 2013 when a proof-of-concept set of simulations should be made available to a Steering Group.

(2) The second step is to conduct genetic simulations to assess the ability of genetic clustering methods to robustly determine the number of breeding populations and assign individuals to a breeding population. Such simulations will build upon the results from the demographic simulations and require that the critical dispersal rates and population sizes reported by the demographic simulations are converted into the corresponding population genetic entities, typically effective population size (N_e) and gene flow (mN_e). An outline of such genetic simulations is presented in Appendix II. One key issue discussed by the group is linkage among genetic markers. If large numbers of new markers are developed, it will become increasingly untenable to continue to assume that all markers are unlinked. Therefore, it will be necessary to explicitly consider linkage relationships among the markers, although it was noted that for one recommended method (DAPC, Jombart *et al.*, 2010), linkage is accounted for. Provided that initial genetic simulations reveal that some stock structure hypotheses may be addressed by genetic analyses, additional genetic simulations should be undertaken to assess the potential biases due to linkage. The genetic simulations are anticipated to be completed late January 2014.

2. Coordinate the generation of genetic data

During the 2012 Annual Meeting the group decided to aim for a standardised data set consisting of 16 microsatellite loci, mitochondrial (mt) control region DNA sequences and sex for each sample. Work is underway to ensure this level of data in a geographically representative set of genetic samples The Norwegian samples have only been analysed at 10 STR loci, but a small subset (samples from 2003-06) has been genotyped at all 16 loci. The effect of collecting 16 loci for a larger subset of the Norwegian samples will be investigated as part of the genetic simulations.

The group discussed the expected power of this agreed-upon data set in terms of resolving the number of North Atlantic minke whale breeding populations. The data analyses reported so far (based upon 10-16 microsatellite loci and mt control region DNA sequences) have failed to identify more than a single breeding population using both standard statistical tests and genetic clustering methods (i.e. STRUCTURE, Pritchard *et al.*, 2000). However, the applied analytical methods are known to perform poorly when the genetic divergence is below a F_{ST} at 0.03-0.02.

Consequently, *if* the demographic simulations, mentioned above, reveal that the critical dispersal rates are at a level that is likely to yield genetic divergence below 0.02-0.03 then the agreed upon genetic data are likely to be insufficient. As a result the group discussed, in great lengths, the possibility of applying a more recent SNP genotyping method known as ddRAD (double digest Restriction-site Associated DNA, Peterson *et al.*, 2012) sequencing, which is expected to yield approximately 4,000-5,000 SNPs (single nucleotide polymorphisms) genotypes in each analysed sample. Work in model species, such as humans, and in non-model species (orange roughy, Hoelzel, unpublished results) has demonstrated the considerable elevated statistical power of this number of markers. At this level of genotypes per individual many loci will be linked and potentially bias the clustering or the very least the level of statistical confidence of the assessment under some models (i.e. those implemented in STRUCTURE, Pritchard *et al.*, 2000) but not in others (e.g. DAPC, Jombart *et al.*, 2010). Accordingly, as described above and in Appendix II, simulations will assess the impact of linkage.

3. Decide on possible additional non-genetic data generation

The group discussed relatively briefly the use of other, non-genetic, data for stock definition. The group **agreed** that such data, while often insufficient on their own add support to groupings defined by other means. One added complication is that different North Atlantic regions collected different kinds of samples (i.e. lethal versus biopsy sampling), Even for comparable samples, different institutions have collected different data. The group **concluded** that while such data are valuable, generation and standardisation of genetic data should be the primary objective. Non-genetic data should be compiled and made available for the implementation review but the group **agreed** that allocating additional resources to generating new non-genetic data was unlikely to be fruitful.

4. Set a timetable for simulation experiment, data inventory and genetic data generation

The group **agreed** upon the following time table, and point persons.

Demographic simulations
- Point person: Punt.
- Deadline: Beginning of October, 2013.

Genetic simulations
- Point person: Palsbøll (with input from Waples and Gaggiotti).
- Deadline: Late January, 2014.

Generation of genetic data
- 16 STR, mtCR and sex.
- Point persons: Hoelzel, Pampoulie (with Tiedemann), Skaug, Palsbøll and Witting.
- Deadline: late January, 2014.

ddRAD sequencing (provided funding) in 200 samples across the North Atlantic
- Point persons: Hoelzel, Skaug/Glover, Pampoulie/Tiedemann and Palsbøll.
- Deadline: SC/66.

Inventory of available samples and non-genetic data by region, year and type
- Point persons: Øien, Witting, Víkingsson/Pampoulie, Palsbøll and Hoelzel.
- Deadline: October 2013.

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Adjunct 1

Strawperson simulations to evaluate [demographic] dispersal rates

Andre Punt, Christophe Pampoulie, Hans Skaug, Lars Witting

Objective

Identify the levels of dispersal between putative breeding stocks which overcomes uncertainty regarding stock structure uncertainty given management based on the RMP.

Approach

(1) Identify stock structure hypotheses (numbers of stocks [W, C, E] and sub-stocks [??]) and where they are located spatially (including their rates of mixing on the feeding groups when surveys are conducted/catches are taken).
(2) Implement RMP/AWMP-lite based on the sub-areas already specified for the NA minke whales – the involves fitting to time-series of abundance estimates for stock structure hypotheses.
(3) Postulate management scenarios based on possible RMP variants (catch cascading, small areas, including bizarre ones such as 'the E Medium Area is a Small Area and all catches comes from sub-area EB').
(4) Identify a management goal (e.g. final depletion above 0.66*K* for all stocks/sub-stocks).
(5) Repeat steps 2-4 for various levels of dispersal among stocks.
(6) Summarise the results in terms of the relationship between dispersal rate and management scenario.

Workload

(1) Obtain catch and survey time series by sub-area.
(2) Set up AWMP/RMP-lite to match the situation for the NA fin whales.
(3) Condition on existing data (for pre-specified rates of dispersal).
(4) Run the management scenarios.

Adjunct 2

Strawperson simulations to evaluate power and precision of genetic clustering at critical [demographic] dispersal rates

Per Palsbøll, Oscar Gaggiotti, Rus Hoelzel, Robin Waples

Objective

Identify the amount of genetic data necessary to determine the number of breeding population and mixing proportions in management areas at critical demographic rates.

Approach

(1) Rank stock hypotheses based on the output from the demographic simulations (Appendix I) in order of expected difficulty in terms of resolving stocks from genetic analyses.
(2) Convert demographic parameter values (breeding population sizes and annual dispersal rates) into corresponding population genetic parameter values (e.g. effective population sizes and migration rates per generation).
(3) Generate microsatellite (16 loci), mt control region DNA sequence and SNP (up to 5,000 loci) data using coalescent simulations for each specific stock hypothesis starting with the least challenging hypothesis.
(4) Apply clustering method (DAPC) to simulated data.
(5) Repeat steps 2-4 for increasingly challenging stock hypotheses until maximum feasible level of data (e.g. 4,000-5,000 SNPs) and samples is unable to resolve the number of breeding populations.
(6) For stock hypotheses requiring large data sets where linkage among loci is likely, repeat steps 2-4 with explicit modeling of linkage among loci to assess bias (e.g. on genetic estimates and precision).
(7) Summarise and report the results in relation to individual stock hypotheses in terms of data, samples as well as relative proportions of breeding population in each management and the genetic divergence between management areas.

Workload

(1) Decide on conversion factors for census versus effective population size as well as dispersal and gene flow.
(2) Code and set up simulation pipeline.
(3) Run simulations for each stock hypothesis using critical values from demographic simulations.

Appendix 4

PREPARING FOR THE 2014 *IMPLEMENTATION REVIEW*

RELEVANT AGENDA ITEM (NO. AND TITLE)

RMP 3.2.2: Prepare for 2014 *Implementation Review.*

BRIEF DESCRIPTION OF PROJECT AND WHY IT IS NECESSARY TO YOUR SUB-COMMITTEE

Over the years it has been brought up at multiple occasions during Scientific Committee meetings, intersessional Workshops and reviews, that identifying stocks from genetic analyses often yield ambiguous results because the values of key parameters at which management recommendations change are not defined. Realising that such 'tipping points' are likely to be case specific it was suggested to use the North Atlantic minke whale as a case study. Conducting an *in silico* pre-assessment will help the IWC SC in two ways; (a) determine which stock hypothesis may be resolved by feasible genetic analyses; and (b) provide an approximate estimate of the amount of genetic data necessary to achieve the required precision. The proposed process consists of two steps.

(1) Conduct demographic simulations under reasonable range of stock hypotheses and management scenarios to determine the dispersal rates such that management performance is acceptable from a conservation point, outlined in Adjunct I of Appendix 3. This first step is anticipated to be completed by the beginning of October, 2013 when a proof-of-concept set of simulations should be made available to a Steering Group.
(2) The second step is to conduct genetic simulations to assess the ability of genetic clustering methods to robustly determine the number of breeding populations and assign individuals to a breeding population. Such simulations will build upon the results from the demographic simulations and require that the critical dispersal rates and population sizes reported by the demographic simulations are converted into the corresponding population genetic entities, typically effective population size (N_e) and gene flow ($_mN_e$). An outline of the genetic simulations is given in Adjunct 2 of Appendix 3.

While the proposed assessment is specific to the North Atlantic minke whale, the general approach (and software developed) is applicable to all stock hypotheses. Two key advantages of the proposed approach are: (i) identification of stock hypotheses which cannot be resolved with current feasible genetic data and analyses; and (ii) resolve one-stock hypotheses, which is impossible without defining a threshold value for dispersal.

TIMETABLE

Demographic simulations finalised by beginning of October 2013. Genetic simulations by beginning of February 2014.

RESEARCHERS' NAMES

Punt and Palsbøll.

ESTIMATED TOTAL COST WITH BREAKDOWN AS NEEDED (E.G. SALARY, EQUIPMENT)

Salary contributions (Punt and Palsbøll) for period up to 2014 Scientific Committee meeting: £15,000 (incl. benefits and OHs).

Annex D1

Report of the Working Group on the *Implementation Review* for Western North Pacific Common Minke Whales

Members: Hammond (Convenor), Allison, An, Baba, Baker, Baulch, Bell, Bjørge, Brownell, Butterworth, Chilvers, Cipriano, Cooke, de la Mare, de Moor, Donovan, Double, Elvarsson, Funahashi, Gaggiotti, Hakamada, Hoelzel, Iñíguez, Jaramillo-Legorreta, Kanaji, Kanda, Kasuya, Kato, Kelly, Kim, D., Kim, H., Kishiro, Kitakado, Lang, Marzari, Miyashita, Morishita, Murase, Øien, Palsbøll, Pampoulie, Park, J., Park, K., Pastene, Punt, Roel, Sakamoto, Simmonds, Skaug, Tiedemann, Víkingsson, Wade, Walløe, Williams, Yasokawa, Yoshida.

1. INTRODUCTORY ITEMS

1.1 Election of Chair and appointment of rapporteur

Hammond was elected Chair. Punt acted as rapporteur.

1.2 Chair's opening remarks

The Chair reminded the Working Group that the *Implementation Review* should be completed at this year's meeting.

1.3 Adoption of Agenda

The adopted Agenda is given in Appendix 1. An *ad hoc* Working Group was established to begin the initial review of trial results with membership Punt (Convenor), Allison, An, Butterworth, de Moor, Donovan and Miyashita.

1.4 Review of documents

Meeting documents available to the Working Group were SC/65a/NPM01-05 and SC/65a/Rep04 (published in this volume). The attention of the Working Group was also drawn to the Committee's Requirements and Guidelines for *Implementations* under the Revised Management Procedure (RMP) (IWC, 2012b) and to a document describing in more practical detail the steps to be taken to complete the *Implementation Review* (Donovan, 2012).

In addition to these documents, the Working Group looked forward to receiving the summarised results of the *Implementation Simulation Trials*.

2. REPORT OF THE INTERSESSIONAL WORKSHOP MARCH 2013

Donovan (Chair) summarised SC/65a/Rep04, the report of the 'Second' Intersessional Workshop on the *Implementation Review* for Western North Pacific Common Minke Whales. He recalled that, given the complexities of this particular *Implementation Review*, it has not been possible to keep to the normal two-year period. This is termed the 'second' Workshop as it was intended to achieve the objectives of the second Intersessional Workshop specified under the Requirements and Guidelines (IWC, 2012b) even though it is, in fact, the third Workshop.

The Workshop was held at the kind invitation on the Southwest Fisheries Science Center, La Jolla, USA, 19-23 March 2013. The Workshop was intended to be primarily a technical workshop, the objectives of which (IWC, 2005, p.87) were to review the results of work agreed at the 2012 Annual Meeting of the Scientific Committee (IWC, 2013a) and to consider the results of the final trials using the agreed approach that forms part of the *Implementation* process (IWC, 2012b). The ultimate objectives were to develop recommendations for consideration by the full Committee on:

(1) management areas;
(2) RMP variants (e.g. catch-cascading, catch-capping);
(3) suggestions for future research (either within or outside whaling operations) to narrow the range of plausible hypotheses/eliminate some hypotheses; and
(4) 'less conservative' variants(s) with their associated required research programmes and associated duration.

The initial focus of the Workshop was to examine progress made since the 2012 Annual Meeting in relation to the work plan. The Workshop first reviewed a draft of the updated trials specifications. The Workshop agreed a number of technical alterations/clarifications to the specifications. These are briefly summarised below; a full discussion and explanation is given in SC/65a/Rep04.

(1) The first year in which catches are set by the RMP variants is 2013 rather than 2012 and the 2012 Special Permit catches are assumed equal to those for 2011; no reconditioning required.
(2) Modifications to the method for splitting incidental catches in sub-areas 7CS and 7CN between stocks in projections (see SC/65a/Rep04, Annex D).
(3) The RMP 'imbalanced sex ratio rule' applies only to commercial catches in the trials.
(4) An approach was agreed to determine the extent of observation error and future survey abundance estimates (see SC/65a/Rep04, Annex E).
(5) Given present difficulties in age determination, continue to use biological parameter values based on North Atlantic common minke whales.
(6) Agreed to delete as unnecessary trials ABC26-1 and C26-4 (see Allison *et al.*, 2013, and Appendix 2).
(7) Agreed to add a new trial (C31) to test an alternative time-invariant proportion of JE-stock whales in sub-area7CN in Jan.-Jun. to remove bycatch.
(8) The frequency with which simulated future catch limit calculations are performed would change from every five to every six years (given the Commission's move to biennial meetings).

The final list of agreed trials is given as Table 1. The sub-areas referred to are shown in Fig. 1.

The Workshop then focused its discussions on the choice of surveys to be used in trials and the months to which these surveys are to be taken to refer. This followed on from quite extensive discussions at the 2012 Annual Meeting (IWC, 2013b). Discussions at the Workshop were greatly assisted by Allison (2013) and information provided by Japanese and Korean scientists about the surveys. Prior to discussing the abundance estimates the Workshop agreed that any updated survey estimates would not be used in the conditioning, which has consistently used the set of estimates agreed earlier by the Committee.

Table 1

The list of trials. Details of the trials are given in Appendix 2. Trial 24 is assigned low plausibility and so is crossed through.

Stock hypothesis	Trial no.	MSYR	Description
A	A01-1 and A01-4	1% and 4%	Baseline A: 2 stocks (‘J’ and ‘O’); *g*(0)=0.8; including Chinese bycatch.
B	B01-1 and B01-4	1% and 4%	Baseline B: 3 stocks (‘J’, ‘O’, and ‘Y’); *g*(0)=0.8; including Chinese bycatch.
C	C01-1 and C01-4	1% and 4%	Baseline C: 5 stocks (‘JW’, ‘JE’, ‘OW’, ‘OE’, and ‘Y’); *g*(0)=0.8; including Chinese bycatch.
AC	A02-1 etc.	1%/4%	With a ‘C’ stock.
ABC	A03-1 etc.	1%/4%	Assume *g*(0)=1.
ABC	A04-1 etc.	1%/4%	High direct catches and alternative Korean and Japanese bycatch level.
ABC	A05-1 etc.	1%/4%	Some ‘O’ or ‘OW’ animals in sub-area 10E. The mixing matrices will be modified such that the proportion of ‘O’/‘OW’ stock in 10E is ~30% of that in 7CN in all months.
ABC	A06-1 etc.	1%/4%	Mixing proportion in 7CS and 7CN calculated using 2/60 weight for bycatch.
ABC	A07-1 etc.	1%/4%	Mixing proportion in 7CS and 7CN calculated using 10/60 weight for bycatch.
ABC	A08-1 etc.	1%/4%	More Korean catches in sub-area 5 (and fewer in 6W).
ABC	A09-1 etc.	1%/4%	More Korean catches in sub-area 6W (and fewer in 5).
ABC	A10-1 etc.	1%/4%	10% J (/JW) -stock in sub-area 12SW in June (base case value = 25%).
ABC	A11-1 etc.	1%/4%	30% J (/JW) -stock in sub-area 12SW in June (base case value = 25%).
C	C12-1 and 4	1%/4%	No ‘C’ animals in sub-area 12NE.
C	C13-1 and 4	1%/4%	No ‘OW’ in 11 or 12 SW. (‘OW’ and ‘OE’ whales mix with ‘JW’ in 11 and 12 SW in the baseline C trials).
C	C14-1 and 4	1%/4%	No ‘OE’ in 11 or 12 SW.
C	C15-1 and 4	1%/4%	No ‘OE’ in 7WR. (OE and OW whales mix in 7WR from Apr.-Sep., while OW whales are present year round in the baseline C trials).
C	C16-1 and 4	1%/4%	Dispersal rate of 0.005 between the ‘OW’ and ‘OE’ and the ‘JW’ and ‘JE’ stocks.
C	C17-1 and 4	1%/4%	Dispersal rate of 0.02 between the ‘OW’ and ‘OE’ and the ‘JW’ and ‘JE’ stocks.
ABC	A18-1 etc.	1%/4%	Chinese incidental catch=0 (the base case value=twice that of Korea in sub-area 5).
ABC	A19-1 etc.	1%/4%	Alternative abundance estimates in 6E (see table 6a in SC/65a/Rep04, Annex H).
ABC	A20-1 etc.	1%/4%	Additional abundance estimate in 10E in 2007 (see table 6a in SC/65a/Rep04, Annex H).
ABC	A21-1 etc.	1%/4%	Abundance estimate in 5=‘minimum’ value listed in table 6b in SC/65a/Rep04, Annex H, with a CV=0.1.
ABC	A22-1 etc.	1%/4%	Abundance estimate in 5=‘maximum’ value listed in Table 6b in SC/65a/Rep04, Annex H (= 5 *baseline value), with a CV=0.1.
C	C23-1 and 4	1%/4%	Single J-stock (with pure ‘J’ stock definition using 6E (all months)).
~~C~~	~~C24-1 and 4~~	~~1%/4%~~	~~Single O-stock (with pure ‘O’ stock definition using 7WR, 7E and 8 (all months)).~~
ABC	A25-1 etc.	1%/4%	The number of bycaught animals is proportional to the square-root of abundance rather than to abundance (in order to examine the impact of possible saturation effects).
AB	A26-1 etc.	1%/4%	A substantially larger fraction of whales ages 1-4 from ‘O’ stock are found in sub-areas 2R, 3 and 4 year-round (so the proportion of 1-4 whales in sub-area 9 is closer to expectations given the length-frequencies of catches from sub-area 9). The mixing matrices are adjusted such that the numbers of age 1-4 of ‘O’ stock animals in sub-area 9 and 9N are no more than half the base case numbers; juveniles will be allowed into subareas 2R, 3 and 4 in the corresponding months.
ABC	A27-1 etc.	1%/4%	Set the proportion of ‘O’/’OE’ animals of ages 1-4 in sub-area 9 and 9N to zero and allow the abundance in sub-areas 7CS and 7CN to exceed the abundance estimates for these sub-areas. Projections for this sub-area will need to account for the implied survey bias.
ABC	A28-1 etc.	1%/4%	The number of 1+ whales in 2009 in sub-area 2C in any month < 200 (if large numbers of whales were found in 2C, the historical catch would be expected to be much greater).
ABC	A29-1 etc.	1%/4%	Abundance estimate in 6W=‘minimum’ value listed in Table 6b in SC/65a/Rep04, Annex H, with a CV=0.1.
ABC	A30-1 etc.	1%/4%	Abundance estimate in 6W=‘maximum’ value listed in Table 6b in SC/65a/Rep04, Annex H (= 5 * baseline value), with a CV=0.1.
C	C31-1 and 4	1%/4%	Alternative time invariant proportion of ‘JE’ stock whales in 7CN in Jan.-Jun. used to remove bycatch.

The Workshop first considered cases where the 2012 Annual Meeting had indicated acceptability for use in the trials, but only after some further work or checks had been requested. The Workshop agreed the following estimates to be acceptable for use in projections:

(1) sub-area 10E in 2002 - coverage of the planned trackline was sufficient to retain the estimate;
(2) sub-area 7CS in 2004 - the estimate pertained to the northern part of the survey only (sightings from outside this area had been used in estimating mean school size and effective search half-width to increase precision);
(3) sub-area 7WR in 2003 - the estimate pertained to a northern part of the sub-area only, for which adequate survey coverage had been obtained;
(4) sub-area 11 in 2007 - only survey transect lines were used in calculating the estimate;
(5) sub-area 12NE in 1999 - areas used in the abundance computations corresponded only to those parts of the various strata that had been covered effectively by the survey transects achieved; and
(6) sub-area 7W in 1991 – modified at the Workshop to take into account different sighting rates by sub-area.

This process towards the last estimate led to a zero estimate of abundance for sub-area 7CS and the Workshop agreed an approach to dealing with zero abundance estimates for this and other cases (see SC/65a/Rep04, Annex F).

The Workshop then reviewed those estimates for which there had been ‘No agreement’ during the 2012 Scientific Committee meeting regarding their acceptability for use in projections for the *Implementation Simulation Trials*. It agreed that the following estimates were acceptable for use in the trials:

(1) sub-area 6E in 2002 - only the northern part where there was adequate survey coverage had been used for the estimate;
(2) sub-area 11 in 2003 - the estimate referred only to that part of the sub-area that had been surveyed, and sightings and effort on transit legs had not been included in computations;

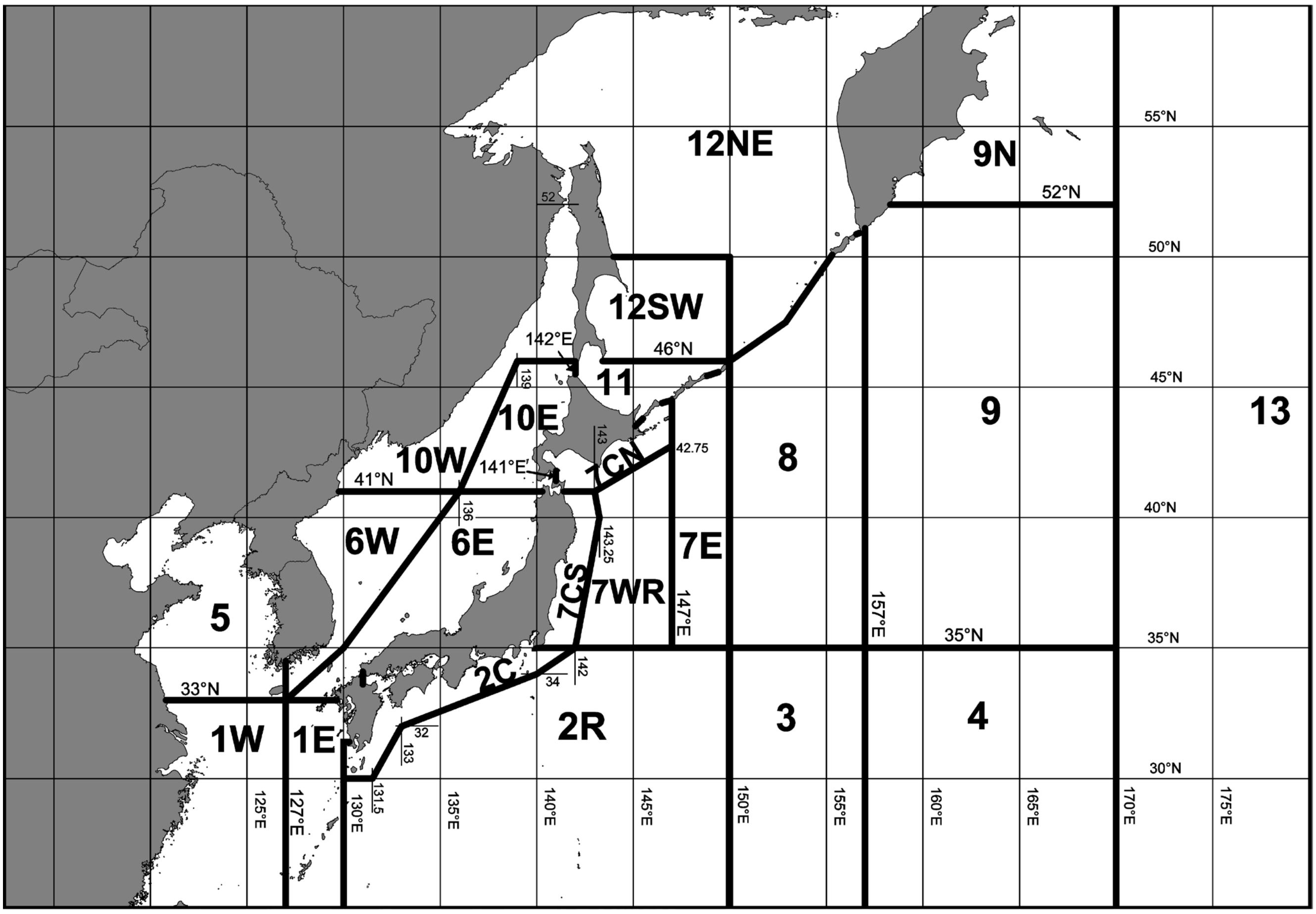

Fig. 1. The 22 sub-areas used for the *Implementation Simulation Trials* for North Pacific minke whales.

(1) sub-area 12SW in 2003 - the estimate referred only to that part of the sub-area over which adequate survey coverage had been obtained; and
(2) sub-area 12NE in 2003 - the estimate included only blocks where survey coverage had been adequate and for the northernmost block only the area covered by the transects completed had been included in the computation.

The Workshop also endorsed updated abundance estimates in Hakamada *et al.* (2013) (that had examined more appropriate survey boundaries in the *Implementation Simulation Trials* in forward projections). The updated summary of agreed abundance estimates is provided in SC/65a/Rep04, Annex G.

More generally, the Workshop noted the difficulties it (and to some extent previous *Implementations*) had faced related to the information that was provided surrounding abundance estimates. In this regard the Workshop had recommended that Miyashita and An develop a document containing a set of plots covering all the western North Pacific minke whale surveys to present at the 2013 Annual Meeting of the Scientific Committee.

To avoid this situation in the future, the Workshop recommended that the Scientific Committee consider including a specified set of associated information to be provided along with abundance estimates in its Requirements and Guidelines for *Implementations* and *Implementation Reviews*:

(1) plots showing survey transects (excluding transit legs) with primary sighting positions, together with survey block boundaries, sub-area boundaries, and those parts of the area surveyed that are included when calculating the abundance estimates; and
(2) a table summarising: the number of primary sightings made; the distance searched on primary effort; the size of the open-ocean area included in the survey design; the mean school size and the effective search half-width inputs, together with population estimates output on a block-by-block basis for these surveys.

The Workshop then turned its attention to the question of future surveys and survey plans. It agreed that the trials would assume that proportional coverage of sub-areas by future surveys would remain fixed at its most recent level. It noted (SC/65a/Rep04, table 2) that for past surveys, there have been instances where this proportional cover had decreased. This is not a problem for the *Implementation Simulation Trials* from a conservation perspective because the effect will be that the trials (and future surveys) reflect an overall abundance that is too low and the *CLA* interprets the apparent past decline in abundance as low productivity. The question of the opposite case (increased coverage leading to apparent increased productivity) was referred to the Scientific Committee (see Annex D, item 2.7). The Workshop noted that if large this case might trigger an immediate *Implementation Review*.

The surveys in the western North Pacific have not all taken place in the same months and the Workshop considered the acceptability of past surveys in relation to the months in which they did take place (the future survey plans of Japan and Korea propose that future surveys in any one subarea will be carried out in the same months). Survey timing is taken into account in conditioning but, in effect, the *CLA* 'expects' that series of abundance estimates by sub-area are comparable over time.

The Workshop agreed to include all agreed surveys including those in different months in simulated applications of the candidate RMP variants (this is conservative in that if a variant is acceptable with these surveys included, it would be acceptable had they been excluded., and the purpose of the trials is purely to determine whether or not different variants are acceptable. The general question as to whether estimates from different months are acceptable for use in an actual application of the RMP was referred to the Scientific Committee (see Annex D, item 2.7).

With respect to variants involving *Combination Areas* where in the past not every sub-area within that *Combination Area* had been surveyed in a given block of years, if the unsurveyed sub-areas made only a relatively small contribution to the *Combination Area* estimate, then they contribute zero to the total estimate which is accepted for input to the computations for the RMP variant concerned. If their contribution to the *Combination Area* should have been large, then computations assume that no abundance estimate is available for that *Combination Area* in the given block of years.

The Workshop then turned its attention to conditioning. Most of the conditioning had been completed and accepted by the Scientific Committee at the 2012 Annual Meeting. Conditioning runs take a considerable time to complete and the Workshop developed a mechanism to review these as they became available prior to the Annual Meeting (see Item 3.2).

Although progress was not sufficient to receive final trial results during the Workshop (many necessary decisions were only able to be taken at the Workshop precluding the possibility of running them), some preliminary results for some trials were available. Review of these led to suggestions to refine (and reduce) the total number of management variants to be considered. The final list of variants is summarised in Item 5.

Given the complexities of the western North Pacific common minke whale *Implementation Review* previously recognised and emphasised at the Workshop, rather than complete its work, the Workshop developed a work plan for the intersessional period aimed at having final results submitted well in advance of the Annual Meeting. Unfortunately, this did not prove possible despite considerable progress being made.

The Working Group **endorsed** the conclusions and recommendations from the Workshop report (SC/65a/Rep04) and expressed its thanks to the Chair, Donovan and all participants for their hard work and progress.

3. PROGRESS SINCE INTERSESSIONAL WORKSHOP

3.1 Update to trial specifications

Allison and de Moor reported on changes to the trial specifications and the code implementing these specifications since the March 2013 Second Intersessional Workshop.

(1) The revised survey plan agreed at the Workshop was implemented (including changes to the control program to allow both input [i.e. observed] and generated abundance estimates to occur in the same year prior to the start of management).
(2) The control program was amended to replace any generated zero abundance estimates with a constant value which depends on the sub-area involved (see SC/65a/Rep04, Annex H, item E). Sub-areas for which a constant value was not evaluated during the Workshop were assigned a default value of 42.
(3) The control program was changed to allow catches from a *Small Area* to be allocated to several sub-areas (the previous version only allowed allocation to a maximum of three sub-areas within a *Small Area*).
(4) The catch series for trials 8 and 9 were created. A large proportion of the catches off Korea are not known by sub-area (i.e. only catches to the west and east of Korea combined are known). The 'Best' catch series allocates these catches to sub-area using the average of the known catches. The catch series for trials 8 and 9 were created using a proportion equal to the average value +/- 20% (retaining the same total catch).
(5) It was found that the large CV (1.199) for the 2006 abundance estimate in sub-area 7CS used in the calculation of the parameter τ (which controls the additional variance associated with the generated estimates of future abundance), led to unrealistically large fluctuations in the abundance estimates generated for this sub-area. This led to the *CLA* being unable to calculate a catch limit for some of the trials. Three potential ways to address this problem were explored:
    (a) no change (RMP variants 1 and 4 could then not be evaluated for some trials);
    (b) ignoring the large CV when calculating τ; and
    (c) replacing the large CV by 0.9 when calculating τ.

The second and third of the options led to similar results. The C trials run were based on option (c) so that a large CV is included in the calculation of τ.

In relation to trials 8 and 9, it was noted that a future *Implementation Review* might wish to examine information on catcher boats by port and/or obtain information from old whalers to inform the split of the combined catches east and west of Korea. Allison noted that the split was done by month to account for temporal differences in where catches were taken.

The Working Group **endorsed** the changes to the trial specifications. Appendix 2 lists the final versions of the trial specifications. The Working Group thanked Allison and de Moor for the enormous amount of work which has been conducted since the Workshop, without which the Working Group would not be in a position to complete its work.

The Working Group noted that the Workshop had identified the following generic issues related to conducting trials which were referred to the RMP sub-committee (see Annex D, item 2.7).

(1) The *Requirements and Guidelines* document should be modified so that a requirement is a document that contains more detailed information related to the surveys to be used in *Implementations*.
(2) What to do when the proportion of the area covered during surveys has changed over time and may change in the future?
(3) Should the RMP variants be provided with survey estimates from different times of the year compared to what is planned for the future during *Implementation Simulation Trials*?
(4) How should imbalanced sex ratios in incidental catches be dealt with under the RMP?

3.2 Review final conditioning results

Some trials had been conditioned since the Workshop. The Working Group noted that this reflected a considerable amount of work and again thanked Allison and de Moor. The Working Group had reviewed the fit diagnostics for the base-case trials and those for many of the sensitivity tests at the 2012 Annual Meeting. Punt reported that he had reviewed the conditioning diagnostics for the trials conducted since that meeting. The Working Group **agreed** that the *ad hoc* Working Group established to review trial results should check the conditioning of any trials that may be influential in the final decisions regarding the selection of RMP variants. The *ad hoc* Working Group **confirmed** that conditioning had been successfully achieved for all influential trials.

4. GUIDELINES FOR REVIEWING RESULTS OF *IMPLEMENTATION SIMULATION TRIALS*

4.1 Overview and procedure to follow

The procedure for defining 'acceptable', 'borderline', and 'unacceptable' performance agreed by the Committee (IWC, 2007) involves conducting the following steps for each stock (or sub-stock) in an *Implementation Simulation Trial* for which $MSYR_{mat}$=1%.

(1) Construct a single stock trial, which is 'equivalent' to the stock. For example, if a particular stock in the *Implementation Simulation Trial* involved carrying capacity halving over the 100-year projection period, the 'equivalent single stock trial' will also involve carrying capacity halving over the next 100 years.

(2) Conduct two sets of 100 simulations based on this single stock trial in which future catch limits are set by the *CLA*. The two sets of simulations correspond to the 0.60 and 0.72 tunings of the *CLA*. Rather than basing these calculations on a single initial depletion, the simulations for each stock shall be conducted for the distribution of initial depletions for the stock concerned in the *Implementation Simulation Trial* under consideration.

(3) The cumulative distributions for the final depletion and for the minimum depletion ratio (the minimum over each of the 100-year projections of a trial of the ratio of the population size to that when there are only incidental catches) shall be constructed for each of these two tunings of the *CLA*.

(4) The lower 5%-ile of these distributions shall form the basis for determining whether the performance of the RMP (i.e. the RMP variant under consideration) for the *Implementation Simulation Trial* is 'acceptable' - A, 'borderline' - B or 'unacceptable' - U, as follows:

(a) if the 5%-ile of the final depletion or the 5%-ile of the minimum depletion ratio for the *Implementation Simulation Trial* is greater than for the equivalent single stock trial with 0.72 tuning of the *CLA* (or the 5%-ile of the minimum depletion ratio for the *Implementation Simulation Trial* is greater than 0.999), the performance of the RMP variant shall be classified as 'acceptable';

(b) if performance is not 'acceptable' and either the 5%-ile of the final depletion or the 5%-ile of the minimum depletion ratio for the *Implementation Simulation Trial* is greater than for the equivalent single stock trial with 0.60 tuning of the *CLA*, the performance of the RMP variant shall be classified as 'borderline'; and

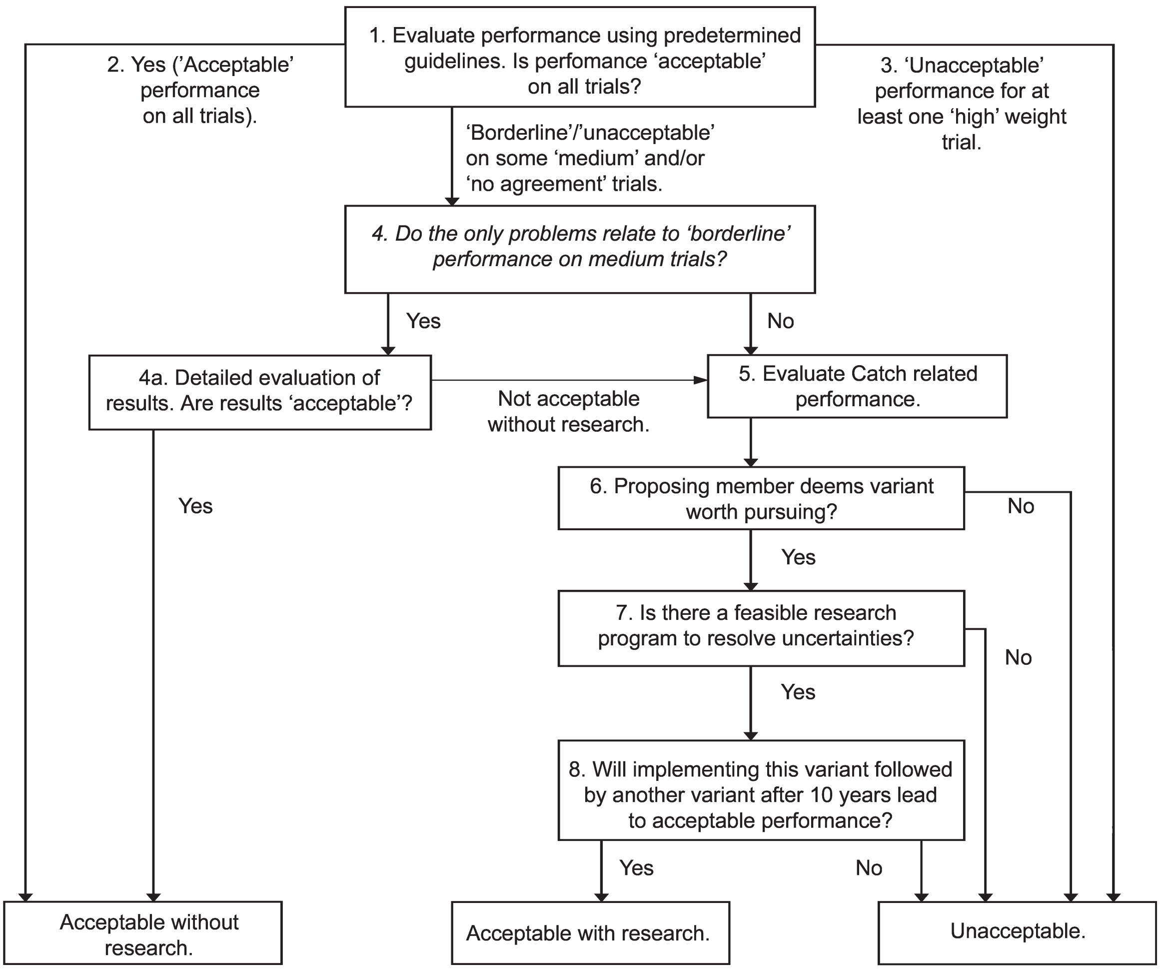

Fig. 2. Flowchart summarising the procedure for review of *IST*s (from IWC, 2005).

(c) if performance is neither 'acceptable' nor 'borderline', then the 5%-ile of the final depletion and the 5%-ile of the minimum depletion ratio for the *Implementation Simulation Trial* are less than those for the equivalent single stock trial with 0.60 tuning of the *CLA*, and the performance of the RMP variant shall be classified as 'unacceptable'.

During application of this algorithm, it was discovered that some stocks (primarily, 'J', 'Y' and 'JE') can be rendered extinct due to incidental catches in more than 5% of simulations. Formally, this implies that an RMP variant in which the catch limit is always zero would be deemed to perform 'unacceptably'. In order to evaluate the RMP variants under consideration, the Working Group agreed: (a) to flag cases in which a stock is rendered extinct in more than 5% of trials; and (b) to ignore that stock when evaluating the conservation performance of RMP variants. The consequences of stocks being predicted to be rendered extinct is discussed under Item 5.

If the performance for a small number of medium weight trials is 'borderline' but close to 'acceptable' then performance of the variant can be considered 'acceptable' without research.

A flow chart summarising the decision process to follow is given as Fig. 2.

4.2 Presentation style for results

The Working Group discussed ways to present and summarise the results of the trials to facilitate identification of the differences in performance among the RMP variants being considered (see Item 5), as well as to facilitate the application of the steps related to reviewing the results of the *Implementation Simulation Trials*. Based on the experience gained during the western North Pacific Bryde's and North Atlantic fin whale *Implementations*, the Workshop developed a variety of graphical and tabular summaries (see SC/65a/Rep04, Annex D for examples). The purposes of the various plots and tables range from providing a quick graphical summary of conservation performance to listing the full set of performance statistics for each trial and RMP variant. The master set of plots and tables is archived by the Secretariat and available to members of the Scientific Committee on request.

(1) A plot for each of the $MSYR_{mat}$=1% trials showing the performance of each RMP variant and scenarios with (a) only the incidental catch; and (b) with no catches of any kind using the procedure for defining 'acceptable', 'borderline' and 'unacceptable' performance. This plot will have panels for the various stocks and the two performance statistics on which the thresholds are based (the lower 5th percentile of the final depletion distribution and the lower 5th percentile of the minimum depletion ratio distribution). The values of the performance statistics for each variant (and the no-catch scenario) are represented as dots, and horizontal lines indicate the thresholds (upper line: 'acceptable'; lower line: 'borderline'). The shaded area in this plot indicates 'unacceptable' performance.

(2) An example plot or plots showing the performance for one of the trials. This plot will consist of the following types of outputs:
   (a) the median population size trajectories by stock for all of the RMP variants and that for the scenario with only the incidental catch;
   (b) the 5%-ile, median and 95%-ile of the population depletion trajectories by stock for all RMP variants (2000 to the end of the projection period);
   (c) the median catch trajectories for the RMP variants (since 1935 and since 2000); and
   (d) ten individual population size trajectories for each stock under the specific RMP variant as well as under the 'no commercial catch' variant.

(3) A table for each of the $MSYR_{mat}$=1% trials showing for each RMP variant: the median catch over the entire projection period; the 5%, median and 95%-iles of the annual catch over the first 10 years; and a summary of the application of the procedure for defining 'acceptable' - A, 'borderline' - B and 'unacceptable' - U performance. The table shows results for each performance statistic and stock separately, results by stock (i.e. after aggregating the outcomes for two performance statistics), and results in total (i.e. after aggregating outcomes from each performance statistic and stock).

(4) A table showing the detailed results for each trial and RMP variant (and the two 'no commercial catch' scenarios). The following information is included in this table:
   (a) median catch over the entire projection period and over the first 10 years;
   (b) lower 5%-ile and median of the final depletion distribution (by stock);
   (c) lower 5%-ile and median of the minimum depletion ratio distribution (by stock); and
   (d) lower 5%-ile and median of the initial depletion distribution (by stock).

This table also includes the values for the thresholds for each performance statistic and stock for the trials for which $MSYR_{mat}$=1% and the outcomes of the application of the procedure for defining 'acceptable', 'borderline' and 'unacceptable' performance using the symbols described in (3).

(5) A table showing all of the performance statistics for each trial and RMP variant (and the scenario with only the incidental catch).

5. REVIEW TRIAL RESULTS

The ten management variants to be considered arising from the 2nd Intersessional Workshop were as follows.

(1) *Small Areas* equal sub-areas. For this option, the *Small Areas* for which catch limits are set are 5, 6W, 7CS, 7CN, 7WR, 7E, 8, 9*, and 11.
(2) Sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CN, 9, and 11.
(3) Sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 9, and 11.
(4) Sub-areas 5, 6W, 7CS, 7CN, 7WR+7E+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 7CN, 7WR, 9 and 11.
(5) Sub-areas 5 and 6W are *Small Areas* and catches are taken from sub-areas 5 and 6W. Sub-areas 7+8+9*+11+12 form a combination area and catches are cascaded to the sub-areas within the combination area. The catch limits for sub-areas 12SW and 12NE are not taken.
(6) Sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* except that the catches from the 7+8 *Small Area* are taken from sub-areas 7CS and 7CN using the same method as for catch cascading to allocate the catch across the two sub-areas.
(7) Sub-areas 5+6W+6E+10W+10E and 7+8+9*+11 are *Small Areas*; catches from the 5+6W+6E+10W+10E

Small Area are taken from subareas 5 and 6W using the same method as for catch cascading to allocate the catch across those five sub-areas, and catches from the 7+8+9+11 *Small Area* are taken in sub-area 7CN.

(8) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 8 and 9 using the same method as for catch cascading to allocate the catch across the two sub-areas.

(9) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across these sub-areas.

(10) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8, 9 and 11 using the same method as for catch cascading to allocate the catch across these sub-areas. Catches from sub-area 11 occur in May and June only.

After reviewing the initial results at the meeting, Japan requested that the Working Group evaluate an 11th variant:

(11) Sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* and catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across these sub-areas, except the catches from sub-areas 7CS, 7CN, 7WR and 7E are reduced by 50% after first subtracting the bycatches in these sub-areas.

The Working Group noted that additional variants can be proposed for evaluation during the Second Intersessional Workshop as part of the *Implementation* process. However, due to the complexities of this *Implementation Review* the results of only a few trials had been available during the Second Intersessional Workshop rather than the complete set as envisaged in the Committee's Requirements and Guidelines for *Implementations*. Recognising these exceptional circumstances, the Working Group **agreed** to evaluate this additional variant noting that it was in accord

Table 2

The factors in the *Implementation Simulation Trials* and their plausibility (IWC, 2013b).
The plausibility assigned to the new Trial 31 occurred during this meeting.

Factor	Plausibility
Stock structure hypothesis	
Stock structure hypothesis A	M*
Stock structure hypothesis B	M*
Stock structure hypothesis C	M*
MSYR$_{mat}$	
1%	M
4%	H
***g*(0)**	
0.8	H
1.00 (Trial 3)	M
Other stock structure issues	
With a 'C' stock (Trial 2)	M
Some 'O' or "O/W' animals in sub-area 10E (Trial 5)	M
10% J (/JW) – stock in sub-area 12SE in June (Trial 10)	M
30% J (/JW) – stock in sub-area 12SE in June (Trial 11)	M
No 'C' animals in sub-area 12NE (Trial 12)	M
No 'OW' in 11 and 12SW (Trial 13)	M
No 'OE' in 11 or 12SW (Trial 14)	M
No 'OE' in 7WR (Trial 15)	M
Single 'J' stock (Trial 23)	M
Single 'O' stock (Trial 24)	**L**
Catches and bycatches	
High direct catches + alternative Korean + Japanese bycatch level (Trial 4) (Total direct catch = 40,224 *cf* baseline value = 38,174)	M
More Korean catches in sub-area 5 (and fewer in 6W) (Trial 8)	M
More Korean catches in sub-area 6W (and fewer in 5) (Trial 9)	M
Chinese incidental catch = 0 (Trial 18) (Baseline value = 2* Korean bycatch in subarea 5)	M
Number of bycaught animals is proportional to square root of abundance (Trial 25)	
Mixing and dispersion	
Mixing proportion in 7Cs and 7CN calculated using 2/60 weight for bycatch (Trial 6)	M
Mixing proportion in 7Cs and 7CN calculated using 10/60 weight for bycatch (Trial 7)	M
Dispersal rate of 0.005 (Trial 16)	M
Dispersal rate of 0.02 (Trial 17)	M
A substantially larger fraction of whales 1-4 from O-/OE-stock are found in sub-areas 2R, 3 and 4 year round (Trial 26) M	M
Set the proportion of O/OE animals of ages 1-4 in sub-area 9 and 9N to zero (Trial 27)	M
Abundance estimates	
Alternative abundance estimates in 6E (Trial 19)	M
Alternative abundance estimates in 10E in 2007 (Trial 20)	M
Abundance estimate in 5 = 'minimum' (Trial 21)	**L**
Abundance estimate in 5 = 'maximum' (Trial 22)	M
The number of 1+ whales in 2009 in sub-area 2C in any month < 200 (Trial 28)	M
Abundance estimate in 6W = 'minimum' (Trial 29)	**L**
Abundance estimate in 6W = 'maximum' (Trial 30)	M
Alternative time invariant proportion of JE-stock whales in 7CN in Jan-Jun used to remove bycatch (Trial 31)	M

*Treated as 'medium' plausibility because of lack of agreement (IWC, 2013b).

Table 3

Overall summary of the conservation performance of the eleven RMP variants. A dash indicates that all of the variants performed 'acceptably' for the trial, variant numbers after 'B:' indicate variants which had 'borderline' performance, and variant numbers after 'U:' indicate variants which had 'unacceptable' performance. Stocks are rendered extinct in some trials due to incidental catches. The stocks for which this occurs are indicated as superscripts after the superscripted asterisks. Trials 21 and 29 were assigned 'low' plausibility and are included here only because the Working Group wished to understand their behaviour (IWC, 2012b).

Trial	Description	Hypothesis A	Hypothesis B	Hypothesis C
Medium weighted trials				
1	Baseline	-	-	U: 7,9,10
2	'C' stock	-	No Trial	B:11; U: 7,9,10
3	*g*(0)=1	B: 10	B: 5, 10	B: 5,11; U: 7, 9, 10 *[JE]
4	High catch	B: 5,7,9,10,11	B: 1,2,3,4,6,7,9,11; U: 5,10	B: 5,11; U 7,9,10
5	'O'/'OW' in 10E	-	B: 10	B: 11; U: 7,9,10
6	Bycatch mix prop 2/60	-	B: 10	B: 11; U: 7,9,10
7	Bycatch mix prop 10/60	-	-	B: 11; U: 7,9,10
8	More Korean catch in 5	-	-	B: 11; U: 7, 9, 10 *[JE]
9	More Korean catch in 6W	-	B: 10	B: 11; U: 7, 9, 10 *[JE]
10	10% J/JW in 12SW in June	-	-	B: 11; U: 7, 9, 10 *[JE]
11	30% J/JW in 12SW in June	-	-	B: 9; U: 7,10
12	No 'C' in 12NE	No Trial	No Trial	B: 11; U: 7,9,10
13	No 'OW' in 11, 12SW	No Trial	No Trial	U: 7,9,10,11
14	No 'OE' in 11,12SW	No Trial	No Trial	B: 7, 9; U: 10
15	No 'OE' in 7WR	No Trial	No Trial	U: 7, 9, 10
16	Dispersal = 0.005	No Trial	No Trial	-
17	Dispersal = 0.02	No Trial	No Trial	B: 7,9,10
18	Chinese incidental catch = 0	-	B: 10	B: 11; U: 7,9,10
19	Alt abundance in 6E	-	-	B: 11; U: 7,9,10
20	Add abundance in 10E	-	B: 10	U: 7,9,10,11 *[JE]
22	Max abundance in 5	-	B: 10	B: 11; U: 7,9,10
23	Single 'J' stock	No Trial	No Trial	U: 7,9,10,11
25	Bycatch prop to √abundance	- *[J]	- *[J,Y]	- *[JW,JE,OW,Y]
26	More age 1-4 'O'/'OE' in 2R,3,4; less in 9,9N	-	-	No Trial
27	No age 1-4 'O'/'OE' in 9,9N; more in 7CS,7CN	-	-	B10
28	1+ in 2C < 200 in 2009	B: 10	B: 10	U: 7,9,10
30	Max abundance in 6W	-	-	B: 9; U: 7,10
31	Alt bycatch propn 'JE' in 7CN	No Trial	No Trial	B: 11; U: 7,9,10
Low weighted trials				
21	Min abundance in 5	B: 10	U: 5, 10	U: 5,7,8,9,10,11 *[JE]
29	Min abundance in 6W	B: 5,7,9,10,11	B: 1,2,3,4,5,6,7,9,11; U: 10	B: 5,11; U: 7,9,10 *[JE]

with the RMP in that catches from all *Small Areas* cannot exceed the RMP catch limit (except when the bycatch exceeds the RMP catch limit when the commercial catch is set to zero).

The Working Group **reiterated** that, under normal circumstances, proposal and evaluation of additional variants should not take place at the Second Annual Meeting.

The full set of results is available as a master set from the Secretariat upon request. In all there were 66 trials of which none were given 'high' weight. Table 2 lists the factors considered in the trials and the plausibility assigned to each. Some of the factors were assigned 'medium' plausibility because the Committee could not reach agreement on whether they should be 'low', 'medium' or 'high'. The Committee assigned 'medium' weight to all of the trials except for 21, 24, and 29 which were assigned 'low' weight. Trial 24 was dropped from further consideration. Trials 21 and 29 were conducted only because the Working Group considered that they might provide useful information regarding the behaviour of the trials. Trial C31 was established during the Second Intersessional Workshop and is a 'medium' weight trial. The Committee had agreed that $MSYR_{mat}$ =4% was 'high' plausibility but given the assignment of all of the stock structure hypotheses as 'medium' then all of the $MSYR_{mat}$ =4% trials are also of 'medium' weight.

There are a number of possible scenarios to consider when evaluating the trials, and it is at this stage that a degree of judgement is required, including consideration of the overall balance of the trials and the characteristics of the specific trials for which performance is questionable. The process can be summarised as follows (IWC, 2012a):

(1) if the performance is close to 'acceptable' for a small number of borderline trials then the Committee may agree that the variant is 'acceptable';
(2) if the performance is close to 'unacceptable' or is 'unacceptable' for a number of trials based on a specific hypothesis, then the Committee may agree that this is a candidate for the 'acceptable with research'; and
(3) if the performance is close to 'unacceptable' or is 'unacceptable' for a number of trials under several hypotheses, then the Committee may agree that the variant is unacceptable and thus eliminated from further consideration.

Tables 3 and 4 summarise the application of the rules for evaluating conservation performance. Results are shown in Table 3 by stock-structure hypothesis and in Table 4 by variant. Table 5 lists the average catches by sub-area for each variant for the six base-case trials. Average catches are reported in Table 5 for years 1-10 and for the entire 100-year projection period. The results in this table are illustrative only; the actual catches will depend on the application of the *CLA* to the abundance estimates and catches selected by the Committee (see Item 6.3).

The Working Group noted that cases in which stocks are rendered extinct in more than 5% of simulations under zero commercial catch were not used in evaluating the performance of RMP variants (see Item 4.1). These cases are denoted by * in Table 3.

Table 4

Summary of the 'medium' plausibility trials on which each of the variants failed to achieve 'acceptable' performance.

Variant	Borderline Trials	Unacceptable Trials	Recommendation
1	B04	None	Acceptable without research
2	B04	None	Acceptable without research
3	B04	None	Acceptable without research
4	B04	None	Acceptable without research
5	B03, C03, A04, C04	B04	Potentially acceptable with research
6	B04	None	Acceptable without research
7	A04, B04, C14, C17	C01, C02, C03, C04, C05, C06, C07, C08, C09, C10, C11, C12, C13, C15, C18, C19, C20, C22, C23, C28, C30, C31	Potentially acceptable with research
8	None	None	Acceptable without research
9	A04, B04, C11, C14, C17,C30	C01, C02, C03, C04, C05, C06, C07, C08, C09, C10, C12, C13, C15, C18, C19, C20, C22, C23, C28, C31	Potentially acceptable with research
10	A03, B03, A04, B05, B06, B09, C17, B18, B20, B22, A28, C27, B28	C01, C02, C03, B04, C04, C05, C06, C07, C08, C09, C10, C11, C12, C13, C14, C15, C18, C19, C20, C22, C23, C28, C30, C31	Unacceptable
11	C02, C03, A04, B04, C04, C05, C06, C07, C08, C09, C10, C12, C18, C19 C22, C31	C13, C20, C23	Potentially acceptable with research

Table 5

Average (over the six base-case trials) median annual commercial catches (years 1-100 and 1-10) by sub-area and RMP variant.

Sub-area	Variant										
Years 1-100											
	1	2	3	4	5	6	7	8	9	10	11
5	0	0	0	0	0	0	0	0	0	0	0
6W	0	0	0	0	0	0	0	0	0	0	0
7CS	0	0	0	0	0	0	0	0	14	12	7
7CN	0	0	0	0	0	0	17	0	3	3	2
7WR	2	0	0	7	3	0	0	0	7	7	4
7E	1	0	0	0	1	0	0	0	3	0	1
8	1	0	0	0	2	0	0	7	5	4	5
9	43	43	43	43	37	43	0	113	82	74	81
11	0	0	0	0	2	0	0	0	0	14	0
Total	48	43	43	50	48	43	17	123	123	122	105
Years 1-10											
5	0	0	0	0	0	0	0	0	0	0	0
6W	0	0	0	0	0	0	0	0	0	0	0
7CS	0	0	0	0	0	0	0	0	7	6	3
7CN	0	0	0	0	0	0	0	0	4	4	2
7WR	1	0	0	2	2	0	0	0	4	4	2
7E	0	0	0	0	1	0	0	0	1	1	1
8	0	0	0	0	1	0	0	5	3	3	3
9	19	19	19	19	20	19	0	60	44	39	44
11	0	0	0	0	0	0	0	0	0	6	0
Total	20	19	19	21	24	19	0	65	65	65	56

5.1 Variants 1, 2, 3, 4 and 6

These variants did not have 'unacceptable' performance for any trials, but had 'borderline' performance for one trial B04 (high historical catch and bycatch) as shown in Fig. 3. They also had 'borderline' performance in trial B29 (abundance in sub-area 6W is conditioned to equal the minimum estimates for this sub-area rather than the average of the minimum and maximum values) that was included only to examine the behaviour of the trials.

The 'borderline' performance for these variants occurs for J-stock where final depletion is below the 0.60 tuning of the *CLA* (although this is also the case for zero commercial catch case because of incidental catches) and the minimum depletion ratio is only slightly below that for the 0.72 tuning of the *CLA*. Given that the 'borderline' performance was close to 'acceptable', and that 'borderline' performance occurred only once out of 66 trials, these variants can be considered as candidates for 'acceptable without research' (step 4a in Fig. 2).

5.2 Variant 5

Variant 5 had 'unacceptable' performance for trial B04 (Fig. 3). It had 'borderline' performance for trials A04 (Fig. 4), B03 ($g(0)=1$) (Fig. 5), C03 (Fig. 6), and C04 (Fig. 7). It also had 'unacceptable' performance for trials B21 and C21 and 'borderline' performance for trials A29, B29 and C29, but trials 21and 29 were given low weight and were only included to examine whether the RMP behaved as expected. Focus is thus on trials B04, A04, B03, C03 and C04. Given that this variant fails for only one trial (B04) and is 'borderline' on four trials in which it is close to 'acceptable' for trial A04, this variant can be considered as a candidate for 'acceptable with research' because it fails only for stock structure hypothesis B (step 4a in Fig. 2).

5.3 Variant 7

Variant 7 performed 'unacceptably' on 22 out of 27 trials for stock-structure hypothesis C and 'borderline' on two (C14 - no OE-stock in sub-areas 11 or 12SW, C17 - dispersal rate of

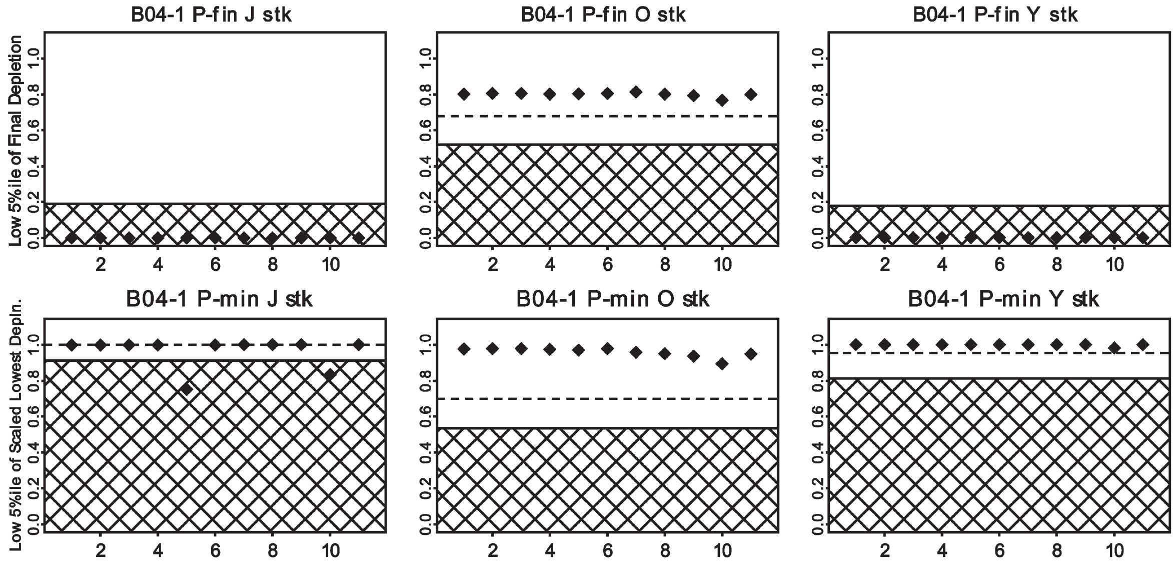

Fig. 3. Performance plot for trial B04. The columns show results for each stock while the row summarise performance for the two statistics (final depletion upper panel, minimum population ratio lower panel). Variants are 'acceptable' for a stock if their performance exceeds that for the 0.72 tuning of the *CLA* on one of the two statistics (solid dots above the upper horizontal line) and are 'unacceptable' for a stock if their performance is in the hashed area for both statistics. Variants are 'borderline' for a stock if they are neither 'acceptable' nor 'unacceptable'.

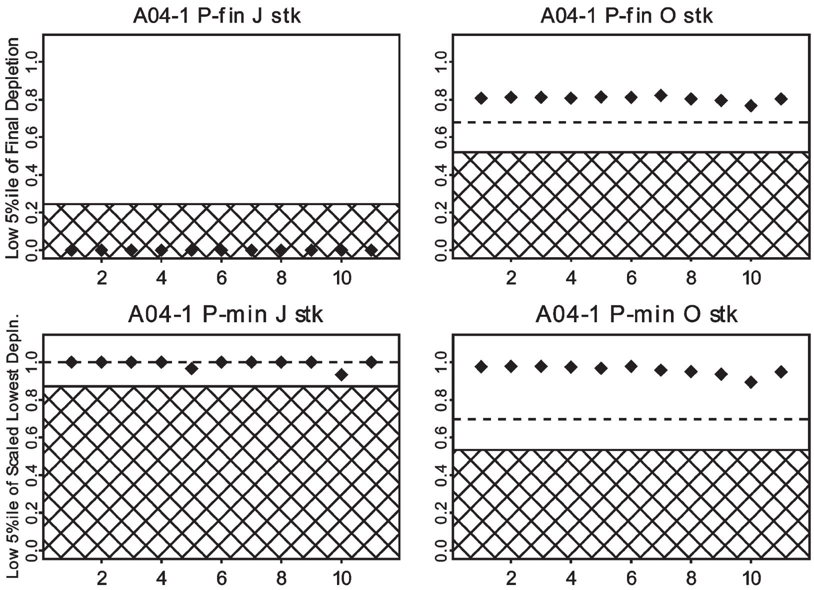

Fig. 4. Performance plot for trial A04.

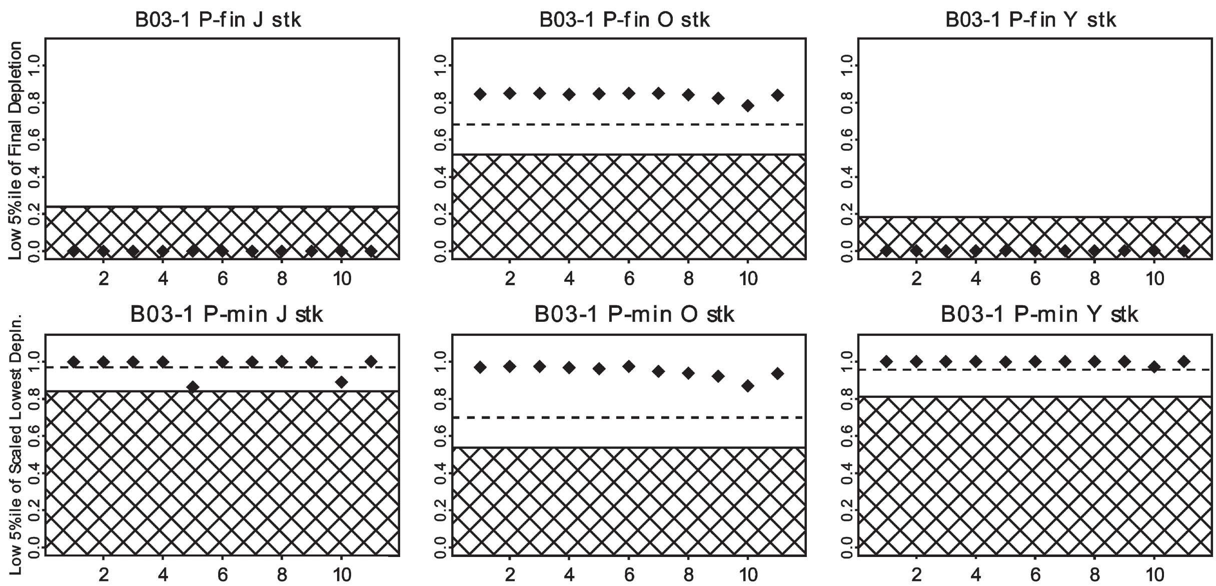

Fig. 5. Performance plot for trial B03.

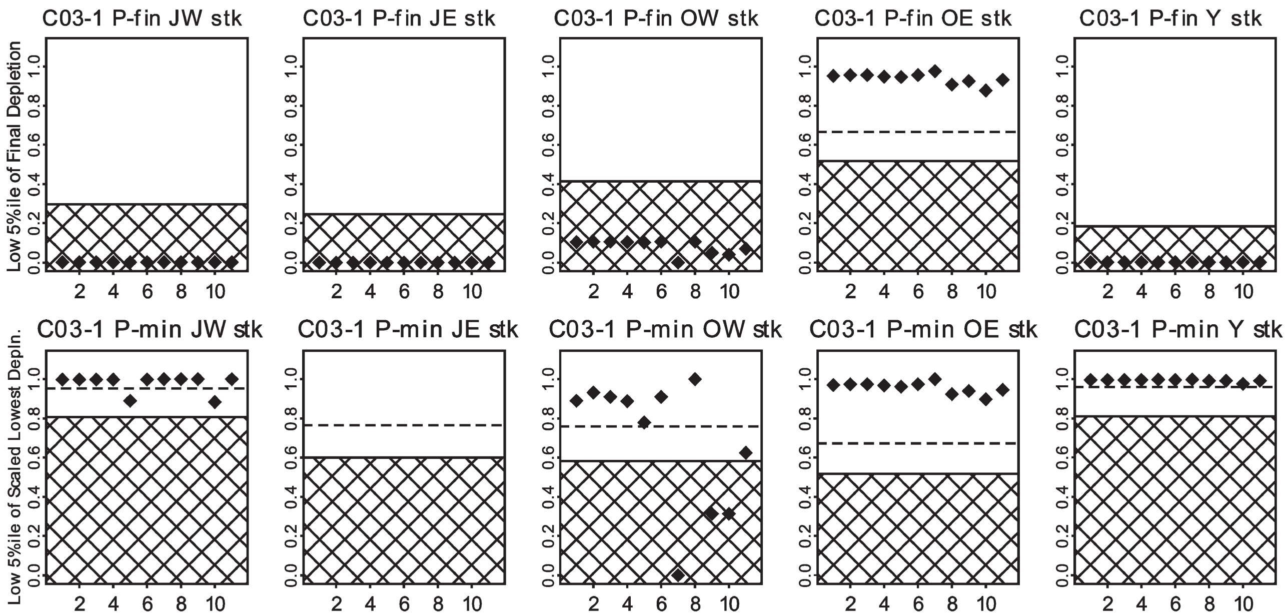

Fig. 6. Performance plot for trial C03.

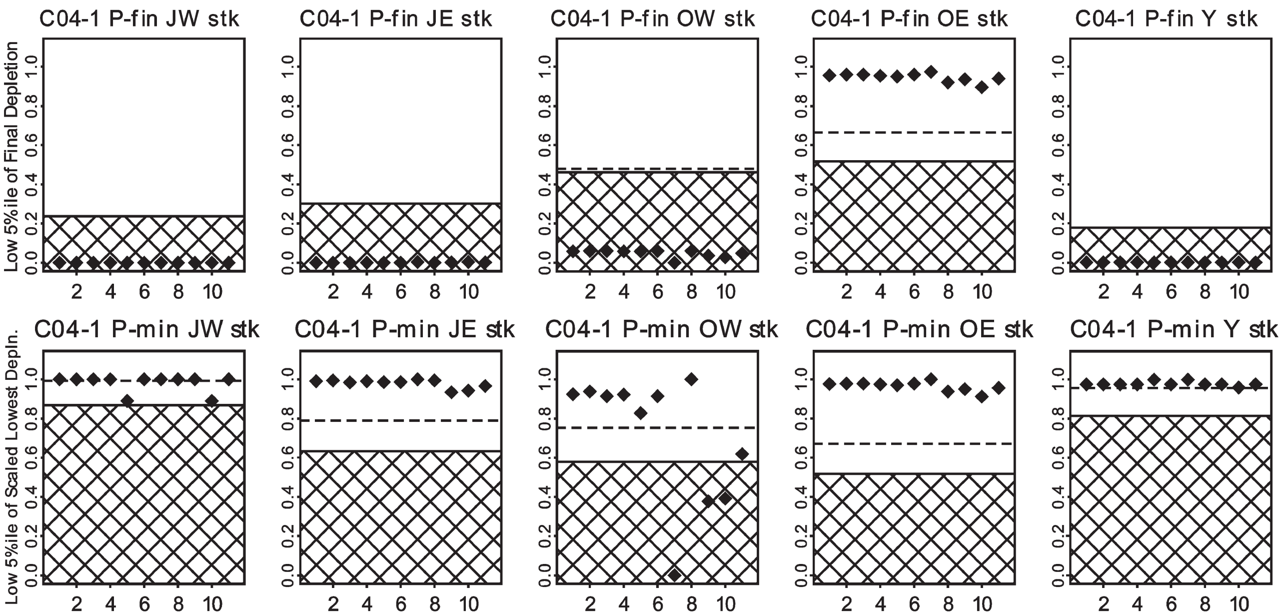

Fig. 7. Performance plot for trial C04.

0.02 between OW and OE and between JW and JE). It also had 'borderline' performance for two trials based on stock-structure hypotheses A and B (A04, B04). This variant was close to 'acceptable' for these two trials (Figs. 3 and 4). This variant can be considered as a candidate for 'acceptable with research' because it was 'borderline' for only two out of 39 trials for hypotheses A and B, while its performance was 'unacceptable' for hypothesis C; that is, this variant fails for only one stock structure hypothesis (step 4a in Fig. 2).

5.4 Variant 8

Variant 8 was acceptable for all medium plausibility trials. It had 'unacceptable' performance in trial C21 which was given low weight and was only included to examine whether the RMP behaved as expected. Therefore this variant can be considered to be 'acceptable without research' (steps 1 and 2 in Fig. 2).

5.5 Variant 9

Variant 9 performed 'unacceptably' on 20 out of 27 trials for stock-structure hypothesis C, and had 'borderline' performance for four trials (C11, C14, C17 and C30 [abundance in sub-area 6W is conditioned to equal the maximum estimates for this sub-area rather than the average of the minimum and maximum values]). It had 'borderline' performance on only two out of 39 trials based on stock-structure hypotheses A and B (A04, B04). This variant can thus be considered as a candidate for 'acceptable with research' because it fails only for stock structure hypothesis C (step 4a in Fig. 2).

5.6 Variant 10

Variant 10 performed 'unacceptably' on 23 out of 27 trials for stock-structure hypothesis C and had 'borderline' performance for two trials (C17 and C27). It also performed 'unacceptably' for one trial for stock structure hypothesis B (B04) and 'borderline' for 8 trials (B03, B05, B06, B09, B18, B20, B22, B28). 'Borderline' performance was also observed for 3 trials for stock structure hypothesis A (A03, A04, A28). This variant is therefore 'unacceptable'.

5.7 Variant 11

Variant 11 performed 'unacceptably' on three out of 27 trials for stock-structure hypothesis C (C13, C20 and C23) and had 'borderline' performance for 16 trials. The conservation performance of this variant is between that of variants 5 and 9, which were both considered to be candidates for variants with research. Therefore, this variant can be considered as a candidate for 'acceptable with research'

Fig. 8 shows the time-trajectories of population size by stock and RMP variant for the six base-case trials.

The Working Group once again thanked Allison and de Moor for conducting the trials and providing the required summary statistics. It also thanked the small group (Punt [Convenor], Allison, An, Butterworth, de Moor, Donovan, Miyashita) that conducted the initial review of all the trial results.

5.8 Variants with research

With respect to variants that are candidates for 'acceptable with research', it is the responsibility of relevant governments to inform the Committee whether it wishes additional trials to be run to determine the conservation performance of proposed 'hybrid variants'. A 'hybrid variant' is one for which catches for the first 12 years are set using the candidate 'acceptable with research' followed by a six-year phase down/phase out period and then catches set by an 'acceptable without research' variant. The conservation performance of the 'hybrid variant' must be 'acceptable' under the criteria described above. If the 'hybrid variant' performs acceptably then, before it can be recommended, the Committee must agree a research programme that it believes has a realistic chance of determining whether the trial(s) for which this variant performed poorly should be accorded low weight. The Committee will review progress with the research programme annually and may recommend early reversion to the 'acceptable' variant if progress is not sufficient.

6. RECOMMENDATIONS TO THE SCIENTIFIC COMMITTEE

6.1 Management Areas

Under the management options recommended, the designations are as follows.

(1) Variant 1: sub-areas 5, 6W, 7CS, 7CN, 7WR, 7E, 8, 9* and 11 are *Small Areas*.
(2) Variant 2: sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* (all of the catch from the 7+8 *Small Area* is taken from sub-area 7CN).
(3) Variant 3: sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* (all of the catch from the 7+8 *Small Area* is taken from sub-area 7CS).
(4) Variant 4: sub-areas 5, 6W, 7CS, 7CN, 7WR+7E+8, 9* and 11 are *Small Areas* (all of the catch from the 7WR+7E+8 *Small Area* is taken from sub-area 7WR).
(5) If Variant 5 proves to be acceptable with research: sub-areas 5 and 6W are *Small Areas* and catches are taken from sub-areas 5 and 6W. Sub-areas 7+8+9*+11+12 form a Combination Area (catch limits for sub-areas 12SW and 12NE are not taken).
(6) Variant 6: sub-areas 5, 6W, 7+8, 9* and 11 are *Small Areas* (catches from the 7+8 *Small Area* are taken from sub-areas 7CS and 7CN using the same method as for catch cascading).
(7) If Variant 7 proves to be acceptable with research: sub-areas 5+6W+6E+10W+10E and 7+8+9*+11 are *Small Areas*; (catches from the 5+6W+6E+10W+10E *Small Area* are taken from sub-areas 5 and 6W using the same method as for catch cascading ; catches from the 7+8+9+11 *Small Area* are taken in sub-area 7CN).
(8) Variant 8: sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* (catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 8 and 9 using the same method as for catch cascading).
(9) If Variant 9 proves to be acceptable with research: sub-areas 5, 6W and 7+8+9*+11+12 are *Small Areas* (catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading).
(10) If Variant 11 proves to be acceptable with research: sub-areas 5, 6W, and 7+8+9*+11+12 are *Small Areas* (catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading).

6.2 Variants

The Working Group **agreed** that, according to the Committee's Requirements and Guidelines for *Implementations* under the Revised Management Procedure (RMP) (IWC, 2012b):

(1) variants 1, 2, 3, 4, 6 and 8 are 'acceptable without research';
(2) variants 5, 7, 9 and 11 are candidates for 'acceptable with research'; and
(3) variant 10 is 'unacceptable'.

Some members stated that in reviewing the trials it was apparent that, with only two exceptions, all of the 'unacceptable' trials were under stock structure hypothesis C. Under the Committee's current Requirements and Guidelines for *Implementations* under the RMP, when there is no agreement on plausibility of the hypotheses, the plausibility is automatically assigned as 'medium'. In the case of stock structure hypothesis C, there was no agreement and therefore the plausibility became 'medium' as for the other stock structure hypotheses. However these members reiterated their view that the plausibility of stock structure hypothesis C is 'low' (Waples, 2012). Whilst agreeing that the review of trials had been appropriately followed under the Committee's current Requirements and Guidelines for *Implementations*, under these circumstances they could not accept the recommendations on management based on the conservation performance of the *Implementation Simulation Trials* reviewed at this meeting. They pointed out that the problem of assigning plausibility has been an ongoing problem and suggested that it is necessary to review the method of determining plausibility.

6.3 Inputs for the *CLA*

6.3.1 Estimates of abundance

The Working Group did not have sufficient time to finalise the estimates of abundance for use in actual applications of the RMP. Table 6 (SC/65a/Rep04, Annex G) summarises the Second Intersessional Workshop's recommendations on the acceptability of the abundance estimates for use in the current *Implementation Simulation Trials*. It also lists the estimates which could be used in actual applications of

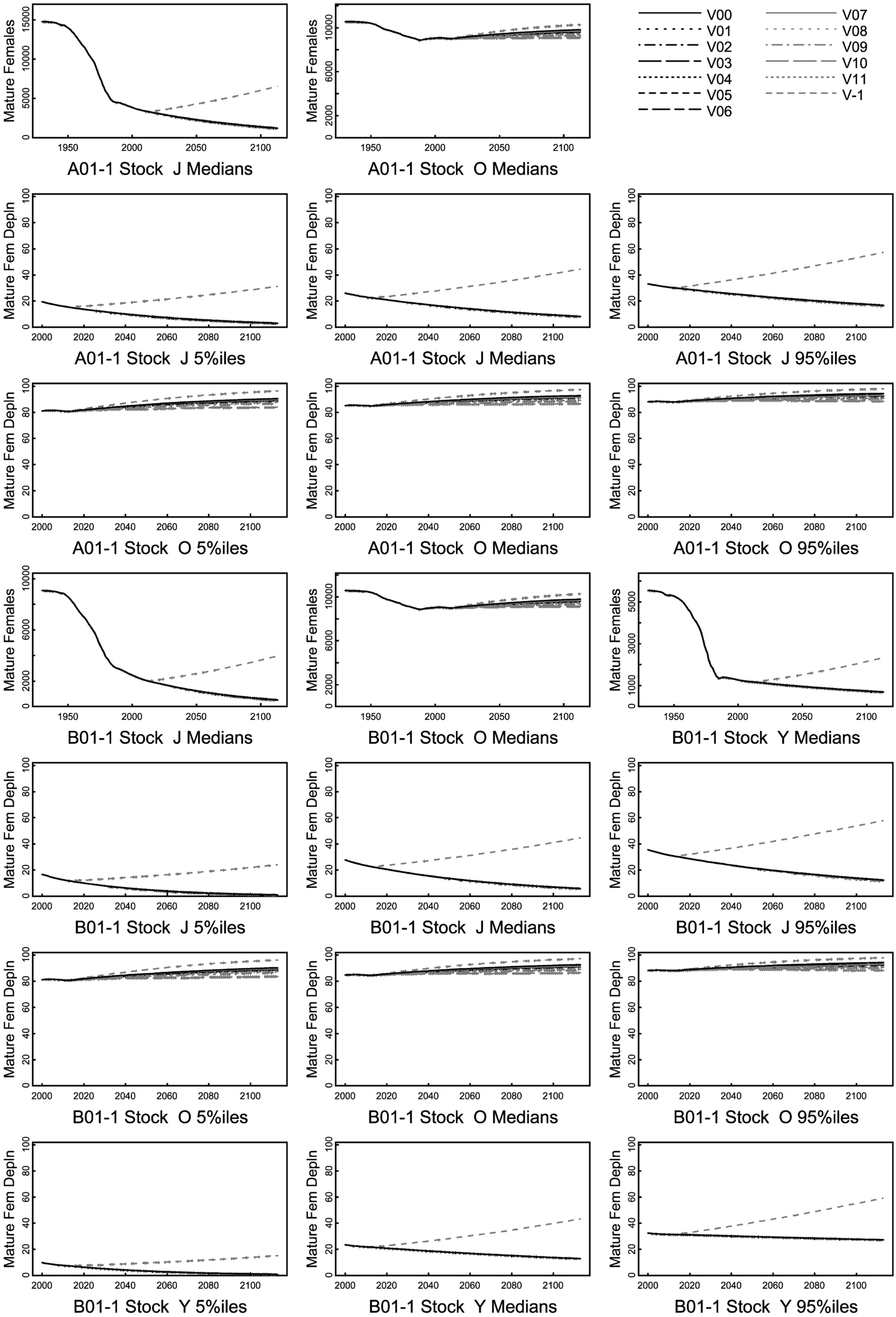

Fig. 8a. A01-1 and B01-1 projection trajectories.

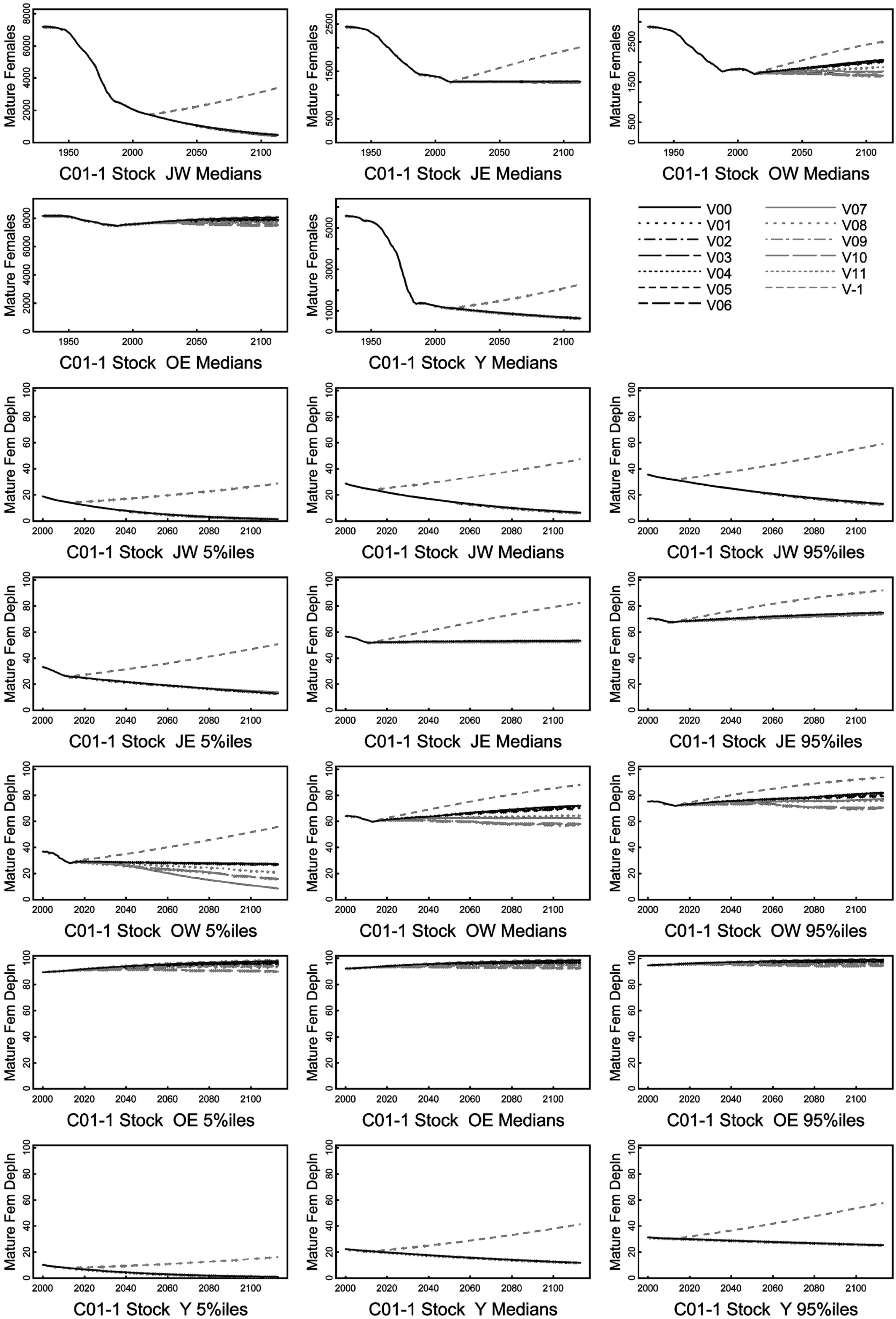

Fig. 8b. C01-1. Projection trajectories.

Table 6

Table of abundance estimates. The intersessional Workshop's recommendations on acceptance of the abundance estimates for use in the current *Implementation Simulation Trials* are reflected in the final two columns of the Table below in the form of Yes/No Agreement (N/A)/No, followed by a brief rationale for any disagreement. The two 'No Agreement' estimates were not used in the current trials. The notation * indicates that further analysis needs to be considered for an estimate to become acceptable for use in a real application; values in brackets were considered acceptable but were not used in the current trials.

Sub-area	Year	STD estimate[1]	CV[2]	Areal cover %	Timing	Original reference[3]	Used in 2003 trials?	Condition 2013 Trials?[4]	Used in 2013 Trials?	Rationale and notes
5	2001	1,534	0.523	13	Apr.-May	An *et al.* (2010)	-	Min.	Yes*	Low area coverage. Only area completed. Needs further analysis.
5	2004	799	0.321	13	Apr.-Jun.	An *et al.* (2010)	-	Min.	Yes*	Low area coverage. Only area completed. Needs further analysis.
5	2008	680	0.372	13	Apr.-May	An *et al.* (2010)	-	Min.	Yes*	Low area coverage. Only area completed. Needs further analysis.
5	2011	587	0.405	13	Apr.-May	Park *et al.* (2012)	-	No	(Yes*)	Only area completed. Needs further analysis. Estimate acceptable but was not used in 2013 trials.
6W	2000	549	0.419	14.3	May-Jun.	An *et al.* (2010)	-	Min.	Yes*	Low area coverage. Use inshore segment only with adjustment for differential extent of inshore coverage. No extrapolation.
6W	2002	391	0.614	14.3	May-Jun.	An *et al.* (2010)	-	Min.	Yes*	As above
6W	2003	485	0.343	14.3	Apr.-May	An *et al.* (2010)	-	Min.	Yes*	As above
6W	2005	336	0.317	14.3	Apr.-May	An *et al.* (2010)	-	Min.	Yes*	As above
6W	2006	459	0.516	14.3	Apr.-May	An *et al.* (2010)	-	Min.	Yes*	As above
6W	2007	574	0.437	14.3	Apr.-May	An *et al.* (2010)	-	Min.	Yes*	As above
6W	2009	884	0.286	14.3	Apr.-May	An *et al.* (2010)	-	Min.	Yes*	As above
6W	2010	1,014	0.397	14.3	Apr.-May	An *et al.* (2011)	-	No	Yes*	As above
6E	2002	891	0.608	79.1	May-Jun.	Miyashita *et al.* (2009)	-	Yes	Yes*	Poor coverage and analysis difficulties. Poor availability. Northern part only used to avoid double counting.
6E	2003	935	0.357	79.1	May-Jun.	Miyashita *et al.* (2009)	-	Yes	Yes	Northern part only used to avoid double counting.
6E	2004	727	0.372	79.1	May-Jun.	Miyashita *et al.* (2009)	-	Yes	Yes	Incomplete coverage. Only N offshore block used.
10W	2006	2,476	0.312	59.9	May-Jun.	Miyashita and Okamura (2011)	-	Yes	Yes	
10E	2002	816	0.658	100	May-Jun.	Miyashita *et al.* (2009)	-	Yes	Yes	Sufficient effort to retain estimate (61% of pre-determined track line covered).
10E	2003	405	0.566	100	May-Jun.	Miyashita *et al.* (2009)	-	Yes	Yes	
10E	2004	474	0.537	100	May-Jun.	Miyashita *et al.* (2009)	-	Yes	N/A*	Design question: (most sightings in concentration near coast).
10E	2005	599	0.441	64.6	May-Jun.	Agreed in 2013 IWC (2014, pp.504-56)	-	Yes[#]	Yes	In 2005, survey blocks were surveyed twice. Estimate was recalculated using 2nd part and only in offshore block to avoid double counting, using estimates of ESW and *S* from the whole area. (No. of primary sightings: 1st part: 1 over 387 n.miles, 2nd part: 9 over 842 n.miles).
10E	2007	575	0.327	80.1	May-Jun.	Miyashita *et al.* (2009)	-	(Yes[#])	No	Estimate used to condition a sensitivity trial.
7CS	1991	0		100	Aug.-Sep.	Butterworth and Miyashita (2014)	Yes	No	Yes*	7W estimate (1,164 CV 0.183, IWC, 2004, p.124) was split to subarea (prorated by *nA/L* from the total.
7CS	2004	504	0.291	36.7	May	Agreed in 2013 IWC (2014, pp.492-96; pp.504-06)	-	Yes[#]	Yes*	Estimate was recalculated for the northern part only using estimates of ESW and *S* from the whole area.
7CS	2006	3,690	1.199	100	Jun.-Jul.	Hakamada and Kitakado (2010rev)	-	Yes	Yes*	Analysis for non-random start. Note different survey timings.
7CS	2012	890	0.393	100	May-Jun.	Hakamada *et al.* (2013rev)	-	No	Yes*	See Item 2.2 of 2013 Workshop report, IWC (2014).
7CN	1991	853	0.23		Aug.-Sep.	Butterworth and Miyashita (2014)	Yes	No	Yes*	7W estimate (1,164 CV 0.183, IWC, 2004, p.124) was split to subarea (prorated by *nA/L* from the total).
7CN	2003	184	0.805	75.4	May	Hakamada and Kitakado (2010rev)	-	Yes	N/A*	Inadequate and heterogeneous coverage.
7CN	2012	302	0.454	66.7	May-Jun.	Hakamada *et al.* (2013rev)	-	No	(Yes*)	See Item 2.2 of 2013 Workshop report, IWC (2014). Estimate acceptable but was not used in the trials (see [5]).
7CN	2012	398	0.507	66.7	Sep.	Hakamada *et al.* (2013rev)	-	No	Yes*	See Item 2.2 of 2013 Workshop report, IWC (2014).
7WR	1991	311	0.23		Aug.-Sep.	Butterworth and Miyashita (2014)	Yes	No	Yes*	7W estimate (1,164 CV 0.183, IWC, 2004, p.124) was split to subarea (prorated by *nA/L* from the total).
7WR	2003	267	0.70	26.7	May-Jun.	Agreed in 2013 IWC (2014, pp.492-96; pp.504-06)	-	Min.[#]	Yes*	Low area coverage. Estimate recalculated for northern part only. With analysis for non random starts.
7WR	2004	863	0.648	88.8	May-Jun.	Hakamada and Kitakado (2010rev)	-	Yes	Yes	
7WR	2007	546	0.953	88.8	Jun.-Jul.	Hakamada and Kitakado (2010rev)	-	Yes	Yes*	With analysis for non-random start.

Cont.

Sub-area	Year	STD estimate[1]	CV[2]	Areal cover %	Timing	Original reference[3]	Used in 2003 trials?	Condition 2013 Trials?[4]	Used in 2013 Trials?	Rationale and notes
7E	1990	791	1.848		Aug.-Sep.	IWC (2004, p.124)	Yes	No	No	CV too high to be meaningful. Pro-rata to fraction of area from 1990 estimate because of almost uniform distribution of effort in 1990 (Miyashita, pers. comm.)
7E	2004	440	0.779	57.1	May-Jun.	Hakamada and Kitakado (2010rev)	-	Yes	Yes	
7E	2006	247	0.892	57.1	May-Jun.	Hakamada and Kitakado (2010rev)	-	Yes	Yes	
7E	2007	0	-	57.1	Jun.-Jul.	Hakamada and Kitakado (2010rev)	-	Yes[6]	Yes*	With analysis: non random start; no planned coverage in Russian EEZ (upper left).
8	1990	1,057	0.706	62.2	Aug.-Sep.	IWC (2004, p.124); IWC (1997, p.203 and p.211)	Yes	Yes	Yes	Agreed in 2003. Estimate extracted from Buckland *et al.* (1992). In other years, no whales observed in area not covered.
8	2002	0	-	65	Jun.-Jul.	Hakamada and Kitakado (2010rev)	-	Yes	Yes	Note different survey timings.
8	2004	1,093	0.576	40.5	Jun.	Hakamada and Kitakado (2010rev)	-	Yes	Yes	In other years, no whales observed in area not covered.
8	2005	132	1.047	65	May-Jul.	Hakamada and Kitakado (2010rev)	-	Yes	Yes*	With analysis: non random start; no planned coverage in Russian EEZ (upper left), 2 sets of lines in lower blocks.
8	2006	309	0.677	65	May-Jul.	Hakamada and Kitakado (2010rev)	-	Yes	Yes	
8	2007	391	1.013	65	Jun.-Jul.	Hakamada and Kitakado (2010rev)	-	Yes[6]	Yes*	With analysis: non random start; no planned coverage in Russian EEZ (upper left).
9	1990	8,264	0.396	35.1	Aug.-Sep.	IWC (2004, p.124); IWC (1997, p.203 and p.211)	Yes	Yes	Yes	Agreed in 2003. Estimate extracted from Buckland *et al.* (1992).
9	2003	2,546	0.276	33.2	Jul.-Sep.	Hakamada and Kitakado (2010rev)	-	Min.	Yes	Survey not co-incident with density peak in Aug.-Sep.
9N	2005	420	0.969	67.8	Aug.-Sep.	Miyashita and Okamura (2011)	-	Yes	(Yes)	Agreed estimate. Not used in 2013 trials as catch limits are not set for 9N.
11	1990	2,120	0.449	100	Aug.-Sep.	IWC (2004, p.124); IWC (1997, p.203 and p.211)	Yes	Yes	Yes	Agreed in 2003. Estimate extracted from Buckland *et al.* (1992).
11	1999	1,456	0.565	100	Aug.-Sep.	IWC (2004, p.124); IWC (2003, pp.470-72)	Yes	Yes	Yes	Agreed in 2003. Estimate is based on pooling data from 1999 and 2000 surveys.
11	2003	882	0.820	33.9	Aug.-Sep.	Miyashita and Okamura (2011)	-	Yes	Yes*	Potential bias due to weather induced coverage omission to North. Unacceptable to include coastal transect in analysis. Estimate refers to surveyed part of subarea only and excludes transit legs.
11	2007	377	0.389	20.2	Aug.-Sep.	Miyashita and Okamura (2011)	-	Min.	Yes*	Low area coverage. Estimate confirmed to come from transect lines only.
12SW	1990	5,244	0.806	100	Aug.-Sep.	IWC (2004, p.124)	Yes	Yes	Yes*	Agreed in 2003. Estimate from IWC (2003, pp.470-72) with CV recalculated (Miyashita, pers. comm.).
12SW	2003	3,401	0.409	100	Aug.-Sep.	Miyashita and Okamura (2011)	-	Yes	Yes*	Low area coverage. Estimate refers only to part of sub-area with adequate coverage.
12NE	1990	10,397	0.364	100	Aug.-Sep.	IWC (2004, p.124)	Yes	Yes	Yes*	Agreed in 2003. Estimate from IWC (2003, pp.470-72); Buckland *et al.* (1992) with CV recalculated (Miyashita, pers. comm.).
12NE	1992	11,544	0.380	89.4	Aug.-Sep.	IWC (2004, p.124); Miyashita and Shimada (1994)	Yes	Yes[7]	Yes*	Agreed in 2003. Estimate from IWC (2003, pp.470-72) with CV recalculated (Miyashita, pers. comm.), see[8].
12NE	1999	5,088	0.377	63.8	Aug.-Sep.	Agreed in 2013 IWC (2014, pp.492-96; pp.504-06)	-	No	Yes*	Omit E block – inadequate coverage. Limit N block to area surveyed. Estimate recalculated using only those parts of the strata that were covered effectively.
12NE	2003	13,067	0.287	46	Aug.-Sep.	Miyashita and Okamura (2011)	-	Yes	Yes*	Estimate is based on the 3 blocks with adequate survey coverage; for the northernmost block includes only the area covered by completed transects. 2 blocks with inadequate coverage are omitted.

[1] The Standard (STD) estimate based on 'Top and Upper bridge will be used as given in the catch limit calculations (when conditioning the estimates are adjusted for $g(0)$').

[2] CV does not consider any process errors.

[3] References: see list of references below Table 7. Further details of the estimates are given in Appendices 3 and 4.

[4] The Condition 2013 trials column shows whether the estimate was used in conditioning the 2013 trials. 'Min.' indicates that the estimate was used as a minimum value. # indicates that the estimate was revised after the conditioning was performed; for details of the value used for conditioning see Appendix 2, Table 6.

[5] This estimate was agreed to be suitable for use in trials but is not used in the current trials as the September estimate (which has the correct formal time stamp for RMP input) is used instead.

[6] For conditioning, the 2007 estimates from sub-areas 7E and 8 were combined.

[7] The wrong year stamp (1999) was used when conditioning the trials (IWC, 2014).

[8] The estimate for subarea 12 from Miyashita & Shimada 1994 (10,897 CV 0.46 areal coverage 91.2%) was scaled up (to 11,948) to render it comparable to that from 1989/90 (IWC 1997 p211) and was then split between 12SW (404) and NE (11,544).

Table 7

List of accepted abundance estimates used in the RMP context for western North Pacific minke whales. The abundance estimates are provided not for populations but the sub-areas given consideration of existing multiple stock structure hypotheses. If not otherwise stated, the abundance estimates are given under the assumption of *g*(0)=1. Abbreviations used in 'Category': (1) acceptable for use in in-depth assessments or for providing management advice; (2) underestimate - suitable for 'conservative' management but not reflective of general abundance; or (3) while not acceptable for use in (1), adequate to provide a general indication of abundance. Abbreviations in 'Evaluation extent': '1': the estimate was examined in detail by the sub-group; 'C' and 'C_{min}': used in the conditioning as an absolute and minimum abundance, respectively; 'T': used in the trials but further analysis needs to be considered before use in an actual *CLA* calculation. See Table 6 for more detailed annotation. Additional estimates are available but it was agreed they would not be used in the 2013 trials so they are not included here (for details see IWC (2012, pp.422-23; 451-53). See Annex Q for a description of the other abbreviations.

Area	Category	Evaluation extent	Year	Method	Corrected	Estimate and approx. 95% CI or equivalent	IWC reference	Original reference	Comments
Population: Western North Pacific									
Sub-area 6E	1	1	2003	DS	P	940 (470-1,840)	Appendix 3	Miyashita *et al.* (2009)	
Sub-area 6E	1	1	2004	DS	P	730 (360-1,470)	Appendix 3	Miyashita *et al.* (2009)	
Sub-area 10W	1	1	2006	DS	P	2,480 (1,360-4,500)	Appendix 3	Miyashita and Okamura (2011)	*g*(0)-corrected estimate 3,400 (2,600-4,400) Okamura *et al.* (2010)
Sub-area 10E	1	1	2002	DS	P	820 (250-2,640)	Appendix 3	Miyashita *et al.* (2009)	
Sub-area 10E	1	1	2003	DS	P	410 (140-1,140)	Appendix 3	Miyashita *et al.* (2009)	
Sub-area 10E	1	1	2005	DS	P	600 (260-1,370)	Appendix 3	IWC (2014, pp.504-06)	
Sub-area 7WR	1	1	2004	DS	P	860 (270-2,750)	Appendix 3	Hakamada and Kitakado (2010rev)	
Sub-area 7E	1	1	2004	DS	P	440 (110-1,700)	Appendix 3	Hakamada and Kitakado (2010rev)	
Sub-area 7E	1	1	2006	DS	P	250 (60-1,110)	Appendix 3	Hakamada and Kitakado (2010rev)	
Sub-area 8	1	1	1990	DS	P	1,060 (300-3,680)	Appendix 3	IWC (2004, p.124); IWC (1997, p.203)	
Sub-area 8	1	1	2002	DS	P	0	Appendix 3	Hakamada and Kitakado (2010rev)	
Sub-area 8	1	1	2004	DS	P	1,090 (380-3,120)	Appendix 3	Hakamada and Kitakado (2010rev)	
Sub-area 8	1	1	2006	DS	P	310 (90-1,030)	Appendix 3	Hakamada and Kitakado (2010rev)	
Sub-area 9	1	1	1990	DS	P	8,300 (3,900-17,500)	Appendix 3	IWC (2004, p.124); IWC (1997, p.203, p.211)	
Sub-area 9	1	1	2003	DS	P	2,550 (1,500-4,330)	Appendix 3	Hakamada and Kitakado (2010rev)	
Sub-area 9N	1	1	2005	DS	P	420 (90-2,070)	Appendix 3	Miyashita and Okamura (2011)	*g*(0)-corrected estimate 2,080 (1,600-2,600) for SA 8+9+12, Okamura *et al.* (2010)
Sub-area 11	1	1	1990	DS	P	2,120 (920-4,910)	Appendix 3	IWC (2004, p.124); IWC (1997, p.203, p.211)	
Sub-area 11	1	1	1999	DS	P	1,460 (520-4,090)	Appendix 3	IWC (2004, p.124); IWC (2003, pp.470-72)	
Sub-area 5	2	1 [C_{min} & T]	2001	DS	P	1,530 (590-4,020)	Appendix 4	An *et al.* (2010)	13% area coverage
Sub-area 5	2	1 [C_{min} & T]	2004	DS	P	800 (430-1,480)	Appendix 4	An *et al.* (2010)	13% area coverage
Sub-area 5	2	1 [C_{min} & T]	2008	DS	P	680 (340-1,380)	Appendix 4	An *et al.* (2010)	13% area coverage
Sub-area 5	2	1 [T]	2011	DS	P	590 (270-1,260)	Appendix 4	Park *et al.* (2012)	13% area coverage
Sub-area 6W	2	1 [C_{min} & T]	2000	DS	P	550 (250-1,210)	Appendix 4	An *et al.* (2010)	14% area coverage
Sub-area 6W	2	1 [C_{min} & T]	2002	DS	P	390 (130-1,180)	Appendix 4	An *et al.* (2010)	14% area coverage
Sub-area 6W	2	1 [C_{min} & T]	2003	DS	P	490 (250-930)	Appendix 4	An *et al.* (2010)	14% area coverage
Sub-area 6W	2	1 [C_{min} & T]	2005	DS	P	340 (180-620)	Appendix 4	An *et al.* (2010)	14% area coverage
Sub-area 6W	2	1 [C_{min} & T]	2006	DS	P	460 (180-1,190)	Appendix 4	An *et al.* (2010)	14% area coverage
Sub-area 6W	2	1 [C_{min} & T]	2007	DS	P	570 (250-1,300)	Appendix 4	An *et al.* (2010)	14% area coverage
Sub-area 6W	2	1 [C_{min} & T]	2009	DS	P	880 (510-1,530)	Appendix 4	An *et al.* (2010)	14% area coverage
Sub-area 6W	2	1 [T]	2010	DS	P	1,010 (480-2,150)	Appendix 4	An *et al.* (2011)	14% area coverage
Sub-area 6E	2	1 [C & T]	2002	DS	P	890 (300-2,670)	Appendix 3	Miyashita *et al.* (2009)	Poor coverage and analysis difficulties
Sub-area 7CS	2	1 [T]	1991	DS	P	0	Appendix 3	Butterworth and Miyashita (2014)	
Sub-area 7CS	2	1 [C & T]	2004	DS	P	500 (290-880)	Appendix 3	IWC (2014, pp.492-96; pp.504-06)	
Sub-area 7CS	2	1 [C & T]	2006	DS	P	3,700 (600-23,500)	Appendix 3	Hakamada and Kitakado (2010rev)	Non-random start
Sub-area 7CS	2	1 [T]	2012	DS	P	890 (420-1,870)	Appendix 3	Hakamada *et al.* (2013)	
Sub-area 7CN	2	1 [T]	1991	DS	P	850 (550-1,330)	Appendix 3	Butterworth and Miyashita (2014)	
Sub-area 7CN	2	1 [T]	2012	DS	P	300 (130-710)	Appendix 3	Hakamada *et al.* (2013)	
Sub-area 7CN	2	1 [T]	2012	DS	P	400 (160-1,020)	Appendix 3	Hakamada *et al.* (2013)	
Sub-area 7WR	2	1 [T]	1991	DS	P	310 (200-490)	Appendix 3	Butterworth and Miyashita (2014)	
Sub-area 7WR	2	1 [C_{min} & T]	2003	DS	P	270 (80-920)	Appendix 3	IWC (2014, pp.492-96; pp.504-06)	27% coverage.
Sub-area 7WR	2	1 [C & T]	2007	DS	P	550 (110-2,640)	Appendix 3	Hakamada and Kitakado (2010rev)	Non-random start

Cont.

Area	Category	Evaluation extent	Year	Method	Corrected	Estimate and approx. 95% CI or equivalent	IWC reference	Original reference	Comments
Sub-area 7E	2	1 [C & T]	2007	DS	P	0	Appendix 3	Hakamada and Kitakado (2010rev)	Non-random start etc.
Sub-area 8	2	1 [C & T]	2005	DS	P	130 (24-710)	Appendix 3	Hakamada and Kitakado (2010rev)	Non-random start etc.
Sub-area 8	2	1 [C & T]	2007	DS	P	390 (80-2,030)	Appendix 3	Hakamada and Kitakado (2010rev)	Non-random start etc.
Sub-area 11	2	1 [C & T]	2003	DS	P	880 (220-3,600)	Appendix 3	Miyashita and Okamura (2011)	*g*(0)-corrected estimate 42,100 (32,700-54,200) in SA 11+12SW+12NE Okamura *et al.* (2010)
Sub-area 11	2	1 [C_{min} & T]	2007	DS	P	380 (180-790)	Appendix 3	Miyashita and Okamura (2011)	20% coverage. *g*(0)-corrected estimate 500 (250-1,000) in SA11. Okamura *et al.* (2010)
Sub-area 12SW	2	1 [C & T]	1990	DS	P	5,240 (1,300-21,000)	Appendix 3	IWC (2004, p.124)	
Sub-area 12SW	2	1 [C & T]	2003	DS	P	3,400(1,570-7,350)	Appendix 3	Miyashita and Okamura (2011)	*g*(0)-corrected estimate 42,100 (32,700-54,200) in SA 11+12SW+12NE Okamura *et al.* (2010)
Sub-area 12NE	2	1 [C & T]	1990	DS	P	10,400 (5,200-20,800)	Appendix 3	IWC (2004, p.124)	
Sub-area 12NE	2	1 [C & T]	1992	DS	P	11,500 (5,620-23,700)	Appendix 3	IWC (2004, p.124)	
Sub-area 12NE	2	1 [T]	1999	DS	P	5,100 (2,500-10,400)	Appendix 3	IWC (2014, pp.492-96; pp.504-06)	
Sub-area 12NE	2	1 [C & T]	2003	DS	P	13,100 (7,500-22,700)	Appendix 3	Miyashita and Okamura (2011)	*g*(0)-corrected estimate 42,100 (32,700-54,200) in SA 11+12SW+12NE Okamura *et al.* (2010)
Sub-area 10E	3	1 [C]	2004	DS	P	470 (180-1,270)	Appendix 3	Miyashita *et al.* (2009)	Design questioned
Sub-area 10E	3	1 [C]	2007	DS	P	580 (310-1,070)		Miyashita *et al.* (2009)	
Sub-area 7CN	3	1 [C]	2003	DS	P	180 (50-740)	Appendix 3	Hakamada and Kitakado (2010rev)	Problem in coverage
Sub-area 7E	3	1	1990	DS	P	790 (70-8,620)	Appendix 3	IWC (2004, p.124)	CV too high to be meaningful

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the RMP following further analysis. The Working Group re-established the Intersessional Steering Group to co-ordinate the work needed to determine whether the abundance estimates marked with asterisks can be accepted for use in actual applications of the RMP (see Item 11). Final decisions regarding which abundance estimates can be used in actual applications of the RMP will be made at next year's meeting.

6.3.2 Historical and future removals

Last year, the Committee had agreed that the best estimates of the direct catches and the average predicted bycatch from the six baseline trials would be used in actual applications of the *RMP*.

7. CONSIDERATION OF DATA/ANALYSES TO REDUCE HYPOTHESES IN FUTURE

The Working Group did not have sufficient time to discuss this item fully. It **encouraged** those contracting governments which are contemplating application of the RMP to review previous discussions on this matter in the Committee. The Working Group highlighted that the *Implementation Simulation Trials* structure provided a way to identify the value of information to resolve uncertainties. In particular, analyses could be undertaken to assess where data on mixing proportions and abundance would be most informative in terms of resolving the plausibility of various hypotheses. The Working Group recognised that becoming familiar with how to use the *Implementation Simulation Trials* structure to evaluate the value of information could be complicated, and **encourages** members of the Working Group to work with the Secretariat to develop the ability to condition and run trials.

The Working Group identified some potential areas for consideration during the development of a research proposal:

(1) identification of breeding areas;
(2) examination of movements from feeding to breeding areas using, for example, satellite tagging;
(3) sampling animals from the breeding areas and the Okhotsk Sea;
(4) studies to examine whether some minke whales are resident in coastal waters year-round; and
(5) analyses based on close-kin for evaluation of stock structure hypotheses.

The Working Group noted that any proposal submitted would be reviewed at next years' meeting. It established an Advisory Group consisting of members of the Intersessional Steering Group as well as Waples, Gaggiotti, and Hoelzel. The function of the Advisory Group is to provide feedback to those developing research programmes during the intersessional period.

8. SURVEYS

8.1 Results from recent surveys

SC/65a/NPM01 presented the results of satellite tracking of common minke whales in the Sea of Japan in autumn 2012. The survey was conducted from 12 October to 20 November 2012, using a research vessel, S*honan-maru No. 2*. The survey was initially planned for Russian waters in the Sea of Japan, but the Government of the Russian Federation did not issue a survey permit. A total of 1,537.7 n.miles was searched using closing mode, and eight schools of nine individual common minke whales were sighted. Satellite tags (Argos transmitter) were deployed on two common minke whales off the east coast of Rishiri Island on 6 November 2012 using a handheld air gun. Biopsy sampling of the tagged animal was unsuccessful. A mother with a calf was tracked for 14 days. She mostly stayed in the area where she was tagged. Common minke whales might feed on the fish in this area even in late autumn because sandlance are common in the area. Little information on migration behaviour was obtained given the short transmission duration.

The Working Group welcomed this information. Members noted that limpet tags had been used to attach transmitters successfully to Antarctic minke whales. Deploying these tags requires the use of small boats rather than from the research vessel. The Working group **recommended** that researchers conducting tagging studies on North Pacific minke whales work together with those conducting similar work in other areas, particularly in relation to tag technology and deployment. With larger sample sizes, satellite tagging could help to resolve questions regarding the behaviour of animals, such as whether some J-stock animals are resident year-round in the Sea of Japan.

SC/65a/NPM04 provided a cruise report on a sighting survey which was conducted to obtain information on the distribution and abundance of minke whales and other cetaceans in the East Sea using the research vessel, *Tamgu 3* from 18 April to 13 May in 2012. During the survey period, the research vessel searched 1,109.37 n.miles and 4 minke whales in 4 primary sightings were observed. In addition, 957 small cetaceans in 6 primary sightings were sighted during the survey.

The Working Group noted that An provided oversight on behalf of the Committee but was not present on the survey itself. It was also noted that the tracklines did not correspond to the original design. This was partly because the original tracklines included Japanese waters but the survey was not conducted in Japanese waters. The tracklines also deviated from the planned tracklines in coastal waters to the south and east of Korea.

8.2 Plans for future surveys

SC/65a/NPM02 presented the research plan for a sighting survey for common minke whales in the Sea of Okhotsk, including the Russian EEZ, in summer 2014. The primary objective of the survey is to obtain a new estimate of abundance for sub-areas 11 and 12. A systematic line transect survey will be conducted following the guidelines for conducting surveys under the RMP. The secondary objective of the survey will be biopsy sampling and satellite tagging for common minke whales, if permission is obtained from the Government of the Russian Federation. This latter objective is important given the need to obtain information on the mixing rate of J- and O-stocks, and the distribution of J-stock in the Sea of Okhotsk. The survey will be conducted using one or two dedicated sighting survey vessels. Each vessel will cruise for about 40 days in July to September, although the details of the research plan may be changed depending on logistics. Onboard Russian observers or co-researchers will be welcomed.

The Working Group welcomed the plan for a survey for common minke whales in this area given there have been no surveys in sub-area 12 in recent years. It **strongly recommends** that the Government of the Russian Federation give permission for the survey to take place in its EEZ throughout sub-area 12, given the importance of abundance estimates for sub-area 12 to the understanding of the status of common minke whales in the western North Pacific. The Working Group appointed Miyashita to provide oversight on behalf of the Committee.

The Working Group noted the value of collecting biopsies for whale species other than common minke whales,

Table 8

Possible populations for CMPs.

Population	Abundance	% of unexploited	Trend	Range states	Known/likely threats	Information gaps
Minke whales in the coastal waters of China, Japan and Republic of Korea	J-like stocks: 5,078-15,868 [1] Y-stock: 4,019-4,683 [1]	J-like stocks: 24-84% [1] Y- stock: 20-31% [1]	Historical: not quantified using surveys Future: projected substantial future decline	China, Republic of Korea, North Korea, Japan, Russian Federation	Catches[2]	Stock structure Survey coverage for Yellow Sea; Sea of Japan/East Sea

[1]Estimated from trials. Values given are the maximum and minimum values from the 1+ population from all of the best fit runs of the Baseline trials (A01, B01 and C01 with MSYR 1% and 4%) for the year 2012. [2]Catches comprise incidental catches, illegal catches and Special Permit catches.

particularly for North Pacific right whales, and also suggested that weather patterns should be considered when planning surveys to enable predictions of likely realised effort.

SC/65a/NPM05 reported that a sighting survey for common minke whale will be conducted using the research vessel *Tamgu 3* in the Yellow Sea in spring 2014. The first objective of this survey is to obtain information on the distribution and abundance of common minke whales. The second objective is to collect information on the distribution of other cetaceans in the area. A total of 769.7 n.miles is planned to be searched using closing mode. Other research activities including biopsy sampling and photo identification will be conducted during the survey. This survey is part of a four-year programme to survey the waters of sub-areas 5 and 6W and increase survey coverage from 13% to 35%.

The survey will not cover waters close inshore in the north of the survey area because of the concentration of fishing gear and aquaculture in that area. The Working Group appointed An to provide oversight on behalf of the Committee.

9. UPDATED LIST OF ACCEPTED ABUNDANCE ESTIMATES

Appendices 3 and 4 summarise information on primary effort, primary sighting position, survey blocks, sub-areas, and area definitions for surveys for western North Pacific minke whales. The Working Group thanked Miyashita, Hakamada and An for providing this information, which had been requested by the Second Intersessional Workshop.

Table 7 lists the estimates of abundance in the format proposed by the Convenors for consideration by the Scientific Committee.

10. CONSERVATION MANAGEMENT PLANS

The Working Group considered the request from the Commission to identify populations for which Conservation Management Plans (CMPs) could be developed. Donovan advised the Working Group that the development of CMPs was the responsibility of range states rather than the Commission. Of the populations considered by the Working Group, only minke whales in the coastal areas of Japan, China and the Republic of Korea satisfied the guidelines for populations which could be subject to a Conservation Management Plan. The Working Group was not in full agreement on whether to forward any populations to the Scientific Committee for further discussion. Some members proposed that minke whales in the coastal waters of China, Japan and the Republic of Korea should be forwarded because of the projected impact of incidental bycatch (see Table 8).

Other members believed that it was premature to forward any populations given there is uncertainty regarding stock structure and because the survey coverage for the western North Pacific minke whales is low in some areas, particularly the sub-areas 5 and 6W. Regarding stock structure, those members proposing that minke whales in coastal waters should be the subject of a CMP noted that J- and Y-stocks were depleted under all stock structure hypotheses. Regarding low survey coverage, the Working Group noted that the estimates of depletion in the table have not been able to take this into account.

11. WORK PLAN

The Working Group **agrees** the following work plan for the 2014 Annual Meeting:

(1) review the results of 'hybrid' versions of RMP variants to allow an evaluation of any candidate 'variant with research';
(2) review any research proposals related to a candidate 'variant with research'; and
(3) agree the estimates of abundance for use in actual applications of the RMP.

The Secretariat will additionally need to create documents that include all of the conditioning plots, all of the catch plots, all of the trajectory plots and all of the tabular output for all the *Implementation Simulation Trials*.

The Working group re-established the Intersessional Steering Group (Butterworth (Convenor), Allison, An, Baker, de Moor, Donovan, Double, Kanda, Kelly, Kitakado, Miyashita, Park, Pastene, Punt, and Wade) to co-ordinate the intersessional work, and prepare for the 2014 Annual Meeting.

12. ADOPTION OF REPORT

The Report was adopted at 16:55 on 11 June 2013.

The Working Group thanked Punt for rapporteuring. It expressed its appreciation to the Steering Group for their guidance, to Butterworth and Donovan for guiding the *Implementation Review* during the intersessional periods, to Hammond for his chairmanship of what has proved the most complicated *Implementation* to date and finally, and particularly, to Allison and de Moor without whom it would not have been possible to complete the *Implementation Review*.

The Working Group gratefully acknowledged the provision of computing facilities by the University of Cape Town's ICTS High Performance Computing team for some of the computations.

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Appendix 1

AGENDA

1. Introductory items
    - 1.1 Election of chair and appointment of rapporteurs
    - 1.2 Chair's opening remarks
    - 1.3 Adoption of Agenda
    - 1.4 Review of documents
2. Report of the intersessional Workshop, March 2013 (SC/65a/Rep04)
3. Progress since intersessional Workshop
    - 3.1 Updates to trial specifications
    - 3.2 Review final conditioning results
4. Guidelines for reviewing results of *Implementation Simulation Trials*
    - 4.1 Overview and procedure to follow
    - 4.2 Presentation style for results
5. Review trial results
    - 5.1 Variants 1, 2, 3, 4 and 6
    - 5.2 Variant 5
    - 5.3 Variant 7
    - 5.4 Variant 8
    - 5.5 Variant 9
    - 5.6 Variant 10
    - 5.7 Variant 11
    - 5.8 Variants with research
6. Recommendations to the Scientific Committee
    - 6.1 Management areas
    - 6.2 Variants
    - 6.3 Inputs for *CLA*
        - 6.3.1 Estimates of abundance
        - 6.3.2 Historical and future removals
7. Consideration of data/analyses to reduce hypotheses in future
8. Surveys
    - 8.1 Results from recent surveys
    - 8.2 Plans for future surveys
9. Table of estimates of abundance
10. Conservation Management Plans
11. Adoption of Report

Appendix 2

NORTH PACIFIC MINKE WHALE *IMPLEMENTATION SIMULATION TRIAL* SPECIFICATIONS

C. Allison, C.L. de Moor and A.E. Punt

A. Basic concepts and stock structure

The objective of the North Pacific minke whale *Implementation Simulation Trials* is to examine the performance of the RMP in scenarios that relate to the actual problem of managing a likely fishery for minke whales in the North Pacific. The trials attempt to bound the range of plausible hypotheses regarding the number of minke whale stocks in the North Pacific, how they feed (by sex, age and month) and recruit and how surveys index them. The underlying dynamics model is age- and sex-structured and allows for multiple stocks. Allowance is made for possible dispersal (permanent transfer of animals between stocks).

The region to be managed (the western North Pacific) is divided into 22 sub-areas (see Fig. 1). Future surveys are unlikely to cover sub-areas 1, 2, 3, 4 and 13 (see Table 3) so these sub-areas are taken to be *Residual Areas* in the current trials (although allowance is made for future bycatches from some of these sub-areas – see section D). The term 'stock' refers to a group of whales from the same breeding ground.

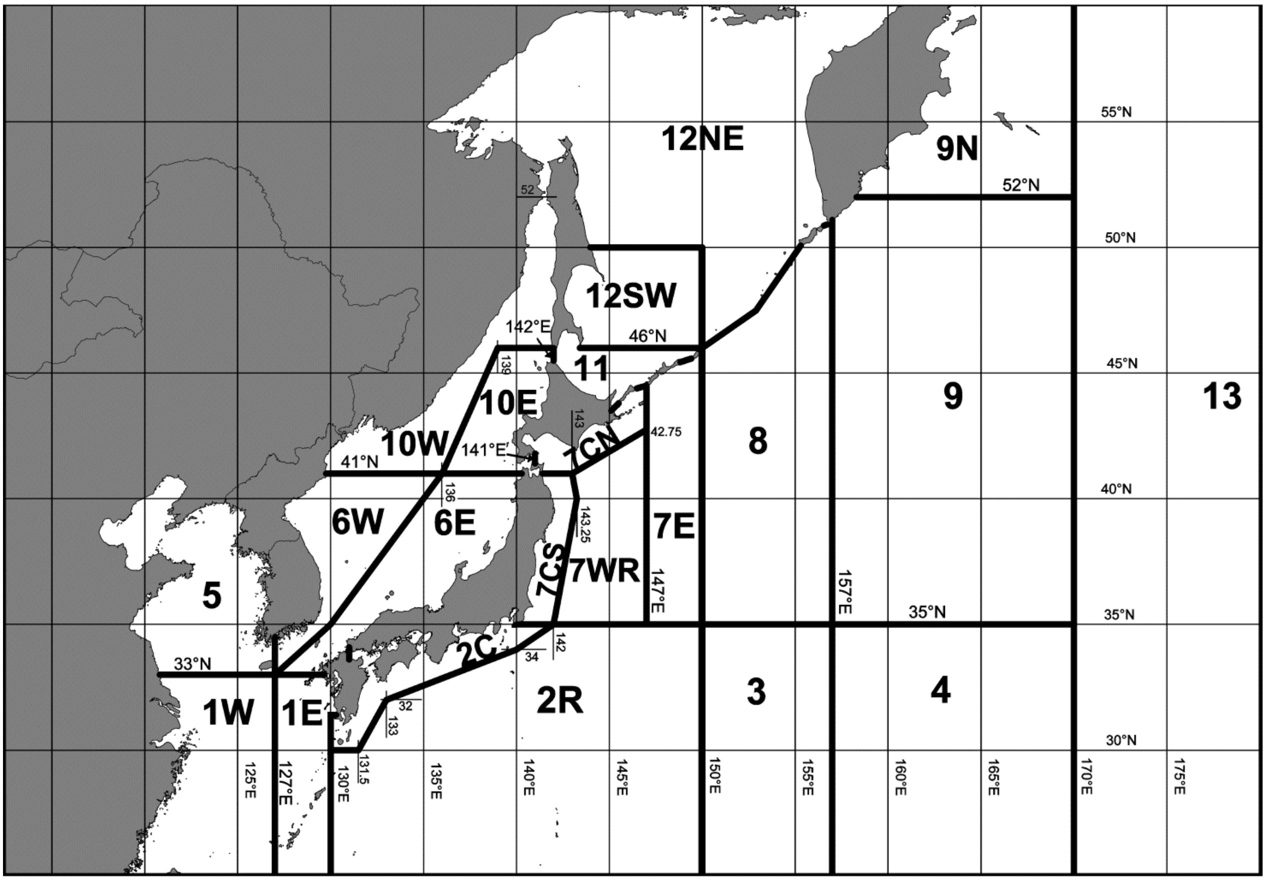

Fig. 1. The 22 sub-areas used for the *Implementation Simulation Trials* for North Pacific minke whales.

Three fundamental hypotheses are considered to account for patterns observed in the results from the genetic analyses:

(a) there is a single J-stock distributed in the Yellow Sea, Sea of Japan, and Pacific coast of Japan, and a single O-stock in sub-areas 7, 8, and 9 (referred to as hypothesis A);

(b) as for hypothesis (A), but there is a third stock (Y-stock) which resides in the Yellow Sea and overlaps with J-stock in the southern part of sub-area 6W (referred to as hypothesis B); and

(c) there are five stocks, referred to Y, JW, JE, OW, and OE, two of which (Y and JW) occur in the Sea of Japan, and three of which (JE, OW, and OE) are found to the east of Japan (referred to as hypothesis C).

Sensitivity tests in which there is a C-stock are also conducted based on stock structure hypotheses A and C. The C-stock stock is found in sub-areas 9 and 9N for the sensitivity test based on stock structure hypothesis A and in these sub-areas as well as sub-area 12NE for the sensitivity test based on stock structure hypothesis C. There is uncertainty regarding whether C-stock is found in sub-area 12NE because of the lack of genetics data for this sub-area.

B. Basic dynamics

Further details of the underlying age-structured model and its parameters can be found in IWC (1991, p112), except that the model has been extended to take sex-structure and dispersal into account. The dynamics of the animals in stock j are governed by equations B.1(a) for stocks for which there is no dispersal (permanent movement) between stocks as is the case in all the base case trials. Stocks for which there is dispersal are governed by Equations B.1(b):

$$N_{t+1,a}^{g,j} = \begin{cases} 0.5 b_{t+1}^{j} & \text{if } a = 0 \\ (N_{t,a-1}^{g,j} - C_{t,a-1}^{g,j})\tilde{S}_{a-1} & \text{if } 1 \le a < x \\ (N_{t,x}^{g,j} - C_{t,x}^{g,j})\tilde{S}_{x} + (N_{t,x-1}^{g,j} - C_{t,x-1}^{g,j})\tilde{S}_{x-1} & \text{if } a = x \end{cases} \quad \text{(B.1a)}$$

$$N_{t+1,a}^{g,j} = \begin{cases} 0.5 b_{t+1}^{j} & \text{if } a = 0 \\ \sum_{j \ne j'} [\left(1 - D^{j,j'}\right)(N_{t,a-1}^{g,j} - C_{t,a-1}^{g,j})\tilde{S}_{a} + D^{j',j}(N_{t,a-1}^{g,j'} - C_{t,a-1}^{g,j'})\tilde{S}_{a}] & \text{if } 1 \le a < x \\ \sum_{j \ne j'} [\left(1 - D^{j,j'}\right)\left((N_{t,x}^{g,j} - C_{t,x}^{g,j})\tilde{S}_{x} + (N_{t,x-1}^{g,j} - C_{t,x-1}^{g,j})\tilde{S}_{x-1}\right) & \\ \quad \ldots\ldots\ldots + D^{j',j}\left((N_{t,x}^{g,j'} - C_{t,x}^{g,j'})\tilde{S}_{x} + (N_{t,x-1}^{g,j'} - C_{t,x-1}^{g,j'})\tilde{S}_{x-1}\right)] & \text{if } a = x \end{cases} \quad \text{(B.1b)}$$

where

$N_{t,a}^{g,j}$ is the number of animals of gender *g* and age *a* in stock *j* at the start of year *t*;

$C_{t,a}^{g,j}$ is the catch (in number) of animals of gender *g* and age *a* in stock *j* during year *t* (whaling is assumed to take place in a pulse at the start of each year);

b_t^j is the number of calves born to females from stock *j* at the start of year *t*;

$\tilde{S}_a$ is the survival rate = e^{-M_a} where M_a is the instantaneous rate of natural mortality (assumed to be independent of stock and sex);

x is the maximum age (treated as a plus-group); and

$D^{j,j'}$ is the dispersal rate (i.e. the probability of an animal moving permanently) from stock *j* to *j′* (note: there is only dispersal between the OW and OE stocks and between the JW and JE stocks).

Note that *t*=0, the year for which catch limits might first be set, corresponds to 2013.

For computational ease, the numbers-at-age by sex are updated at the end of each year only, even though catching is assumed to occur from March to October. This simplification is unlikely to affect the results substantially for two reasons: (1) catches are at most only a few percent of the number of animals selected to the fisheries; and (2) sightings survey estimates are subject to high variability so that the resultant slight positive bias in abundance estimates is almost certainly inconsequential.

C. Births

Density-dependence is assumed to act on the female component of the mature population. The convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition.

$$b_t^j = B^j N_t^{\mathrm{f},j}\{1 + A^j(1 - (N_t^{\mathrm{f},j} / K^{\mathrm{f},j})^{z^j})\} \quad \text{(C.1)}$$

where

B^j is the average number of births (of both sexes) per year for a mature female in stock *j* in the pristine population;

A^j is the resilience parameter for stock *j*;

z^j is the degree of compensation for stock *j*;

$N_t^{\mathrm{f},j}$ is the number of 'mature' females in stock *j* at the start of year *t*:

$$N_t^{\mathrm{f},j} = \sum_{a=a_m}^{x} N_{t,a}^{\mathrm{f},j} \quad \text{(C.2)}$$

a_m is the age-at-first-parturition; and

$K^{\mathrm{f},j}$ is the number of mature females in stock *j* in the pristine (pre-exploitation, written as *t*=-∞) population:

$$K^{\mathrm{f},j} = \sum_{a=a_m}^{x} N_{-\infty,a}^{\mathrm{f},j} \quad \text{(C.3)}$$

The values of the parameters A^j and z^j for each stock are calculated from the values for $MSYL^j$ and $MSYR^j$ (Punt, 1999). Their calculation assumes harvesting equal proportions of males and females.

D. Catches

The operating model considers two sources for non-natural mortality: direct catches and bycatches (which are also referred to as incidental catches). In future ($t \geq 2013$), the former are set by the RMP, while the latter are a function of abundance and future fishery effort. In cases in which the catch limit set by the RMP is less than the level of incidental catch, the total removals are taken to be the incidental catch only whereas if the RMP catch limit exceeds the incidental catch (if any), the level of the commercial removals is taken to be the difference between the RMP catch limit and the best estimate of the incidental catch (see 'Future incidental catches' below).

Direct catches

The direct historical (pre-2013) catch series used are listed in Adjunct 1 and include both commercial and special permit catches. The baseline trials use the 'best' direct catch series and an alternative 'high' catch series is used in sensitivity trial 4. Sensitivity trials 8 and 9 test the effect of the method used to allocate historical catches between sub-areas 5 and 6W. The RMP will use the 'best' series in all trials. Consequently, the RMP will use what are in effect incorrect catches for trials 4, 8 and 9 in order to examine the implications of uncertainty about historical catches.

Catch limits are set by *Small Area*. (Catches are always reported by *Small Area*, i.e. the RMP is not provided with catches by sub-area for cases in which sub-areas are smaller than *Small Areas*.) As it is assumed that whales are homogeneously distributed across a sub-area, the catch limit for a sub-area is allocated to stocks by sex and age relative to their true density within that sub-area, and a catch mixing matrix V that depends on sex, age and time of the year (and may also depend on year), i.e.

$$C^{g,j}_{t,a} = \sum_k \sum_q F^{g,k,q}_t \sum_a V^{g,j,k,q}_{t,a} S^g_a \tilde{N}^{g,j}_{t,q,a} \tag{D.1}$$

$$F^{g,k,q}_t = \frac{C^{g,k,q}_t}{\sum_{j'} \sum_{a'} V^{g,j',k,q}_{t,a'} S^g_{a'} \tilde{N}^{g,j'}_{t,q,a'}} \tag{D.2}$$

where

$F^{g,k,q}_t$ is the exploitation rate in sub-area k on fully recruited ($S^g_a \to 1$) animals of gender g during month q of year t;

S^g_a is the selectivity on animals of gender g and age a :

$$S^g_a = (1 + e^{-(a - a^g_{50})/\delta^g})^{-1} \tag{D.3}$$

$\tilde{N}^{g,j}_{t,q,a}$ is the number of animals of gender g and age a in stock j at the start of month q in year t after removal of catches in earlier months and after any bycatches have been removed;

a^g_{50}, δ^g are the parameters of the (logistic) selectivity ogive for gender g; and

$C^{g,k,q}_t$ is the catch of animals of gender g in sub-area k during month q of year t (see Adjunct 1 for the historical catches).

Each entry in the catch mixing matrix, $V^{g,k,q}_{t,a}$, is the fraction of males/females of age a from stock j which are found in sub-area k during month q of year t. The catch mixing matrix is different for each month to reflect the effects of migration between the breeding and the feeding grounds. Adjunct 2 lists the catch mixing matrices considered. The matrices are based on the presence/absence matrices developed at the September 2010 workshop (IWC, 2012b) and give the relative fraction of an age-class in each of the sub-areas during the months March-October. Once the values of the parameters related to mixing rates (the γs – see section F) are specified (these are estimated separately for each trial and each replicate in the conditioning process), the catch mixing matrices can be converted to fractions of each age-class in each sub-area. The values for the γ parameters are selected to mimic available data (see Section F).

Catch mixing matrices are specified for ages 4 and 10 (these being three years below and above the assumed age-at-50%-maturity). Few animals of age 4 are mature while most of age 10 are. The catch mixing matrices for ages 0-3 are assumed to be the same as that for age 4, and those for ages 11+ the same as that for age 10. The catch mixing matrices for ages 5-9 are set by interpolating linearly between those for ages 4 and 10.

The trials model whale movements in the eight-months from March to October. In order to account for historical direct and incidental catches outside these months, all catches in January-March are modelled as being taken in March and the catches after October are assumed to have been taken in October. The historical direct catches by sex, sub-area, month and year are given in Adjunct 1. Details of the sources and construction of the catch data series are given in Allison (2011).

The trials are conducted assuming that the sub-areas for which future catch limits might be set are:

Sub-area	5	March to November (coastal whaling >60 n.miles offshore)
	6W	March to November (coastal whaling >30 n.miles offshore)
	7CS and 7CN	April to October (coastal/pelagic whaling outside 10 n.miles)
	7WR and 7E	April to October (pelagic whaling)
	8 and 9	April to October (pelagic whaling)
	11	August to October (coastal and pelagic whaling)

The future ($t \geq 2013$) commercial catches by sex, sub-area, month and year are calculated using the equation:

$$C^{g,k,q}_t = C^k_t \, Q^{g,k,q} \tag{D.4}$$

$Q^{g,k,q}$ is the fraction of the commercial catch in sub-area k of gender g which is taken during month q, the values of which are given in Table 1a; and

C_t^k is the commercial catch limit for sub-area k and year t ($t \geq 2013$). Note that C_t^k is equal to the catch limit set by the RMP less any reported incidental catch (constrained to be non-negative).

Some of the entries in the Q matrix are determined by the options related to the sub-areas for which catch limits might be set (e.g. Q is zero from April-July for sub-area 11). The non-zero entries in the Q matrix (see Table 1a) reflect the historical breakdown of catches over the last 10 years of commercial whaling (1978-87) within each sub-area. In sub-areas for which there was no catch between 1978-87 (7E, 8 and 9), the entries in the Q matrix are set using the entire historical commercial and scientific catch in these sub-areas. In some instances where regulations limited the commercial whaling season, the matrix entries have been adjusted using the special permit data.

Table 1a.

The Q matrix: the percentage of the future commercial catch in sub-area k that is taken by sex and month for sub-areas other than *Residual Areas*. Dashes indicate sub-areas/months for which catch limits are defined to be zero. See text for description of how the entries are set.

Sub-area	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
				Males								Females				
5	5.8	19.2	10.9	6.7	8.0	4.6	1.7	0.0	5.3	13.0	7.1	4.6	7.2	3.3	2.7	0.0
6W	0.2	1.9	14.8	11.4	5.5	2.0	8.9	9.9	0.2	0.9	13.3	9.8	3.4	1.2	8.4	8.2
7CS	-	24.3	21.5	10.1	4.8	0.8	0.3	0.0	-	21.7	12.6	2.8	0.7	0.3	0.0	0.0
7CN	-	0.0	0.8	7.9	15.1	14.9	23.2	15.1	-	0.1	0.3	4.8	6.7	3.4	5.1	2.5
7WR	-	1.1	47.9	30.9	3.2	1.1	1.1	0.0	-	0.0	9.6	2.1	3.2	0.0	0.0	0.0
7E	-	0.0	36.5	11.0	2.2	8.3	14.4	1.1	-	0.0	4.4	2.2	5.5	5.5	8.8	0.0
8	-	0.0	12.6	34.2	32.0	4.5	3.3	2.2	-	0.0	3.0	2.2	3.3	0.0	0.7	1.9
9	-	0.0	5.8	14.8	33.2	34.7	1.8	0.0	-	0.0	1.6	1.8	2.7	3.5	0.0	0.0
11	-	-	-	-	-	27.0	20.3	3.7	-	-	-	-	-	30.3	15.7	3.0
11 for Variant 10	-	-	10.4	18.1	-	-	-	-	-	-	36.5	35.0	-	-	-	-

The future commercial catches in sub-areas 7CS and 7CN are removed based on the mixing proportions from the offshore (>10 n.miles) samples only. Denote the modelled mixing proportion used when conditioning to be R^k as:

$$R^k = \sum_{t=1996}^{2007} P_{1+,t}^{J/JE,k} \Big/ \sum_j \sum_{t=1996}^{2007} P_{1+,t}^{j,k} \quad \text{where } P_{1+,t}^{j,k} \text{ is the average 1+ population of stock } j \text{ in sub-area } k \text{ in year } t.$$

The mixing proportions obtained from the offshore samples, $\tilde{R}^k$, are given in Table 2a. The proportion of J/JE-animals in some future year would normally be $P_{1+,t}^{J/JE,k} \big/ (P_{1+,t}^{J/JE,k} + P_{1+,t}^{O/OW,k})$. For sub-areas 7CS and 7CN in future this equation is adjusted to:

$$(\tilde{R}^k \neq R^k):\ \alpha^k P_{1+,t}^{J/JE,k} \big/ (\alpha^k P_{1+,t}^{J/JE,k} + P_{1+,t}^{O/OW,k}) \quad \text{where} \quad \alpha^k = \frac{(1-R^k)\tilde{R}^k}{(1-\tilde{R}^k)R^k} \qquad \text{(D4.a)}$$

The α^k factor is then applied to the recruited population from stock J/JE in sub-area k when setting the commercial catch by stock using equations D.1 and D.2.

In order to comply with RMP specifications regarding the sex ratio in catches (IWC, 1999), if the proportion, P_f, of females in the total direct catch (i.e. commercial and/or special permit) taken from a *Small Area* in the five years prior to the catch limit calculation exceeds 50%, the catch limits are adjusted downwards by the ratio $0.5/P_f$.

Incidental catches

Incidental catches of minke whales are known to occur off Japan (in sub-areas 1E, 2C, 6E, 7CS, 7CN, 10E and 11 and small numbers in 6W) and the Republic of Korea (sub-areas 5 and 6W and small numbers in 1W, 6E and 10W).

Japan: It has been obligatory to report bycatches in Japan since 2001 since when the bycatch numbers are considered to be reliable. Based on the sudden increase in reported bycatches in 2001, earlier bycatches are believed to be under-reported. In view of this, the relationship between bycatch and set-net effort is integrated into the conditioning process, with the advantage that the method is independent of the reporting rate prior to 2001. The reporting rate since 2001 is assumed to be constant at 100% (except in sensitivity trial 4 – see below).

Almost all of the reported bycatch off Japan occurred in set-net fisheries. Three types of set net are used off Japan: large-scale (excluding salmon nets), salmon nets and small scale. For fishing gears other than set-nets, incidental catch, retention and marketing of whales are prohibited by the 2001 regulation and a diagnostic DNA registry is used to deter illegal distribution of whales caught. Ideally, the catch by each gear type should be modelled separately to allow the historical (pre 2001) bycatch to be predicted. However, information on numbers of catches by net type is not available. Therefore the pre 2013 bycatches for each sub-area are set using the total number of incidental catch and the combined number of large-scale and salmon nets in each sub-area. For the best effort series, the number of nets from Japan is extrapolated from 1946 to 1969 assuming a linear relationship from 0 in 1935 to the known number in 1970 (Hakamada, 2010; Tobayama *et al.*, 1992). Incidental catches before 1946 are ignored because although some set-nets were in operation before 1946 (Brownell, pers. comm.) the numbers are highly uncertain and are sufficiently small that they are unlikely to effect the implementation. The years 2007-9 are excluded from the fitting as the number of nets is incomplete, and 2001 is excluded because the catch data are incomplete (as the new regulations date from June 2001). A high effort series is also generated, for use in sensitivity trial 4, in which the number of nets is double the best case values from 1946-1969, up to a maximum equal to the number of nets in 1969. In sensitivity trial 4 all bycatches are under-reported by a factor of 2.

Korea: The same method is used as for Japan above except the incidental catch numbers from 1996-2009 (sub-area 6W) and 2000-2009 (sub-area 5) are used to extrapolate backwards and the catch numbers are adjusted to allow for underreporting. The bycatches in sub-area 6W (the East Sea) are adjusted upward by a factor of 2. The factor 2 is based on DNA profiling and a capture-recapture analysis of market products which estimated a total of 887 whales going through Korean markets from 1999-2003, in comparison to the reported catch of 458 whales (Baker *et al.*, 2007). The base case assumes that the bycatches in the Yellow Sea (sub-area 5) are fully reported as there is no evidence that this is not the case. The 'high' effort series for sub-area 5 used in sensitivity trial 4 will apply the same estimate of under-reporting as for sub-area 6W (i.e. a factor of 2) and the number of nets is double the best case values from 1946-1969, up to a maximum equal to the number of nets in 1969.

To account for bycatch prior to 1996, the average for the *adjusted* takes are used to extrapolate backwards to 1946 based on fisheries effort using the same approach as for Japan. Incidental catches before 1946 are ignored as for Japan.

China: There are no data on incidental catches off China, although they are known to occur. The trials therefore consider two [essentially arbitrary] scenarios: (i) the incidental catches in sub-area 5 are multiplied by 3 (i.e. the incidental catch by China is twice that by Korea in sub-area 5); and (ii) incidental catches off China are ignored. The first of the options forms part of the base case specifications and the second is included in a sensitivity test (see trial 18) to determine the effects of the base case assumptions.

Allocation to sex and month: Bycatches by sex, sub-area (except for sub-areas 7CS and 7CN in future years), month and year are calculated using the equation:

$$C_{B,t}^{g,k,q} = C_{B,t}^{k}\, Q_B^{g,k,q} \tag{D.5}$$

$Q_B^{g,k,q}$ is the fraction of the by-catch in sub-area k which is taken during month *q* and gender *g*, the values of which are given in Table 1b; and

$C_{B,t}^{k}$ is the by-catch in sub-area *k* and year *t* (as estimated by the model).

Table 1b

QB matrix: the percentage of the incidental catch in sub-area *k* that is taken by sex and month.
The values are set using all the available bycatch data known by sub-area, sex and month. There is no incidental catch in the other sub-areas.

Sub-area	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Sample size
	Males								**Females**								
1E	18.6	14.0	0.0	4.7	0.0	0.0	0.0	4.7	20.9	2.3	9.3	7.0	7.0	2.3	0.0	9.3	43
2C	12.0	3.4	2.4	0.5	1.4	1.0	0.0	14.4	27.9	1.4	4.3	1.9	3.4	1.4	0.5	24.0	208
5	4.8	0.0	9.6	13.3	7.2	3.6	2.4	12.0	13.3	0.0	4.8	12.0	2.4	0.0	3.6	10.8	83
6W	10.3	5.4	5.7	5.1	3.1	2.5	5.1	14.4	11.3	5.6	6.4	7.2	2.0	1.6	1.8	12.5	610
6E	14.5	6.7	5.8	2.1	2.9	2.5	1.7	9.1	18.9	6.7	7.3	4.0	2.1	2.3	1.2	12.1	519
7CS	6.5	7.1	9.7	9.0	1.9	1.3	0.6	10.3	11.0	10.3	7.7	9.7	3.2	1.3	1.3	9.0	155
7CN	5.5	4.4	5.5	7.7	5.5	3.3	1.1	7.7	4.4	8.8	9.9	11.0	7.7	3.3	2.2	12.1	91
10E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.7	0.0	0.0	0.0	8.3	0.0	0.0	0.0	50.0	12
11	0.00	0.00	0.00	0.00	0.00	0.00	5.41	29.73	0.00	0.00	16.22	16.22	2.70	0.00	0.00	29.73	37

Table 2a

Time invariant fixed proportions of J/JE-stock whales used in removing **future commercial catches** from sub-areas 7CS and 7CN for each for Hypothesis, based on the mixing proportions from the offshore samples (>10nm) only The values are set using data from 1996-2007.

Hypothesis	Stocks	Trials	Sub-area	Months	Sample size	mtDNA proportion	SE	Sample size	Allele proportion	SE	Weighted mean
A & B	J & O	A & B	7CS	Apr	76	0.166	0.047	76	0.214	0.028	0.201
A & B	J & O	A & B	7CS	May	99	0.159	0.040	99	0.215	0.024	0.200
A & B	J & O	A & B	7CS	Jun-Sep	52	0.027	0.025	52	0.080	0.029	0.050
A & B	J & O	A & B	7CN	Apr-Jun	96	0.067	0.032	96	0.058	0.021	0.061
A & B	J & O	A & B	7CN	Jul-Dec	320	0.084	0.018	318	0.128	0.012	0.114
C	JE & OW	C	7CS	Apr-May	175	0.166	0.038	175	0.229	0.018	0.217
C	JE & OW	C	7CS	Jun-Sep	52	0.035	0.037	52	0.088	0.030	0.067
C	JE & OW	C	7CN	Apr-Jun	96	0.000	0.001	96	0.001	0.000	0.001
C	JE & OW	C	7CN	Jul-Dec	320	0.071	0.020	318	0.145	0.013	0.123
C23	J & OW	C23	7CS	Apr-May	175	0.136	0.030	175	0.231	0.018	0.206
C23	J & OW	C23	7CS	Jun-Sep	52	0.022	0.024	52	0.088	0.030	0.048
C23	J & OW	C23	7CN	Apr-Jun	96	0.000	0.001	96	0.000	0.000	0.000
C23	J & OW	C23	7CN	Jul-Dec	320	0.060	0.016	318	0.141	0.013	0.109
C24	JE & O	C24	7CS	Apr-May	175	0.186	0.036	175	0.210	0.018	0.205
C24	JE & O	C24	7CS	Jun-Sep	52	0.028	0.028	52	0.065	0.029	0.046
C24	JE & O	C24	7CN	Apr-Jun	96	0.085	0.042	96	0.054	0.021	0.060
C24	JE & O	C24	7CN	Jul-Dec	320	0.097	0.022	318	0.122	0.013	0.116

A different limit was used in sub-area 7CN in June for the definition of the pure OW-stock for Hypothesis C, because there were 3 June SP samples at distances 8.81, 9.67 and 9.82n.miles which proponents considered to be from the OW-stock. When considering all months (June-Oct) for which SP data is available in sub-area 7CN, there are 19 data points between 8.8nm and 10nm. (These data points are not used in >10n.mile analyses.) When considering all months (April-June with 4 samples from Aug and 1 sample in Sep) for which SP data are available in sub-area 7CS, there are 32 data points between 8.8n.miless and 10n.miles.

To avoid a proliferation of sub-areas and to avoid the need for finer time-steps than month, the probability of the bycatch in sub-areas 7CS and 7CN being one of the two stocks in the sub-area is assumed to be time-invariant while the incidental catches in sub-areas other than 7CS and 7CN are apportioned to stock and age class in the same way as for the commercial catches (i.e. using Equations D.1 and D.2 but assuming that the bycatch is taken uniformly from all age classes (the selectivity=1)). The bycatches in 7CS and 7CN are split to stock using mixing proportions calculated from the weighted average of the mixing proportions obtained from mtDNA haplotype and microsatellite allele bycatch samples, as listed in the final column of Table 2b.

Table 2b

Time invariant fixed proportions of J/JE-stock whales used in removing bycatch from sub-areas 7CS and 7CN.

Hypothesis	Trials	Sub-area	Months	mtDNA Proportion	SE	Allele Proportion	SE	Weighted Mean
A & B	A & B	7CS	Jan.-Apr	0.419	0.086	0.440	0.041	0.44
A & B	A & B	7CS	May	0.160	0.078	0.168	0.047	0.17
A & B	A & B	7CS	Jun.-Oct.	0.645	0.067	0.664	0.030	0.66
A & B	A & B	7CN	Jan.-Jun.	0.477	0.071	0.507	0.033	0.50
A & B	A & B	7CN	Jul.-Oct.	0.758	0.074	0.680	0.036	0.69
C	C	7CS	Jan.-May	0.375	0.088	0.356	0.032	0.36
C	C	7CS	Jun.-Dec.	0.696	0.078	0.646	0.032	0.65
C	C	7CN	Jan.-Mar.					1.00[1]
C	C	7CN	Apr.-Jun.	0.486	0.095	0.426	0.037	0.43
C	C	7CN	Jul.-Dec.	0.764	0.091	0.670	0.036	0.68
C	C23	7CS	Jan.-May	0.280	0.069	0.348	0.032	0.34
C	C23	7CS	Jun.-Dec.	0.652	0.073	0.661	0.031	0.66
C	C23	7CN	Jan.-Mar.					1.00[1]
C	C23	7CN	Apr.-Jun.	0.396	0.080	0.441	0.037	0.43
C	C23	7CN	Jul.-Dec.	0.707	0.082	0.693	0.036	0.70
C31	31	7CN	Jan.-Jun.	0.569	0.087	0.480	0.035	0.49

The historical bycatch model: The historical bycatch $C^k_{B,t}$ in sub-area k in year t is given by:

$$C^k_{B,t} = A^k \, P^k_t E^k_t \tag{D.6}$$

where A^k is the bycatch constant, E^k_t is the number of nets in sub-area k in year t and P^k_t is the total population (including calves) in sub-area k in year t averaged over all 8 time periods. In trial 25, the abundance P^k_t in equation D.6 is replaced by $\sqrt{(P^k_t)}$ in order to test a different assumption for the relationship between bycatch and abundance and the impact of possible saturation effects. The values of the bycatch constants are set by fitting during the conditioning process (see section F). The recent by catches and the numbers of set-nets by type, year and area are listed in Adjunct 1. Further details are given in Annex H of IWC (2012a).

Future bycatches: Future bycatches by sub-area (except in sub-areas 7CS and 7CN) are generated assuming that the exploitation rate due to bycatch in the future equals that estimated for the trial in question for the most recent five-years of data used in the conditioning process, i.e.:

$$C^k_{B,t} = \overline{F}^k \, P^k_t \tag{D.7}$$

where $C^k_{B,t}$ is the by-catch in sub-area k in year t, P^k_t is the total population (including calves) in sub-area k in year t averaged over all 8 time periods (March-October), and $\overline{F}^k$ is the average exploitation rate (sum over years of bycatch divided by the sum over years of P^k_t) over the last five years of the period used for conditioning (2002-06 for sub-areas off Japan and 2005-09 for those off Korea) i.e F is reset for each of the 100 simulations within a trial. Thus the future bycatch by sex, month and sub-area is given by:

$$C^{g,k,q}_{B,t} = Q^{g,k,q}_B \overline{F}^k \, P^k_t \tag{D.7a}$$

For trial 25, the abundance P^k_t in equation D.7a is replaced by $\sqrt{(P^k_t)}$.

To avoid possible dis-proportionate bycatches of J/JE- to O/OW-stock whales, equation (D.7a) is replaced with (D.7b) in sub-areas 7CS and 7CN.

$$C^{g,k,q}_{B,t} = \tilde{P}^{k,q}_t \overline{F}^k Q^{g,k,q}_B \tag{D.7b}$$

where $\tilde{P}^{k,q}_t$ is the availability-weighted population size in sub-area k during month q:

$$\tilde{P}^{k,q}_t = (P^{k,q,J/E}_t + \lambda^{k,q} P^{k,q,O/OW}_t) \frac{\overline{P}^{k,q,J/JE} + \overline{P}^{k,q,O/OW}}{\overline{P}^{k,q,J/JE} + \lambda^{k,q} \overline{P}^{k,q,O/OW}} \tag{D.8}$$

where $\overline{P}^{k,q,j}$ is the average population (including calves) of stock j in sub-area k during month q over the last five years of the period used for conditioning;

[1]This proportion corresponded to the original assumption of no OW-stock in 7CN in Jan-Mar. Trial C31 tests sensitivity to alternative mixing proportions corresponding to this assumption.

$P_t^{k,q,j}$ is the total population (including calves) of stock *j* in sub-area *k* during month *q* of year *t*;

$\lambda^{k,q}$ is a relative availability factor for J/JE whales relative to O/OW whales:

$$\lambda^{k,q} = \frac{(1-\ddot{P}^{k,q})}{\ddot{P}^{k,q}} \frac{\overline{P}^{k,q,J/JE}}{\overline{P}^{k,q,O/OW}} \tag{D.9}$$

$\ddot{P}^{k,q}$ is the weighted mean proportion of stock J/JE in sub-area k during month q (as given in Table 2b).

This catch is allocated to stock as follows:

$$C_{B,t}^{g,k,q,J/JE} = \frac{P_t^{g,k,q,J/JE}}{\lambda^{k,q} P_t^{g,k,q,O/OW} + P_t^{g,k,q,J/JE}} C_{B,t}^{g,k,q} \tag{D.10a}$$

$$C_{B,t}^{g,k,q,O/OW} = \frac{\lambda^{k,q} P_t^{g,k,q,O/OW}}{\lambda^{k,q} P_t^{g,k,q,O/OW} + P_t^{g,k,q,J/JE}} C_{B,t}^{g,k,q} \tag{D.10b}$$

where $P_t^{g,k,q,j}$ is the total population (including calves) of animals of gender *g* from stock *j* in sub-area *k* during month *q* of year *t*.

Reported bycatches

A single series of historical bycatches will be used for all of the trials when applying the RMP (i.e. for calculating catch limits), irrespective of the true values of the bycatches, which differ both among trials and simulations within trials. The estimate of the bycatches used by the *CLA* will be set to the averages of the predicted bycatches based on the fit to the actual data[2] of the operating model for the six baseline trials (i.e. using the 'best fit' simulation (0)). The series is given in Adjunct 2, Table 9.

The future by-catches used when applying the RMP are the true by-catches in all sub-areas[3], except for trial 4 (in which the estimated by-catches are in error to reflect the under-estimation of bycatch inherent in these trials) and trial 18 (in which the bycatch by China is taken to be zero).

E. Generation of data

The plan for future sightings surveys is listed in Tables 3a and 3b. Surveys will be conducted by Japan in sub-areas 6E, 7CS, 7CN, 7WR, 7E, 8, 9, 10W, 10E, 11, 12SW and 12N and by Korea from mid-April to late-May in sub-areas 5 and 6W.

The estimates of absolute abundance (and their associated CVs) for the years prior to 2012 provided to the *CLA* are given in Table 4a. To allow for results of surveys already conducted, but for which the results are not yet available, estimates of abundance are generated for surveys listed for 2011 in sub-area 5 and 2012 in sub-area 6W using the same method as for future estimates.

Table 3a

List of past and planned future sighting surveys of minke whales to the West of Japan.

-=No survey, 1=survey (% coverage). All surveys are carried out in April-May except the historic surveys in 6E, 10W and 10E which were in May-June. For areas that are combinations of sub-areas, the last three columns specify how the survey estimates for the component sub-areas are combined.

	5	6W	6E	10W	10E	C1=6W,6E,10W	C2=6W,6E,10W,10E	C3=5,6W,6E,10W,10E
2000	-	1 (14.3%)	-	-	-	-	-	-
2001	1 (13%)	-	-	-	-	- (see [1])	- (see [1])	- (see [1])
2002	-	1 (14.3%)	1 (79.1%)	-	1 (100%)	-	-	-
2003	-	1 (14.3%)	1(79.1%)	-	1 (100%)	-	-	-
2004	1 (13%)	-	1(79.1%)	-	-	-	-	-
2005	-	1 (14.3%)	-	-	1 (64.6%)	-	-	-
2006	-	1 (14.3%)	-	1 (59.9%)	-	-	-	-
2007	-	1 (14.3%)	-	-	-	1 = 2003-10	1 = 2003-10	1 = 2003-11
2008	1 (13%)	-	-	-	-	-	-	-
2009	-	1 (14.3%)	-	-	-	-	-	-
2010	-	1 (14.3%)	-	-	-	-	-	-
2011	1	-	-	-	-	-	-	-
2012	-	1	-	-	-	-	-	-
2013	1	-	-	-	-	-	-	-
2014	1	-	-	-	-	1 = 2012-15	1 = 2012-15	1 = 2012-15
2015	-	1	1(79.1%)	1(59.9%)	1(100%)	-	-	-
2016	-	1	-	-	-	-	-	-
2017	1	-	-	-	-	-	-	-
2018	1	-	-	-	-	1 = 2016-19	1 = 2016-19	1 = 2016-19
2019	-	1	1(79.1%)	1(59.9%)	1(100%)	-	-	-
2020	-	1	-	-	-	-	-	-
2021	1	-	-	-	-	-	-	-
2022	1	-	-	-	-	1 = 2020-23	1 = 2020-23	1 = 2020-23
2023	-	1	1(79.1%)	1(59.9%)	1(100%)	-	-	-

Continue in future in the same pattern.

(1) There is no 10W estimate for inclusion in the combination estimates for 2000-02, so a combination estimate is not generated in this period.

(2) Abundance estimates will be generated for all surveys from 2011 on.

(3) The 2003-11 surveys are combined in combinations C1, C2 and C3 so that the most recent surveys in 5 and 6W are used in the 2012 assessment.

[2]In the case of sub-area 6W the actual data is the *adjusted* bycatch data.

[3]Including sub-area 6W since the best estimate of bycatches in this area is the adjusted figure.

Table 3b

List of past and planned future sighting surveys of minke whales to the North and East of Japan.
-=No survey, 1=survey (% coverage). All surveys are carried out in August-September unless otherwise noted.
For areas that are combinations of sub-areas, the last four columns specify how the survey estimates for the component sub-areas are combined.

	7CS	7CN	7WR	7E	8	9	11	12SW	12NE	C4=7,8	C5 = 7WR,7E,8	C6 = 7,8,9,11	C7 = 7,8,9,11,12
1990	-	-	-	-	1 (61.8%)	1 (35.0%)	1 (100%)	1 (100%)	1 (100%)	-	-	-	-
1991	1*	1	1	-	-	-	-	-	-	1 =90-91	1 =90-91	1 =90-91	1 =90-92
1992	-	-	-	-	-	-	-	-	1 (89.4%)	-	-	-	-
1999	-	-	-	-	-	-	1 (100%)	-	1 (63.8%)	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	1 (Jn-Jl 65.0%)*	-	-	-	-	-	-	-	-
2003	-	-	1 (My-Jn 26.7%)	-	-	1 (Jl-S 33.2%)	1 (33.9%)	1 (100%)	1 (46.0%)	1 =02-04	1 =02-04	1 =99-04	1 =99-04
2004	1 (My 36.7%)	-	1 (My-Jn 88.8%)	1 (My-Jn 57.1%)	1 (Jn 40.5%)	-	-	-	-	-	-	-	-
2005	-	-	-	-	1 (My-Jl 65.0%)	-	-	-	-	-	-	-	-
2006	1 (J-J 100%)	-	-	1 (My-Jn 57.1%)	1 (My-Jl 65.0%)	-	-	-	-	1 =05-07	1 =05-07	- (see[8])	- (see[8])
2007	-	-	1 (Jn-Jl 88.8%)	1 (Jn-Jl 65.0%)*	1 (Jn-Jl 65.0%)	-	1 (20.2%)	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	-	-	-	-	-
2010	-	-	-	-	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-	-	-	-	-	-	-
2012	1[5](My-Jn)	1[5](My-Jn) 1 (Au-Se)	-	-	-	-	-	-	-	- -	- -	- -	- -
2013	-	-	1 (88.8%)	1 (57.1%)	1 (100%)	1 (100%)	-	-	-	1=12-3	1=2013	1=12-14	1=12-14
2014	-	-	-	-	-	-	1 (30.1%)	1 (48.9%)	1 (46.4%)	-	-	-	-
2015	-	-	-	-	-	-	-	-	-	-	-	-	-
2016	1 (100%)	1 (75.4%)	0	0	0	0	-	-	-	-	-	-	-
2017	-	-	1 (88.8%)	1 (57.1%)	1 (100%)	1 (100%)	-	-	-	1=16-17	1=2017	1=16-18	1=16-18
2018	-	-	-	-	-	-	1 (30.1%)	1 (48.9%)	1 (46.4%)	-	-	-	-
2019	-	-	-	-	-	-	-	-	-	-	-	-	-
2020	1 (100%)	1 (75.4%)	-	-	-	-	-	-	-	-	-	-	-
2021	-	-	1 (88.8%)	1 (57.1%)	1 (100%)	1 (100%)	-	-	-	1=20-21	1=21	1=20-22	1=20-22
2022	-	-	-	-	-	-	1 (30.1%)	1 (48.9%)	1 (46.4%)	-	-	-	-
2023	-	-	-	-	-	-	-	-	-	-	-	-	-

*Abundance estimate=0.

(4) Future coverage in 7CN, 7WR and 7E is expected to be similar to above (because of territorial issues). Coverage in 8 and 9 assumes that future surveys include the Russian EEZ. Future coverage in 11 and 12SW (of 30.1% and 48.9% respectively) excludes areas in the Russian EEZ which cannot be surveyed until the resolution of territorial issues with Japan. Future coverage in 12NE (of 46.4) reflects the area which cannot be surveyed in the North and East because of Russian restrictions.

(5) The 2012 estimates will be made available a year early – this will be effected by assuming the 2012 surveys occurred in 2011 and so are available in 2013 to set the catch limits for 2013-8.

(6) The abundance estimates set for the combined areas in 1990-92 assume a zero contribution from 7E as there is no available estimate for 7E to include.

(7) The abundance estimates set for combined areas C4 and C5 in 2005-07 assume a zero contribution from 7CN as there is no 7CN estimate to include.

(8) There are no 2005-2011 abundance estimates for sub-areas 9 and 12 to include in combination estimates C6 and C7; no C6 or C7 estimates are generated in this period.

Table 4a

List of historical abundance estimates for use by the *CLA* (*= zero estimate – see text and Table 4b).
Further details are given in Table 6 of Annex D1 (this volume, pp.126-127).

Year	SubA	Period	Est.	CV	Year	SubA	Period	Est.	CV	Year	SubA	Period	Est.	CV
2001	5	Apr.-May	1,534	0.523	2002	10E	May-Jun.	816	0.658	1990	8	Aug.-Sep.	1,057	0.705
2004	5	Apr.-May	799	0.321	2003	10E	May-Jun.	405	0.566	2002	8	Jun.-Jul.	63.6*	0.603
2008	5	Apr.-May	680	0.372	2005	10E	May-Jun.	599	0.441	2004	8	Jun.	1,093	0.576
2000	6W	Apr.-May	549	0.419	1991	7CS	Aug.-Sep.	42*	0.603	2005	8	May-Jul.	132	1.047
2002	6W	Apr.-May	391	0.614	2004	7CS	May	504	0.291	2006	8	May-Jul.	309	0.677
2003	6W	Apr.-May	485	0.343	2006	7CS	Jun.-Jul.	3,690	1.199	2007	8	Jun.-Jul.	391	1.013
2005	6W	Apr.-May	336	0.317	2012	7CS	May-Jun.	890	0.393	1990	9	Aug.-Sep.	8,264	0.396
2006	6W	Apr.-May	459	0.516	1991	7CN	Aug.-Sep.	853	0.23	2003	9	Jul.-Sep.	2,546	0.276
2007	6W	Apr.-May	574	0.437	2012	7CN	Sep.	398	0.507	1990	11	Aug.-Sep.	2,120	0.449
2009	6W	Apr.-May	884	0.286	1991	7WR	Aug.-Sep.	311	0.23	1999	11	Aug.-Sep.	1,456	0.565
2010	6W	Apr.-May	1,014	0.397	2003	7WR	May-Jun.	267	0.700	2003	11	Aug.-Sep.	882	0.820
2002	6E	May-Jun.	891	0.608	2004	7WR	May-Jun.	863	0.648	2007	11	Aug.-Sep.	377	0.389
2003	6E	May-Jun.	935	0.357	2007	7WR	Jun.-Jul.	546	0.953	1990	12SW	Aug.-Sep.	5,244	0.806
2004	6E	May-Jun.	727	0.372	2004	7E	May-Jun.	440	0.779	2003	12SW	Aug.-Sep.	3,401	0.409
2006	10W	May-Jun.	2,476	0.312	2006	7E	May-Jun.	247	0.892	1990	12NE	Aug.-Sep.	10,397	0.364
					2007	7E	Jun.-Jul.	52.6*	0.603	1992	12NE	Aug.-Sep.	11,544	0.380
										1999	12NE	Aug.-Sep.	5,088	0.377
										2003	12NE	Aug.-Sep.	13,067	0.287

The sightings mixing matrix for a year in which a survey takes place is the average of the catch mixing matrices over the two survey months in that year (April-May for surveys to the west of Japan or August-September for the remainder). The values for the parameters of the various distributions have been selected to achieve CVs for *Small Areas* comparable to those for the surveys in Table 6(a). The future estimates of abundance for a *Small Area* (say *Small Area E*) are generated using the formula:

$$\hat{P} = PYw/\mu = P^* \beta^2 Yw \tag{E.1}$$

Y is a lognormal random variable $Y = e^{\varepsilon}$ where $\varepsilon \sim N[0,\sigma^2]$ and $\sigma^2 = Ln(\alpha^2+1)$;

w is Poisson random variable with $E(w) = \text{var}(w) = \mu = (P/P^*)/\beta^2$; (Y and w are independent);

P is the average current total (1+) population size in the *Small Area* (E) over the survey period:

$$P = P_t^E = \frac{1}{2}\sum_{k\in F}\ \sum_{q\in SurveyPeriod}\ \sum_j\ \sum_g \sum_{a=1}^{x}\left(V_{t,a}^{g,j,k,q} N_{t,a}^{g,j}\right) \tag{E.2}$$

P^* is the reference population level, and is equal to the mean total (1+) population size in the *Small Area* prior to the commencement of exploitation in the area being surveyed; and

F is the set of sub-areas making up *Small Area E*.

Note that under the approximation CV2(ab) ≅ CV2(a) + CV2(b): $E(\hat{P}) \cong P$ and $CV^2(\hat{P}) \cong \alpha^2 + \beta^2 P^*/P$

For consistency with the first stage screening trials for a single stock (IWC, 1991, p.109; 1994, pp.85-86), the ratio $\alpha^2:\beta^2 = 0.12:0.025$, so that:

$$CV(\hat{P}) = \tau(0.12 + 0.025P^*/P)^{1/2} \tag{E.3}$$

and the CV of a survey estimate prior to the commencement of exploitation in the area being surveyed would be:

$$\sqrt{(\alpha^2+\beta^2)} = 0.38\tau \tag{E.4}$$

The values of τ applicable to each sub-area are calculated separately for each replicate once the conditioning has been accomplished by substituting the true value of the CV for each abundance estimate used in conditioning (Table 6a)[4] and the corresponding model depletion level into equation E.3. If more than one abundance estimate exists for a particular sub-area, the value assumed for τ is calculated taking the true CV to be the root mean square of the values obtained from the abundance estimates for that sub-area, and the depletion to be the mean value over the corresponding years.

An estimate of the *CV*, X_t is also generated for each sightings estimate, $\hat{P}_t$:

$$X_t = \sqrt{(\sigma_t^2 \chi^2/n)} \tag{E.5}$$

where $\sigma_t^2 = Ln(1+\alpha^2+\beta^2 P^*/\hat{P}_t)$, and χ^2 is a random number from a Chi-square distribution with n=10 degrees of freedom. The value 10 is chosen to roughly indicate the number of trackline segments in a sightings survey in a *Small Area*.

The trials will be based on the use of two alternative values for *g(0)* in the conditioning process: *g(0)* = 0.798[5] (the base case value) and *g(0)*=1 (trial 03) (IWC, 2012a, p.417; Okamura *et al.*, 2010). When *g(0)* = 0.798 the values of the operating model abundances are multiplied by this factor when setting the future survey estimates of abundance.

The trials assume that it takes two years for the results of a sighting survey to become available to be used by the management procedure, i.e. a survey conducted in 2012 would first be used for setting the catch limit in 2014. Table 4 lists the pattern for future surveys and also shows how results of surveys from different sub-areas are combined for use in variants in which *Small Areas* are comprised of more than one sub-areas. If a *Small Area* is comprised of sub-areas that are surveyed in different years, the combination abundance estimate is taken to be a summation of the estimates of abundance in the sub-areas over the years and taken to refer to the mean year (where the mean year is defined as the centre year in the set, or the later of two if this yields a half-integral year) (IWC, 1999). In cases in which the combined survey used more than one abundance estimate from the same sub-area, the abundance estimates are pooled using inverse variance weighting. For example, for the management variant in which the RMP sets a catch limit for the combined 6W+6E+10W+10E area, an estimate dated 2007 will be generated using of the abundances from the constituent sub-areas for 2003 to 2010 for combinations C1 and C2 (and from 2003-11 for combination C3).

In cases where a zero abundance estimate occurs (either in the historical series or in the generated future estimates), a fixed standard deviation of 0.603 is assumed, and the zero estimate is replaced by a value which depends on the what the population estimates would have been for recent surveys in the areas had there been only one minke whale sighting made. Specifically, the averages taken over such population estimates are calculated separately for each of the surveys listed and then scaled by 42/98.6 as given in Table 4b. Details of the rationale are given in Annex G (this volume, p.504)[6].

[4]Excluding zero, minimum and maximum estimates and those assumed to apply to adjacent areas, except for sub-areas 5 and 6W where the pooled minimum values are used.

[5]This value of *g*(0) is rounded to 0.8 in the trial simulations.

[6]The approach is based on that for the zero abundance estimate obtained in sub-area 7CS in 1991 for which there was a final output negative log – likelihood component of P/98.6 where P is the true abundance present. This form was replaced by a negative log-likelihood based on the assumption of a log-normally distributed pseudo estimate, which as with the Poisson form would yield a value of 1when P = 98.6. Since this is not sufficient to define this likelihood term unambiguously, the mean was fixed at 42 (Adams, 1995) which resulted in a standard deviation of 0.603.

Table 4b

Population estimates which replace any zero estimates in the historical series or which are generated in future. A default value of 42 is used to replace a future zero estimate generated in any other sub-area.

Sub-area	6E			10E			10W	7CS	7CN		7WR		7E	8		11	
Season	2002	2003	2004	2002	2003	2005	2006		1991	1992	1991	1992	2006	2006	2007	2003	2007
n	21	19	7	10	7	9	36		11	6	1	2	2	3	2	10	19
P	891	935	727	816	405	599	2,477		976	730	188	434	247	309	391	882	377
Scaled	18.1	21.0	44.2	34.8	24.6	28.4	29.3		37.8	51.8	80.1	92.4	52.6	43.9	83.3	37.6	8.5
Average	27.8			29.3			29.3	42.0	44.8		86.3		52.6	63.6		23.0	

F. Parameter values and conditioning

The biological parameters (natural mortality, age-at-maturity) and the technological parameters (selectivity) will be the same as for the previous *Implementation* (IWC, 1992a, p.160) (based on those for N Atlantic minke whales, IWC, 1992b, p.249)[7] i.e.:

Table 5

The values for the biological and technological parameters that are fixed.

Parameter	Value
Plus group age, x	20 years
Age-at-first-parturition, a_m	$m_{50} = 7$; $\sigma_m = 1.2$; first age at which a female can be mature is three
Selectivity: males and females	$r_{50} = 4$; $\sigma_r = 1.2$
Maximum Sustainable Yield Level, *MSYL*	0.6 in terms of mature female component of the population

Natural mortality is age-dependent, and identical to that for the North Atlantic minke trials:

$$M_a = \begin{cases} 0.085 & \text{if } a \le 4 \\ 0.0775 + 0.001875a & \text{if } 4 < a < 20 \\ 0.115 & \text{if } a \ge 20 \end{cases}$$

The MSYR scenarios are specified in Section G.

The 'free' parameters of the above model are the initial (pre-exploitation) sizes of each of the stocks, the values that determine the mixing matrices (i.e. the γ parameters), the bycatch constants (A_k) and the dispersion rates between OW- and OE- stock and between the JW- and JE-stocks in trials C16-17. The process used to select the 'free' parameters is known as conditioning. The conditioning process involves first generating 100 sets of 'target' data as detailed in steps (a) and (b) below, and then fitting the population model to each (in the spirit of a bootstrap). The number of animals in sub-area k at the start of year t is calculated starting with guessed values of the initial population sizes and projecting the operating model forward to 2013 in order to obtain values of abundance etc. for comparison with the generated data[8]. (When performing the projections, the direct catches from each sub-area are set to their historical values – Adjunct 1 and the bycatches are set as detailed below).

The information used in the conditioning process is as follows.

(a) Abundance estimates

The target values for the historical abundance by sub-area (excepting for the minimum and maximum values – see below) are generated using the formula:

$$P_t^k = O_t^k \exp[\mu_t^k - (\sigma_t^k)^2/2] \qquad \mu_t^k \sim N[0;(\sigma_t^k)^2] \tag{F.1}$$

P_t^k is the abundance for sub-area k in year t (or sub-areas 7E+8 for the 2007 abundance estimate)

O_t^k is the actual survey estimate for sub-area k in year t (see Table 6a); and

σ_t^k is the CV of O_t^k.

The abundance estimate for sub-area 8 in 2002 is zero. The value of O_t^k is set to 0 for all trials when fitting to this datum, and the likelihood is assumed to be normal rather than log-normal.

The trials are based on the two alternative values for $g(0)$ in the conditioning process: $g(0)$=0.8 [9](the base case value) and g $g(0)$=1 (IWC, 2012a, p.417; Okamura *et al.*, 2010). When $g(0)$=0.8 the values of the operating model abundances (P_t^k) are multiplied by this factor for comparison with the conditioning targets.

[7]The values are consistent with the results from JARPN. Japanese scientists advised that the above approach is appropriate given the well-known practical difficulties in using earplugs for age determination of North Pacific common minke whales. However, they also noted that technical advances mean that it may be possible to obtain age estimates in the future (see Item 2.1, this volume, p.492).

[8]In order to check that the conditioning exercise has been successfully achieved, plots such as those shown in IWC (2003, pp.473-80) will be examined, together with time-trajectories of the fraction of each stock in each sub-area.

[9]The value of 0.8 used for $g(0)$has been rounded from value of 0.798 given in IWC (2012a, p.417).

Table 6a

Abundance data used to condition the trials.

Sub-area	Year	Season	Survey type[10]	Mode[11]	Areal coverage (%)	STD estimate[12]	CV[13]	Conditioning	Source
5	2001	Apr.-May	KD	NC	13.0	1,534	0.523	Min	An *et al.* (2010)
	2004	Apr.-May	KD	NC	13.0	799	0.321	Min	Ditto
	2008	Apr.-May	KD	NC	13.0	680	0.372	Min	Ditto
6W	2000	Apr.-May	KD	NC	14.3	549	0.419	Min	Ditto
	2002	Apr.-May	KD	NC	14.3	391	0.614	Min	Ditto
	2003	Apr.-May	KD	NC	14.3	485	0.343	Min	Ditto
	2005	Apr.-May	KD	NC	14.3	336	0.317	Min	Ditto
	2006	Apr.-May	KD	NC	14.3	459	0.516	Min	Ditto
	2007	Apr.-May	KD	NC	14.3	574	0.437	Min	Ditto
	2009	Apr.-May	KD	NC	14.3	884	0.286	Min	Ditto
6E	2002	May-Jun.	JD	NC	79.1	891	0.608	Yes (see #)	Miyashita (2010)
	2003	May-Jun.	JD	NC	79.1	935	0.357	Yes (see #)	Ditto
	2004	May-Jun.	JD	NC	79.1	727	0.372	Yes (see #)	Ditto
7CS	2004	May	JR	NC	100.0	886	0.502	Yes	Hakamada and Kitakado (2010) (rev)
	2006	Jun.-Jul.	JR	NC	100.0	3,690	1.199	Yes	Hakamada and Kitakado (2010) (rev)
7CN	2003	May	JR	NC	75.4	184	0.805	Yes	Hakamada and Kitakado (2010) (rev)
7WR	2003	May-Jun.	JR	NC	54.2	524	0.700	Min	Hakamada and Kitakado (2010) (rev)
	2004	May-Jun.	JR	NC	88.8	863	0.648	Yes	Hakamada and Kitakado (2010) (rev)
	2007	Jun.-Jul.	JR	NC	88.8	546	0.953	Yes	Hakamada and Kitakado (2010) (rev)
7E	2004	May-Jun.	JR	NC	57.1	440	0.779	Yes	Hakamada and Kitakado (2010) (rev)
	2006	May-Jun.	JR	NC	57.1	247	0.892	Yes	Hakamada and Kitakado (2010) (rev)
8	1990	Aug.-Sep.	JD	NC	61.8	1,057	0.705	Yes	IWC (2004, p.124)
	2002	Jun.-Jul.	JR	NC	65.0	0	482[14]	Yes	Hakamada and Kitakado (2010) (rev)
	2004	Jun.	JR	NC	40.5	1,093	0.576	Yes	Ditto
	2005	May-Jul.	JR	NC	65.0	132	1.047	Yes	Ditto
	2006	May-Jul.	JR	NC	65.0	309	0.677	Yes	Ditto
7E+8	2007	Jun.-Jul.	JR	NC	65.0	391[15]	1.013	Yes	Ditto
9	1990	Aug.-Sep.	JD	NC	35.0	8,264	0.396	Yes	IWC (2004, p.124)
	2003	Jul.-Sep.	JR	NC	33.2	2,546	0.276	Min	Hakamada and Kitakado (2010) (rev)
9N	2005	Aug.-Sep.	JD	IO-PS	67.8	420	0.969	Yes	Extract from Miyashita and Okamura (2011)
10W	2006	May-Jun.	JD	IO-PS	59.9	2,476	0.312	Yes	Ditto
10E	2002	May-Jun.	JD	NC	100.0	816	0.658	Yes	Miyashita (2010)
	2003	May-Jun.	JD	NC	100.0	405	0.566	Yes	Ditto
	2004	May-Jun.	JD	NC	100.0	474	0.537	Yes	Ditto
	2005	May-Jun.	JD	NC	100.0	666	0.444	Yes	Ditto
11	1990	Aug.-Sep.	JD	NC	100.0	2,120	0.449	Yes	IWC (2004, p.124)
	1999	Aug.-Sep.	JD	NC	100.0	1,456	0.565	Yes	Ditto
	2003	Aug.-Sep.	JD	IO-AC	33.9	882	0.820	Yes	Extract from Miyashita and Okamura (2011)
	2007	Aug.-Sep.	JD	IO-PS	20.2	377	0.389	Min	Ditto
12SW	1990	Aug.-Sep.	JD	NC	100.0	5,244	0.806	Yes	IWC (2004, p.124)
	2003	Aug.-Sep.	JD	IO-AC	100.0	3,401	0.409	Yes	Extract from Miyashita and Okamura (2011)
12NE	1990	Aug.-Sep.	JD	NC	100.0	10,397	0.364	Yes	IWC (2004, p.124) extract from SC/46/NP6
	1999	Aug.-Sep.	JD	NC	89.4	11,544	0.380	Yes	Ditto
	2003	Aug.-Sep.	JD	IO-AC	46.0	13,067	0.287	Yes	Extract from Miyashita and Okamura (2011)
# Trial 19: Use estimates in full area in 2002 & 2003 (originally 100% coverage) and one extrapolated to the full area in 2004 (79.1% coverage)									
6E	2002	May-Jun	JD	NC	100.0	1,795	0.458	Yes	Miyashita (2010)
	2003	May-Jun	JD	NC	100.0	1,059	0.322	Yes	Ditto
	2004	May-Jun	JD	NC	100.0	919	0.372	Yes	Ditto
Trial 20: Use only in sensitivity as an estimate extrapolated to the full area									
10E	2007	May-Jun	JD	IO-PS	100.0	552	0.159	Yes	From Miyashita

Table 6b

The minimum and maximum abundance estimates used.

Sub-area	Year	Season		STD estimate	CV	Minimum = Mean-SE	Maximum = Mean*5
5	2004	Apr.-May	Pooled	848	0.220	661	4,240
6W	2005	Apr.-May	Pooled	533	0.144	456	2,665
7WR	2003	May-Jun.		524	0.700	157	n/a
9	2003	Jul.-Sep.		2,546	0.276	1,843	n/a
11	2007	Aug.-Sep.		377	0.389	230	n/a
2R	2009	Aug.-Sep.		-	-	-	500[16]

[10]KD=Korean dedicated survey, JD=Japanese dedicated survey, JR=JARPN II.

[11]NC=Normal-closing, IO-PS=Passing with IO mode, IO-AC=Abeam-closing with IO mode. (STD estimates by different modes, NC, IO-AC, IO-NC, are considered comparable.).

[12]Standard (STD) estimate based on 'Top and Upper bridge', which will be corrected by estimate of $g(0)$ for the combined platform 'Top and Upper bridge'.

[13]CV does not consider any process errors.

[14]Average of the SEs for the non-zero estimates.

[15]The estimate of 0 from sub-area 7E was combined with the estimate of 391 from sub-area 8.

[16]A maximum abundance of 500 whales in sub-area 2R in August-September 2009 is imposed in hypothesis C to avoid undesirably high numbers of animals in this area.

MINIMUM ABUNDANCE ESTIMATES

The levels of abundance listed in Table 6(a) for sub-areas 5 and 6W, and for sub-areas 7WR and 9 in 2003 and sub-area 11 in 2007 are assumed to be minima – in the conditioning process the terms for those sub-areas/years are not added to the log-likelihood but the 'true' abundance in those sub-areas must exceed a value that is one standard error below the specified values. The values are listed in Table 6(b). Where there is more than one estimate for a sub-area, the estimates for the area were pooled using inverse variance weighting. The minimum estimate is the same across all replicates.

MAXIMUM ABUNDANCE ESTIMATES

Bounds need to be placed on the maximum size of populations in sub-areas 5 and 6W. These bounds are generated by multiplying the inverse variance weighted minimum (i.e. the 848 and 533) by 5 (see Table 6b). The maximum estimate is the same across all replicates.

There is insufficient information in the trials to estimate the abundance in sub-areas 5 and 6W, given the absence of a population estimate (only a minimum and a maximum given). Thus, for stochastic trials, the conditioning process will fit to a low variance (CV=0.1) pseudo-estimate of abundance for sub-area 5 and for sub-area 6 which are drawn from a uniform distribution across [minimum; maximum] for each of the 100 simulated projections within each trial. For 'deterministic' projections, the conditioning will fit to (maximum+minimum)/2. Trials 21, 22, 29 and 30 investigate sensitivities to the baseline assumptions and replace the random draws above by a fixed value for the sub-area 5 abundance equal to either the 'minimum' or 'maximum' estimate (Trials 21 and 22) or by a fixed value for the sub-area 6W abundance equal to either the 'minimum' or 'maximum' estimate (Trials 29 and 30).

(b) Proportion estimates

Estimates of the proportion of recruited 'J', 'JW', 'JE' and 'OW' stock whales in sub-areas 2C, 6W, 7CS, 7CN, 7WR and 11 (see Adjunct 3 for how these proportions are estimated) are generated from appropriately truncated normal distributions that correspond to the observed data and are based on mtDNA and other genetic information (see Table 7). Some of the mixing proportions are based on data from several years so the model estimates to which these proportions are fitted during conditioning are sample size-weighted year-specific proportions. A minimum standard error for the mixing proportions of 0.05 was imposed so as to prevent a few of the mixing proportions from dominating the conditioning processes – see IWC (2012c, p.106).

The genetics data provide two proportion estimates for most sub-area / time periods: one from the mtDNA haplotypes and another from the microsatellite alleles. These estimates are used separately i.e. both go in the likelihood, with their standard errors, so that effectively the overall likelihood will combine them under inverse variance weighting. There is some non-independence here because the same animals are involved, but this is not seen as a major problem.

(c) Fixed stock proportion in sub-area 12SW

The data for sub-area 12SW is limited and so the proportion of J-stock (JW-stock for hypothesis C) in sub-area 12SW in June is fixed at 20% in the base case trials. The value reflects a rough average of the J-stock mixing proportions for sub-area 11 (J-stock animals in sub-area 12SW need to pass through sub-area 11). Since the proportions for sub-area 11 are calculated from the 1984-1999 data, the 20% will be taken as an average over these same years. Sensitivity trials test different levels of the 12SW proportion. In trial 10 the proportion is 10 % (with 0% J/JW-stock in 12NE as for the base case) and in trial 11 the proportion is 30% (with 10% J/JW-stock in 12NE in the same months/years; the mixing matrix is adjusted accordingly).

In addition, the proportion of OE:OW-stock in sub-area 12SW in June from 1984-1999 is set equal to that in sub-area 11 (excluding trials 13 and 14).

(d) Fixed stock proportion in sub-area 9 and 9N

The data for sub-area 9 is also limited. For sensitivity trials 2 and 12 which assume a C-stock that mixes with the O-stock (OE-stock for hypothesis C) in 9 and 9N, the proportion of O/OE-stock is assumed to be 0.5 during August and September in 1995. This is based on the ratio assumed in 9W in 2003. For hypothesis C trial 2 the same proportion is also assumed in 12NE in August and September 1995 (but not in trial 12).

(e) Dispersal rate

The model allows dispersal between the OW- and OE-stocks and between the JW- and JE-stocks (trials 16 and 17). To ensure equilibrium in the pristine population:

$$K^{1+,\mathrm{OW}} D^{\mathrm{OW,OE}} = K^{1+,\mathrm{OE}} D^{\mathrm{OE,OW}} \quad \text{and} \quad K^{1+,\mathrm{JW}} D^{\mathrm{JW,JE}} = K^{1+,\mathrm{JE}} D^{\mathrm{JE,JW}} \tag{F.2}$$

where
$$K^{1+,j} = \sum_{a=1}^{x} (N_{-\infty,a}^{m,j} + N_{-\infty,a}^{f,j}) \tag{F.3}$$

Table 7a

Estimates of the proportion of recruited 'J', 'JE', 'JW', and 'OE' whales used to condition the trials unless otherwise specified in Tables 7b and 7c.

Hypothesis	Area	Years	Months	Sex	Ratio	CV[17]	Data Type	Stock	
A & B	2C	2002-07	Jan.-Mar.	M+F	0.868	0.05	mtDNA	J:Total	Bycatch samples
A & B	2C	2002-07	Jan.-Mar.	M+F	0.853	0.05	Allelle	J:Total	Bycatch samples
A & B	2C	2002-07	Apr.-Jun.	M+F	0.660	0.095	mtDNA	J:Total	Bycatch samples
A & B	2C	2002-07	Apr.-Jun.	M+F	0.648	0.05	Allelle	J:Total	Bycatch samples
A & B	2C	2001-07	Jul.-Dec.	M+F	0.923	0.05	mtDNA	J:Total	Bycatch samples
A & B	2C	2001-07	Jul.-Dec.	M+F	0.920	0.05	Allelle	J:Total	Bycatch samples
A & B	7CS	2002-07	Jan.-Apr.	M+F	0.161	0.05	mtDNA	J:Total	5/60 BC+55/60SP samples[18]
A & B	7CS	2002-07	Jan.-Apr.	M+F	0.198	0.05	Allelle	J:Total	5/60 BC + 55/60SP samples
A & B	7CS	2001-07	May	M+F	0.191	0.05	mtDNA	J:Total	5/60 BC + 55/60SP samples
A & B	7CS	2001-07	May	M+F	0.225	0.05	Allelle	J:Total	5/60 BC + 55/60SP samples
A & B	7CS	2000-07	Jun.-Dec.	M+F	0.077	0.05	mtDNA	J:Total	5/60 BC + 55/60SP samples
A & B	7CS	2000-07	Jun.-Dec.	M+F	0.128	0.05	Allelle	J:Total	5/60 BC + 55/60SP samples
A & B	7CN	1999-2007	Jan.-Jun.	M+F	0.098	0.05	mtDNA	J:Total	5/60 BC + 55/60SP samples
A & B	7CN	1999-2007	Jan.-Jun.	M+F	0.090	0.05	Allelle	J:Total	5/60 BC + 55/60SP samples
A & B	7CN	1996-2007	Jul.-Dec.	M+F	0.176	0.05	mtDNA	J:Total	5/60 BC + 55/60SP samples
A & B	7CN	1996-2007	Jul.-Dec.	M+F	0.216	0.05	Allelle	J:Total	5/60 BC + 55/60SP samples
A & B	11	1984-86	Apr.-May	M	0.175	0.099	mtDNA	J:Total	Comml samples
A & B	11	1984-99	Jun.-Sep.	M	0.201	0.054	mtDNA	J:Total	Comml & SP samples
A & B	11	1984-99	Jun.-Sep.	M	0.327	0.050	Allelle	J:Total	Comml & SP samples
A & B	11	1984-87	Apr.	F	0.645	0.069	mtDNA	J:Total	Comml samples
A & B	11	1984-87	May	F	0.013	0.05	mtDNA	J:Total	Comml samples
A & B	11	1984-99	Jun.-Sep.	F	0.245	0.056	mtDNA	J:Total	Comml & BC & SP samples
A & B	11	1984-99	Jun.-Sep.	F	0.390	0.05	Allelle	J:Total	Comml & BC & SP samples
B	6W	1999-2007	Jan.-Mar.	M+F	0.584	0.131	mtDNA	J:Total	Bycatch samples
B	6W	1999-2007	Jan.-Mar.	M+F	0.672	0.05	Allelle	J:Total	Bycatch samples
B	6W	1999-2007	Apr.-Jun.	M+F	0.496	0.126	mtDNA	J:Total	Bycatch samples
B	6W	1999-2007	Apr.-Jun.	M+F	0.812	0.05	Allelle	J:Total	Bycatch samples
B	6W	1999-2007	Jul.-Aug.	M+F	1.000	0.05	mtDNA	J:Total	Bycatch samples
B	6W	1999-2007	Jul.-Aug.	M+F	0.749	0.077	Allelle	J:Total	Bycatch samples
B	6W	1999-2007	Sep.-Dec.	M+F	0.593	0.123	mtDNA	J:Total	Bycatch samples
B	6W	1999-2007	Sep.-Dec.	M+F	0.761	0.05	Allelle	J:Total	Bycatch samples
C	2C	2002-07	Jan.-Mar.	M+F	0.960	0.05	mtDNA	JE:Total	Bycatch samples
C	2C	2002-07	Jan.-Mar.	M+F	0.840	0.05	Allelle	JE:Total	Bycatch samples
C	2C	2002-07	Apr.-Jun.	M+F	0.721	0.103	mtDNA	JE:Total	Bycatch samples
C	2C	2002-07	Apr.-Jun.	M+F	0.672	0.05	Allelle	JE:Total	Bycatch samples
C	7CS	2001-07	Jan.-May	M+F	0.188	0.050	mtDNA	JE:Total	5/60 BC + 55/60SP samples
C	7CS	2001-07	Jan.-May	M+F	0.234	0.050	Allelle	JE:Total	5/60 BC + 55/60SP samples
C	7CS	2000-07	Jun.-Dec.	M+F	0.089	0.050	mtDNA	JE:Total	5/60 BC + 55/60SP samples
C	7CS	2000-07	Jun.-Dec.	M+F	0.139	0.050	Allelle	JE:Total	5/60 BC + 55/60SP samples
C	7CN	1999-2007	Apr.-Jun.	M+F	0.041	0.050	mtDNA	JE:Total	5/60 BC + 55/60SP samples
C	7CN	1999-2007	Apr.-Jun.	M+F	0.036	0.050	Allelle	JE:Total	5/60 BC + 55/60SP samples
C	7CN	1996-2007	Jul.-Dec.	M+F	0.173	0.050	mtDNA	JE:Total	5/60 BC + 55/60SP samples
C	7CN	1996-2007	Jul.-Dec.	M+F	0.230	0.050	Allelle	JE:Total	5/60 BC + 55/60SP samples
C	11	1984-6	Apr.-May	M	0.180	0.099	mtDNA	JW:Total	Comml samples
C	11	1984-1999	Jun.-Sep.	M	0.204	0.054	mtDNA	JW:Total	Comml & SP samples
C	11	1984-1999	Jun.-Sep.	M	0.316	0.050	Allelle	JW:Total	Comml & SP samples
C	11	1984-87	Apr.	F	0.628	0.073	mtDNA	JW:Total	Comml samples
C	11	1984-87	May	F	0.023	0.050	mtDNA	JW:Total	Comml samples
C	11	1984-99	Jun.-Sep.	F	0.254	0.056	mtDNA	JW:Total	Comml & BC & SP samples
C	11	1984-99	Jun.-Sep.	F	0.367	0.050	Allelle	JW:Total	Comml & BC & SP samples
C	11	1984-86	Apr.-May	M	0.000	0.050	mtDNA	OW:Total	Comml samples
C	11	1984-99	Jun.-Sep.	M	0.114	0.142	mtDNA	OW:Total	Comml & SP samples
C	11	1984-99	Jun.-Sep.	M	0.032	0.095	Allelle	OW:Total	Comml & SP samples
C	11	1984-87	Apr.	F	0.147	0.117	mtDNA	OW:Total	Comml samples
C	11	1984-87	May	F	0.290	0.173	mtDNA	OW:Total	Comml samples
C	11	1984-99	Jun.-Sep.	F	0.062	0.132	mtDNA	OW:Total	Comml & BC & SP samples
C	11	1984-99	Jun.-Sep.	F	0.018	0.106	Allelle	OW:Total	Comml & BC & SP samples
C	6W	1999-2007	Jan.-Mar.	M+F	0.584	0.131	mtDNA	JW:Total	Bycatch samples
C	6W	1999-2007	Jan.-Mar.	M+F	0.672	0.05	Allelle	JW:Total	Bycatch samples
C	6W	1999-2007	Apr.-Jun.	M+F	0.496	0.126	mtDNA	JW:Total	Bycatch samples
C	6W	1999-2007	Apr.-Jun.	M+F	0.812	0.05	Allelle	JW:Total	Bycatch samples
C	6W	1999-2007	Jul.-Aug.	M+F	1.000	0.05	mtDNA	JW:Total	Bycatch samples
C	6W	1999-2007	Jul.-Aug.	M+F	0.749	0.077	Allelle	JW:Total	Bycatch samples
C	6W	1999-2007	Sep.-Dec.	M+F	0.593	0.123	mtDNA	JW:Total	Bycatch samples
C	6W	1999-2007	Sep.-Dec.	M+F	0.761	0.05	Allelle	JW:Total	Bycatch samples
C	7WR	1996-2007	Apr.-Aug.	M+F	0.327	0.149	mtDNA	OW:Total	SP samples
C	7WR	1996-2007	Apr.-Aug.	M+F	0.195	0.085	Allele	OW:Total	SP samples

[17]In cases when the sample size used to generate the proportion estimates is small and the se's are small (which will overweight such results), the standard error is set to 0.05.

[18]The mixing proportions in sub-areas 7CS and 7CN are based on the bycatch samples and the offshore samples, with weights of 5/60 and 55/60 respectively. Although most of the bycatch occurs within 2 n.miles of the coast, the density of minke whales is highest closest to coast and there will be movement between inshore and offshore. The weight of 5/60 places higher weight on the mixing proportions from the bycatch samples than the area where bycatch occurs would (i.e. a weight of 2/60) to reflect these considerations.

Table 7b

Alternative proportions of recruited ‘J’, “JE’, ‘JW’, and ‘OE’ whales used to condition trials 06 and 07.
The mixing proportion in 7CS, 7CN is calculated using a 2/60 weight for the bycatch for trial 06 and using a 10/60 weight for trial 07.

Hypothesis	Trial	Area	Years	Months	Sex	Ratio	CV	Data Type	Stock	
A & B	06	7CS	2002-07	Jan.-Apr	M+F	0.147	0.05	mtDNA	J:Total	2/60 BC + 58/60SP samples
A & B	06	7CS	2002-07	Jan.-Apr.	M+F	0.185	0.05	Allelle	J:Total	2/60 BC + 58/60SP samples
A & B	06	7CS	2001-07	May	M+F	0.193	0.05	mtDNA	J:Total	2/60 BC + 58/60SP samples
A & B	06	7CS	2001-07	May	M+F	0.228	0.05	Allelle	J:Total	2/60 BC + 58/60SP samples
A & B	06	7CS	2000-07	Jun.-Dec	M+F	0.046	0.05	mtDNA	J:Total	2/60 BC + 58/60SP samples
A & B	06	7CS	2000-07	Jun.-Dec	M+F	0.099	0.05	Allelle	J:Total	2/60 BC + 58/60SP samples
A & B	06	7CN	1999-2007	Jan.-Jun.	M+F	0.078	0.05	mtDNA	J:Total	2/60 BC + 58/60SP samples
A & B	06	7CN	1999-2007	Jan.-Jun.	M+F	0.067	0.05	Allelle	J:Total	2/60 BC + 58/60SP samples
A & B	06	7CN	1996-2007	Jul.-Dec.	M+F	0.144	0.05	mtDNA	J:Total	2/60 BC + 58/60SP samples
A & B	06	7CN	1996-2007	Jul.-Dec.	M+F	0.191	0.05	Allelle	J:Total	2/60 BC + 58/60SP samples
C	06	7CS	2001-07	Jan.-May	M+F	0.178	0.050	mtDNA	JE:Total	2/60 BC + 58/60SP samples
C	06	7CS	2001-07	Jan.-May	M+F	0.227	0.050	Allelle	JE:Total	2/60 BC + 58/60SP samples
C	06	7CS	2000-07	Jun.-Dec.	M+F	0.056	0.050	mtDNA	JE:Total	2/60 BC + 58/60SP samples
C	06	7CS	2000-07	Jun.-Dec.	M+F	0.111	0.050	Allelle	JE:Total	2/60 BC + 58/60SP samples
C	06	7CN	1999-2007	Apr.-Jun.	M+F	0.016	0.050	mtDNA	JE:Total	2/60 BC + 58/60SP samples
C	06	7CN	1999-2007	Apr.-Jun.	M+F	0.014	0.050	Allelle	JE:Total	2/60 BC + 58/60SP samples
C	06	7CN	1996-2007	Jul.-Dec.	M+F	0.141	0.050	mtDNA	JE:Total	2/60 BC + 58/60SP samples
C	06	7CN	1996-2007	Jul.-Dec.	M+F	0.206	0.050	Allelle	JE:Total	2/60 BC + 58/60SP samples
A & B	07	7CS	2002-07	Jan.-Apr.	M+F	0.185	0.05	mtDNA	J:Total	10/60 BC + 50/60SP samples
A & B	07	7CS	2002-07	Jan.-Apr.	M+F	0.220	0.05	Allelle	J:Total	10/60 BC + 50/60SP samples
A & B	07	7CS	2001-07	May	M+F	0.188	0.05	mtDNA	J:Total	10/60 BC + 50/60SP samples
A & B	07	7CS	2001-07	May	M+F	0.220	0.05	Allelle	J:Total	10/60 BC + 50/60SP samples
A & B	07	7CS	2000-07	Jun.-Dec.	M+F	0.128	0.05	mtDNA	J:Total	10/60 BC + 50/60SP samples
A & B	07	7CS	2000-07	Jun.-Dec.	M+F	0.177	0.05	Allelle	J:Total	10/60 BC + 50/60SP samples
A & B	07	7CN	1999-2007	Jan.-Jun.	M+F	0.133	0.05	mtDNA	J:Total	10/60 BC + 50/60SP samples
A & B	07	7CN	1999-2007	Jan.-Jun.	M+F	0.128	0.05	Allelle	J:Total	10/60 BC + 50/60SP samples
A & B	07	7CN	1996-2007	Jul.-Dec.	M+F	0.229	0.05	mtDNA	J:Total	10/60 BC + 50/60SP samples
A & B	07	7CN	1996-2007	Jul.-Dec.	M+F	0.258	0.05	Allelle	J:Total	10/60 BC + 50/60SP samples
C	07	7CS	2001-07	Jan.-May	M+F	0.205	0.050	mtDNA	JE:Total	10/60 BC + 50/60SP samples
C	07	7CS	2001-07	Jan.-May	M+F	0.245	0.050	Allelle	JE:Total	10/60 BC + 50/60SP samples
C	07	7CS	2000-07	Jun.-Dec.	M+F	0.144	0.050	mtDNA	JE:Total	10/60 BC + 50/60SP samples
C	07	7CS	2000-07	Jun.-Dec.	M+F	0.185	0.050	Allelle	JE:Total	10/60 BC + 50/60SP samples
C	07	7CN	1999-2007	Apr.-Jun.	M+F	0.081	0.050	mtDNA	JE:Total	10/60 BC + 50/60SP samples
C	07	7CN	1999-2007	Apr.-Jun.	M+F	0.071	0.050	Allelle	JE:Total	10/60 BC + 50/60SP samples
C	07	7CN	1996-2007	Jul.-Dec.	M+F	0.227	0.050	mtDNA	JE:Total	10/60 BC + 50/60SP samples
C	07	7CN	1996-2007	Jul.-Dec.	M+F	0.270	0.050	Allelle	JE:Total	10/60 BC + 50/60SP samples

Table 7c

Alternative proportions of recruited ‘J’, ‘JE’, and ‘JW’ whales used to condition trials 13, 14, 15, 23 and 24.
(Note: trial 24 is a low plausibility trial but the proportions are included here for completeness)

Hypothesis	Trial	Area	Years	Months	Sex	Ratio	CV	Data Type	Stock	
C	13	11	1984-86	Apr.-May	M	0.180	0.099	mtDNA	JW:Total	Comml samples
C	13	11	1984-99	Jun.-Sep.	M	0.212	0.054	mtDNA	JW:Total	Comml & SP samples
C	13	11	1984-99	Jun.-Sep.	M	0.317	0.050	Allelle	JW:Total	Comml & SP samples
C	13	11	1984-87	Apr.	F	0.654	0.068	mtDNA	JW:Total	Comml samples
C	13	11	1984-87	May	F	0.032	0.050	mtDNA	JW:Total	Comml samples
C	13	11	1984-99	Jun.-Sep.	F	0.256	0.055	mtDNA	JW:Total	Comml & BC & SP samples
C	13	11	1984-99	Jun.-Sep.	F	0.368	0.050	Allelle	JW:Total	Comml & BC & SP samples
C	14	11	1984-86	Apr.-May	M	0.126	0.103	mtDNA	JW:Total	Comml samples
C	14	11	1984-99	Jun.-Sep.	M	0.181	0.054	mtDNA	JW:Total	Comml & SP samples
C	14	11	1984-99	Jun.-Sep.	M	0.346	0.050	Allelle	JW:Total	Comml & SP samples
C	14	11	1984-87	Apr.	F	0.610	0.075	mtDNA	JW:Total	Comml samples
C	14	11	1984-87	May	F	0.024	0.050	mtDNA	JW:Total	Comml samples
C	14	11	1984-99	Jun.-Sep.	F	0.249	0.058	mtDNA	JW:Total	Comml & BC & SP samples
C	14	11	1984-99	Jun.-Sep.	F	0.399	0.050	Allelle	JW:Total	Comml & BC & SP samples
C	23	2C	2002-07	Jan.-Mar.	M+F	0.875	0.05	mtDNA	J:Total	Bycatch samples
C	23	2C	2002-07	Jan.-Mar	M+F	0.868	0.05	Allelle	J:Total	Bycatch samples
C	23	2C	2002-07	Apr.-Jun.	M+F	0.656	0.102	mtDNA	J:Total	Bycatch samples
C	23	2C	2002-07	Apr.-Jun.	M+F	0.661	0.05	Allelle	J:Total	Bycatch samples
C	23	7CS	2001-07	Jan.-May	M+F	0.154	0.050	mtDNA	J:Total	5/60 BC + 55/60SP samples
C	23	7CS	2001-07	Jan.-May	M+F	0.232	0.050	Allelle	J:Total	5/60 BC + 55/60SP samples
C	23	7CS	2000-07	Jun.-Dec.	M+F	0.074	0.050	mtDNA	J:Total	5/60 BC + 55/60SP samples
C	23	7CS	2000-07	Jun.-Dec.	M+F	0.138	0.050	Allelle	J:Total	5/60 BC + 55/60SP samples
C	23	7CN	1999-2007	Apr.-Jun.	M+F	0.033	0.050	mtDNA	J:Total	5/60 BC + 55/60SP samples

Cont.

Hypothesis	Trial	Area	Years	Months	Sex	Ratio	CV	Data Type	Stock	
C	23	7CN	1999-2007	Apr.-Jun.	M+F	0.037	0.050	Allelle	J:Total	5/60 BC + 55/60SP samples
C	23	7CN	1996-2007	Jul.-Dec.	M+F	0.148	0.050	mtDNA	J:Total	5/60 BC + 55/60SP samples
C	23	7CN	1996-2007	Jul.-Dec.	M+F	0.227	0.050	Allelle	J:Total	5/60 BC + 55/60SP samples
C	23	11	1984-86	Apr.-May	M	0.180	0.099	mtDNA	J:Total	Comml samples
C	23	11	1984-99	Jun.-Sep.	M	0.204	0.054	mtDNA	J:Total	Comml & SP samples
C	23	11	1984-99	Jun.-Sep.	M	0.316	0.050	Allelle	J:Total	Comml & SP samples
C	23	11	1984-87	Apr.	F	0.628	0.073	mtDNA	J:Total	Comml samples
C	23	11	1984-87	May	F	0.023	0.050	mtDNA	J:Total	Comml samples
C	23	11	1984-99	Jun.-Sep.	F	0.254	0.056	mtDNA	J:Total	Comml & BC & SP samples
C	23	11	1984-99	Jun.-Sep.	F	0.367	0.050	Allelle	J:Total	Comml & BC & SP samples
C	23	11	1984-86	Apr.-May	M	0.000	0.050	mtDNA	OW:Total	Comml samples
C	23	11	1984-99	Jun.-Sep.	M	0.114	0.142	mtDNA	OW:Total	Comml & SP samples
C	23	11	1984-99	Jun.-Sep.	M	0.032	0.095	Allelle	OW:Total	Comml & SP samples
C	23	11	1984-87	Apr.	F	0.147	0.117	mtDNA	OW:Total	Comml samples
C	23	11	1984-87	May	F	0.290	0.173	mtDNA	OW:Total	Comml samples
C	23	11	1984-99	Jun.-Sep.	F	0.062	0.132	mtDNA	OW:Total	Comml & BC & SP samples
C	23	11	1984-99	Jun.-Sep.	F	0.018	0.106	Allelle	OW:Total	Comml & BC & SP samples
C	24	2C	2002-07	Jan.-Mar.	M+F	0.920	0.05	mtDNA	JE:Total	Bycatch samples
C	24	2C	2002-07	Jan.-Mar.	M+F	0.834	0.05	Allelle	JE:Total	Bycatch samples
C	24	2C	2002-07	Apr.-Jun.	M+F	0.699	0.097	mtDNA	JE:Total	Bycatch samples
C	24	2C	2002-07	Apr.-Jun.	M+F	0.662	0.05	Allelle	JE:Total	Bycatch samples
C	24	7CS	2001-07	Jan.-May	M+F	0.207	0.050	mtDNA	JE:Total	5/60 BC + 55/60SP samples
C	24	7CS	2001-07	Jan.-May	M+F	0.215	0.050	Allelle	JE:Total	5/60 BC + 55/60SP samples
C	24	7CS	2000-07	Jun.-Dec.	M+F	0.080	0.050	mtDNA	JE:Total	5/60 BC + 55/60SP samples
C	24	7CS	2000-07	Jun.-Dec.	M+F	0.116	0.050	Allelle	JE:Total	5/60 BC + 55/60SP samples
C	24	7CN	1999-2007	Apr.-Jun.	M+F	0.111	0.050	mtDNA	JE:Total	5/60 BC + 55/60SP samples
C	24	7CN	1999-2007	Apr.-Jun.	M+F	0.082	0.050	Allelle	JE:Total	5/60 BC + 55/60SP samples
C	24	7CN	1996-2007	Jul.-Dec.	M+F	0.198	0.050	mtDNA	JE:Total	5/60 BC + 55/60SP samples
C	24	7CN	1996-2007	Jul.-Dec.	M+F	0.213	0.050	Allelle	JE:Total	5/60 BC + 55/60SP samples
C	24	11	1984-86	Apr.-May	M	0.175	0.099	mtDNA	JW:Total	Comml samples
C	24	11	1984-99	Jun.-Sep.	M	0.201	0.054	mtDNA	JW:Total	Comml & SP samples
C	24	11	1984-99	Jun.-Sep.	M	0.327	0.050	Allelle	JW:Total	Comml & SP samples
C	24	11	1984-87	Apr.	F	0.645	0.069	mtDNA	JW:Total	Comml samples
C	24	11	1984-87	May	F	0.013	0.050	mtDNA	JW:Total	Comml samples
C	24	11	1984-99	Jun.-Sep.	F	0.245	0.056	mtDNA	JW:Total	Comml & BC & SP samples
C	24	11	1984-99	Jun.-Sep.	F	0.390	0.050	Allelle	JW:Total	Comml & BC & SP samples

(f) Calculation of likelihood

The likelihood function consists of three components: Likelihood = -2 (L_1+L_2+L_3) Equations F.4-6 list the negative of the logarithm of the objective function for each of the three components:

ABUNDANCE ESTIMATES

$$L_1 = 0.5\sum_n \frac{1}{(\sigma_t^k)^2}\ln\left(P_n / \hat{P}_n\right)^2 \tag{F.4}$$

where $\hat{P}_n$ is the model estimate of the abundance in the same year, period and sub-area as the *n*th estimate of abundance P_n.

STOCK PROPORTIONS

$$L_2 = 0.5\sum_n \frac{1}{(\sigma_n^k)^2}\left(p_n^k - \hat{p}_n^k\right)^2 \tag{F.5}$$

where $\hat{p}_n$ is the model estimate of the proportion of whales in the same year, period and sub-area as the *n*th proportion estimate P_n.

BYCATCH ESTIMATES

$$L_3 = 0.5\sum_n \left(B_n^k - \hat{B}_n^k\right)^2 / 10 \tag{F.6}$$

where $\hat{B}_n^k$ is the model estimate of the total bycatch in sub-area *k* over the years being fitted and B_n^k is the observed bycatch in the same area and period.

G. Trials

The set of trials is given in Table 8. The sensitivity trials are variants of the base-case trials A01-1 etc. (see section A).

Table 8

The list of Trials (Trial 24 is assigned low plausibility and so is crossed through).

Stock hypothesis	Trial no.	MSYR	Mix matrix	Description
A	A01-1 & A01-4	1% & 4%	See Adjunct 2	Baseline A: 2 stocks (‘J’ and ‘O’); g(0) = 0.8; including Chinese bycatch
B	B01-1 & B01-4	1% & 4%	See Adjunct 2	Baseline B: 3 stocks (‘J’, ‘O’, and ‘Y’); g(0) = 0.8; including Chinese bycatch
C	C01-1 & C01-4	1% & 4%	See Adjunct 2	Baseline C: 5 stocks (‘JW’, ‘JE’, ‘OW’, ‘OE’, and ‘Y’); g(0) = 0.8; including Chinese bycatch
AC	A02-1 etc	1% / 4%	See Adjunct 2	With a ‘C’ stock
ABC	A03-1 etc	1% / 4%	Baseline	Assume g(0) = 1
ABC	A04-1 etc	1% / 4%	Baseline	High direct catches + alternative Korean & Japanese bycatch level
ABC	A05-1 etc	1% / 4%	See Adjunct 2	Some ‘O’ or ‘OW’ animals in sub-area 10E. The mixing matrices will be modified such that the proportion of O/OW-stock in 10E is ~30% of that in 7CN in all months. Note: the small no. (9) of genetic samples in 10E (Oct-Dec) precludes mixing proportions being estimated for 10E.
ABC	A06-1 etc	1% / 4%	Baseline	Mixing proportion in 7CS and 7CN calculated using 2/60 weight for bycatch
ABC	A07-1 etc	1% / 4%	Baseline	Mixing proportion in 7CS and 7CN calculated using 10/60 weight for bycatch
ABC	A08-1 etc	1% / 4%	Baseline	More Korean catches in sub-area 5 (and fewer in 6W). Rationale: the baseline uses the best split. Trials 8 and 9 test alternatives in both directions.
ABC	A09-1 etc	1% / 4%	Baseline	More Korean catches in sub-area 6W (and fewer in 5)
ABC	A10-1 etc	1% / 4%	Baseline	10% J (/ JW) -stock in sub-area 12SW in June (base case value = 25%). See section F(c).
ABC	A11-1 etc	1% / 4%	See Adjunct 2	30% J (/ JW) -stock in sub-area 12SW in June (base case value = 25%). See section F(c).
C	C12-1 & 4	1% / 4%	See Adjunct 2	No ‘C’ animals in sub-area 12NE
C	C13-1 & 4	1% / 4%	See Adjunct 2	No ‘OW’ in 11 or 12 SW. (OW & OE whales mix with JW in 11 & 12 SW in the baseline C trials).
C	C14-1 & 4	1% / 4%	See Adjunct 2	No ‘OE’ in 11 or 12 SW
C	C15-1 & 4	1% / 4%	See Adjunct 2	No ‘OE’ in 7WR. (OE & OW whales mix in 7WR from Apr-Sep, while OW whales are present year round in the baseline C trials)
C	C16-1 & 4	1% / 4%	Baseline	Dispersal rate of 0.005 between the OW and OE & the JW and JE stocks
C	C17-1 & 4	1% / 4%	Baseline	Dispersal rate of 0.02 between the OW and OE & the JW and JE stocks
ABC	A18-1 etc	1% / 4%	Baseline	Chinese incidental catch = 0 (the base case value = twice that of Korea in sub-area 5)
ABC	A19-1 etc	1% / 4%	Baseline	Alternative abundance estimates in 6E (see table 6a)
ABC	A20-1 etc	1% / 4%	See Adjunct 2	Additional abundance estimate in 10E in 2007 (see table 6a)
ABC	A21-1 etc	1% / 4%	See Adjunct 2	Abundance estimate in 5 = ‘minimum’ value listed in Table 6b, with a CV=0.1. See section F(a). (The baseline fits to a low variance pseudo-estimate of abundance drawn from U[minimum : maximum] where the ‘minimum’ and ‘maximum’ values are those listed in Table 6b).
ABC	A22-1 etc	1% / 4%	Baseline	Abundance estimate in 5 = ‘maximum’ value listed in Table 6b (= 5 * baseline value), with a CV=0.1
C	C23-1 & 4	1% / 4%	See Adjunct 2	Single J-stock (with pure J-stock definition using 6E (all months))
~~C~~	~~C24-1 & 4~~	~~1% / 4%~~	~~See Adjunct 2~~	~~Single O-stock (with pure O-stock definition using 7WR, 7E and 8 (all months))~~
ABC	A25-1 etc	1% / 4%	Baseline	The number of bycaught animals is proportional to the square-root of abundance rather than to abundance (in order to examine the impact of possible saturation effects)
AB	A26-1 etc	1% / 4%	See Adjunct 2	A substantially larger fraction of whales ages 1-4 from O-stock are found in sub-areas 2R, 3 and 4 year-round (so the proportion of 1-4 whales in sub-area 9 is closer to expectations given the length-frequencies of catches from sub-area 9). The mixing matrices are adjusted such that the numbers of age 1-4 of O-stock animals in sub-area 9 and 9N are no more than half the base case numbers; juveniles will be allowed into sub-areas 2R, 3 and 4 in the corresponding months.
ABC	A27-1 etc	1% / 4%	See Adjunct 2	Set the proportion of O/OE animals of ages 1-4 in sub-area 9 and 9N to zero and allow the abundance in sub-areas 7CS and 7CN to exceed the abundance estimates for these sub-areas. Projections for this sub-area will need to account for the implied survey bias
ABC	A28-1 etc	1% / 4%	See Adjunct 2	The number of 1+ whales in 2009 in sub-area 2C in any month < 200 (if large numbers of whales were found in 2C, the historical catch would be expected to be much greater).
ABC	A29-1 etc	1% / 4%	See Adjunct 2	Abundance estimate in 6W = ‘minimum’ value listed in Table 6b, with a CV=0.1. See section F(a). (The baseline fits to a low variance pseudo-estimate of abundance drawn from U[minimum : maximum] where the ‘minimum’ and ‘maximum’ values are those listed in Table 6b).
ABC	A30-1 etc	1% / 4%	See Adjunct 2	Abundance estimate in 6W = ‘maximum’ value listed in Table 6b (= 5 * baseline value), with a CV=0.1
C	C31-1 etc	1% / 4%	Baseline	Alternative time invariant proportion of JE-stock whales in 7CN in Jan-Jun used to remove bycatch (see Table 2b)

H. Management options

Two issues relate to specifying the management options: (a) the designation of *Areas* (*Small*, *Medium* and *Large*); and (b) the management procedure variants to consider.

The RMP variants include specifications regarding the *Small Areas* (combinations of sub-areas), the use of the capping and cascading options of the RMP, and when and where harvesting will occur. The initial set of RMP variants to be considered in the trials and the sub-areas from which catches are taken when a *Small Area* consists of more than one sub-area are:

(1) *Small Areas* equal sub-areas. For this option, the *Small Areas* for which catch limits would be set are 5, 6W, 7CS, 7CN, 7WR, 7E, 8, 9*, and 11.

(2) 5, 6W, 7+8, 9*, and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CN, 9, and 11.

(3) 5, 6W, 7+8, 9*, and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 9, and 11.

(4) 5, 6W, 7CS, 7CN, 7WR+7E+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 7CN, 7WR, 9* and 11.

(5) 5 and 6W are *Small Areas* and catches are taken from sub-areas 5 and 6W. 7+8+9*+11+12 is a combination area and catches are cascaded to the sub-areas within the combination area. The catch limits for sub-areas 12SW and 12NE are not taken.

(6) 5, 6W, 7+8, 9*, and 11 are *Small Areas* except that the catches from the 7+8 *Small Area* are taken from sub-areas 7CS and 7CN using the same method as for catch cascading to allocate the catch across the two sub-areas.

(7) 5+6W+6E+10W+10E, 7+8+9*+11 are *Small Areas*; catches from the 5+6W+6E+10W+10E *Small Area* are taken from sub-areas 5 and 6W using the same method as for catch cascading to allocate the catch across those two sub-areas, and catches from the Small Area 7+8+9+11 are taken in the sub-area 7CN.

(8) 5, 6W, 7+8+9*+11+12 are *Small Areas*; catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 8 and 9 using the same method as for catch cascading to allocate the catch across the two sub-areas.

(9) 5, 6W, 7+8+9*+11+12 are *Small Areas;* catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across the five sub-areas.

(10) 5, 6W, 7+8+9*+11+12 are *Small Areas;* catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8, 9 and 11 using the same method as for catch cascading to allocate the catch across the six sub-areas. The catch from sub-area 11 is taken in May and June.

(11) 5, 6W, 7+8+9*+11+12 are *Small Areas;* catches from the 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across the five sub-areas but the catch taken from sub-areas 7CS, 7CN, 7WR and 7E is reduced by 50% after first subtracting the bycatches in these sub-areas.

: 9 refers to sub-area 9 alone (i.e. excluding 9N) in the definitions of the variants given above.

Note that the proportions of the whales in a sub-area that belong to each stock will differ from sub-area to sub-area (as well as from year to year). Thus when a *Small Area* is specified which consists of a number of sub-areas, the impact on the various stocks of the catch allowed under the RMP will differ depending on how this catch is distributed amongst the constituent sub-areas. In such cases trials are specified which attempt to bound the extremes of such catch distributions in terms of their likely impact on stocks. The initial trials above incorporate a first attempt to address this aspect, e.g. variants (2) and (3) reflect likely alternative “extremes” in this context regarding a catch taken from 7+8.

Simulations of future catch limit calculations will be performed (i.e. catch limits will be set by the *CLA*) every 6 years, beginning in 2013[19]. No phaseout will be applied so as not to confound comparison of the different management variants.

I. Output statistics

Population-size and continuing catch statistics are produced for each stock, and catch-related statistics for each sub-area. Catch related statistics are produced both for the total catches (commercial and incidental) and for the commercial catches alone.

(1) Total catch (TC) distribution: (a) median; (b) 5th value; (c) 95th value.

(2) Initial mature female population size (P_{2000}) distribution: (a) median; (b) 5th value; (c) 95th value.

(3) Final mature female population size (P_f) distribution: (a) median; (b) 5th value; (c) 95th value.

(4) Lowest mature female population over 100 years (P_{low}) distribution: (a) median; (b) 5th value; (c) 95th value.

(5) Average catch over the last 10 years of the 100-year management period: (a) median; (b) 5th value; (c) 95th value.

(6) Catch by sub-area, stock and catch-type (incidental or commercial): (a) median; (b) 5th value; (c) 95th value.

(7) The median percentage of mature ‘J’ stock females being in sub-area 12 in June-August 1973-75.

(8) The median annual rate of decline in the number of whales assumed recruited to the Korean fishery over the period 1973-1986.

(9) The median 1+ population size for animals in sub-areas 6 and 10 in August-September in 1992 and in 2000 (corresponding to Sea of Japan surveys).

(10) The mean proportion of ‘J’ whales in the total (scientific, commercial and incidental) catch taken by Japan from 1993-98 is output in trials, for comparison with results obtained from market samples.

[19]In practice 2014 is the earliest year in which catch limits could be set, for the 2015 season.

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Adjunct 1

The Historical Catch Series

C. Allison

Direct catches

The baseline trials use the 'best' estimates of the historical direct catch which are summarised in Tables 1 and 2. Details of the sources and construction of the catch series are given in Allison (2011). The data are taken from the IWC individual catch database (Allison, 2013) where available. Information on the direct catches taken in 2012 was not available when the conditioning was performed, so the 2012 catch was assumed to be equal to the 2011 catch. The actual numbers for 2012 are included here in Table 3 for completeness.

An alternative 'high' catch series is used in sensitivity trial 4. Table 4 lists the 'high' catch numbers for the years and sub-areas where they differ from the 'best' catch series. The catches are identical to the 'best' series for all other areas and years. The Japanese coastal catch from 1930-1 and 1936-45 (in sub-areas 7CS, 7CN and 11) is estimated (Ohsumi, 1982) and the values are doubled in the 'high' catch series. The catch series off Korea assumes a linear increase from 60 whales in 1946 to 249 in 1957 in the 'best' series whereas the 'high' series assumes an annual catch of 249 minke whales over this period.

The split between sub-areas 5 and 6W is unknown for most of the catches taken off Korea. The 'best' catch series includes 19,349 minke whales taken off Korea, of which 3,902 are recorded in the Yellow Sea and 4,199 in the Sea of Japan (East Sea) and Southern waters. The remaining 11,248 of unknown area are allocated between sub-areas 5 and 6W in the ratio of the catches known by area from 1940-79[20] (2,028:2,517). Trials 8 and 9 test the sensitivity to this assumption. In trial 8 the number of whales allocated to sub-area 5 is reduced by 20% and reallocated to sub-area 6W. In Trial 9, 20% fewer animals are allocated to sub-area 6W and are reallocated to sub-area 5. The resulting catch series are given in Table 5.

Table 1

Summary of the final western North Pacific minke whale direct catch series (1930-2011) by sub-area, sex and month. The highlighted catches cannot be taken as no whales are modelled the area/month.

	Males								Females										
Area	J-M	Apr	May	Jun	Jul	Aug	Sep	O-D	J-M	Apr	May	Jun	Jul	Aug	Sep	O-D	Total	M	F
1E	17	0	0	0	1	0	0	0	11	0	0	0	0	0	0	0	29	18	11
2C	3	2	2	3	2	0	1	0	2	2	0	0	1	0	0	0	18	13	5
2R	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	4	2	2
5	981	1,280	906	671	568	322	102	174	1,128	1,457	1,244	757	570	300	121	185	10,766	5,004	5,762
6W	181	383	1,325	1,167	392	202	557	1,063	178	364	1,300	1,136	376	189	545	1,009	10,367	5,270	5,097
6E	181	223	135	13	21	0	8	2	95	144	95	16	3	0	6	1	943	583	360
7CS	210	974	1,715	762	126	8	1	0	164	1,087	1,278	464	27	1	0	0	6,817	3,796	3,021
7CN	0	0	34	221	380	424	746	147	0	19	71	96	158	118	243	67	2,724	1,952	772
7W	0	1	45	29	3	1	1	0	0	0	9	2	3	0	0	0	94	80	14
7E	0	0	36	11	3	0	13	1	0	0	7	2	0	0	8	0	81	64	17
8	0	0	34	93	90	20	11	6	0	0	8	10	16	4	5	6	303	254	49
9	0	0	32	82	182	190	10	0	0	0	9	10	15	20	0	0	550	496	54
9N	0	0	1	2	5	8	0	1	0	0	0	6	0	11	0	0	34	17	17
10W	0	0	6	12	1	0	2	0	0	2	0	9	0	0	0	0	32	21	11
10E	2	25	42	119	83	26	5	3	0	1	28	60	26	9	7	0	436	305	131
11	0	62	248	492	557	210	143	29	2	465	872	858	593	240	113	25	4,909	1,741	3,168
12SW	0	0	0	1	11	9	1	0	0	0	1	5	16	27	5	0	76	22	54
12NE	0	0	0	0	36	9	10	0	0	0	0	3	33	14	6	0	111	55	56
13	0	0	0	0	0	2	0	0	0	0	0	0	1	3	0	0	6	2	4
Total	1,576	2,951	4,561	3,678	2,461	1,431	1,611	1,426	1,581	3,541	4,922	3,434	1,838	936	1,060	1,293	38,300	19,695	18,605

[20]The period 1940-79 is used in view of a comment by Gong (1982) that, in 1980, Government policy led to a shift to the western sector in order to direct the minke whale fishery away from areas where the (protected) fin whale might also be caught.

Table 2

Summary of the ‘best’ direct catch series for western North Pacific minke whales by year, sub-area and sex. Catches in 2012 were not available when the conditioning was performed and so are assumed to be equal to the catch in 2011.

	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
Males:																				
1930	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	1	0	0	0	8
1931	0	0	0	0	0	0	7	1	0	0	0	0	0	0	0	0	0	0	0	8
1932	0	0	0	0	9	0	13	1	0	0	0	0	0	0	0	0	0	0	0	23
1933	0	0	0	0	8	0	13	1	0	0	0	0	0	0	0	0	0	0	0	22
1934	0	0	0	1	21	0	20	1	0	0	0	0	0	0	0	0	0	0	0	43
1935	0	0	0	9	9	0	20	1	0	0	0	0	0	0	0	1	0	0	0	40
1936	0	0	0	12	14	0	15	0	0	0	0	0	0	0	0	0	0	0	0	41
1937	0	0	0	13	17	0	37	0	0	0	0	0	0	0	0	1	0	0	0	68
1938	0	0	0	15	20	0	44	0	0	0	0	0	0	0	0	1	0	0	0	80
1939	0	0	0	18	24	0	44	1	0	0	0	0	2	0	0	0	0	0	0	89
1940	0	0	0	15	33	0	52	0	0	0	0	0	0	0	0	1	0	0	0	101
1941	0	0	0	40	40	0	37	1	0	0	0	0	2	0	0	0	0	0	0	120
1942	0	0	0	53	67	0	44	0	0	0	0	0	1	0	0	1	0	0	0	166
1943	0	0	0	42	51	0	67	1	0	0	0	0	0	0	0	0	0	0	0	161
1944	0	0	0	38	47	0	52	0	0	0	0	0	0	0	0	1	0	0	0	138
1945	0	0	0	3	2	0	44	0	0	0	0	0	0	0	0	0	0	0	0	49
1946	0	0	0	11	21	14	51	4	0	0	0	0	1	0	0	4	0	0	0	106
1947	0	0	0	19	21	27	57	7	0	0	0	0	0	0	0	8	0	0	0	139
1948	0	3	0	22	26	56	57	1	0	0	1	0	0	0	0	26	0	0	0	192
1949	0	0	0	25	31	20	61	0	0	0	1	0	2	0	5	6	0	2	0	153
1950	0	3	0	29	37	15	63	41	0	0	2	0	1	0	13	18	0	0	0	222
1951	1	1	0	31	40	62	87	9	0	3	0	0	0	0	5	14	0	0	0	253
1952	0	1	0	36	45	142	92	1	0	0	0	0	1	0	9	20	0	0	0	347
1953	0	0	0	42	50	90	75	1	0	0	3	0	0	0	38	35	1	0	0	335
1954	0	0	1	43	54	35	24	26	0	0	0	0	0	0	32	59	1	0	0	275
1955	0	0	0	49	60	20	108	11	0	0	2	0	0	0	20	43	1	1	0	315
1956	0	0	0	54	62	16	140	25	0	1	3	0	0	0	47	69	0	0	0	417
1957	17	1	0	59	70	2	111	14	2	0	1	0	0	0	31	33	1	0	0	342
1958	0	0	0	67	65	0	126	13	0	0	1	0	0	0	0	86	0	0	0	358
1959	0	0	0	78	71	0	69	7	0	0	0	0	0	0	0	47	0	0	0	272
1960	0	0	0	72	59	0	64	6	0	1	1	0	0	0	0	41	0	0	0	244
1961	0	0	0	39	28	0	81	9	0	0	0	0	0	0	0	56	0	0	0	213
1962	0	0	0	55	52	0	46	7	0	0	0	0	0	0	0	48	0	0	0	208
1963	0	0	0	122	52	0	49	6	0	0	0	0	0	0	0	40	0	0	0	269
1964	0	0	0	139	95	6	85	6	0	0	0	0	0	0	0	39	0	0	0	370
1965	0	1	0	83	101	11	51	3	0	0	0	0	0	0	0	62	0	0	0	312
1966	0	2	0	76	87	0	81	8	1	0	0	0	0	0	0	71	0	0	0	326
1967	0	0	0	109	73	2	50	6	0	0	0	0	0	0	2	55	0	0	0	297
1968	0	0	0	98	75	8	58	4	1	0	0	0	0	2	0	22	0	0	0	268
1969	0	0	0	118	95	10	27	2	0	0	0	0	3	0	7	43	0	0	0	305
1970	0	0	0	186	188	5	101	5	1	0	0	2	4	0	8	38	0	0	2	540
1971	0	0	0	200	189	3	84	6	0	0	0	0	0	0	8	54	1	0	0	545
1972	0	0	0	252	286	0	35	17	0	0	0	0	0	0	0	78	0	0	0	668
1973	0	0	0	215	244	0	83	26	0	2	14	0	0	0	15	95	2	28	0	724
1974	0	0	0	213	271	0	63	34	0	9	0	0	0	1	5	44	4	22	0	666
1975	0	0	0	196	293	9	35	63	0	3	0	0	0	18	2	62	11	1	0	693
1976	0	0	0	353	174	0	35	27	0	0	0	0	0	0	10	89	0	0	0	688
1977	0	0	0	234	304	0	32	71	0	0	0	0	0	0	0	58	0	0	0	699
1978	0	0	0	181	354	0	93	133	0	0	0	0	0	0	0	19	0	0	0	780
1979	0	0	0	164	379	0	95	150	0	0	0	0	0	0	8	17	0	0	0	813
1980	0	0	0	447	147	0	88	72	0	0	0	0	0	0	10	40	0	0	0	804
1981	0	1	0	188	192	0	148	39	1	0	0	0	0	0	13	28	0	0	0	610
1982	0	0	0	229	210	2	105	56	1	0	0	0	0	0	9	5	0	0	0	617
1983	0	0	0	100	142	3	66	68	0	0	0	0	0	0	6	4	0	0	0	389
1984	0	0	0	87	105	0	64	88	0	0	0	0	0	0	0	46	0	0	0	390
1985	0	0	1	23	29	5	39	123	0	0	0	0	0	0	2	30	0	0	0	252
1986	0	0	0	1	31	20	69	89	0	0	0	0	0	0	0	19	0	0	0	229
1987	0	0	0	0	0	0	80	86	0	0	0	0	0	0	0	16	0	0	0	182
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	18
1995	0	0	0	0	0	0	0	0	0	0	0	91	0	0	0	0	0	0	0	91
1996	0	0	0	0	0	0	0	28	0	0	16	0	0	0	0	19	0	0	0	63
1997	0	0	0	0	0	0	0	0	1	1	30	55	0	0	0	0	0	0	0	87
1998	0	0	0	0	0	0	0	0	22	26	41	0	0	0	0	0	0	0	0	89
1999	0	0	0	0	0	0	2	39	2	0	0	0	0	0	0	28	0	0	0	71
2000	0	0	0	0	0	0	4	15	0	0	0	16	0	0	0	0	0	0	0	35
2001	0	0	0	0	0	0	11	10	19	7	20	26	0	0	0	0	0	0	0	93

Cont.

	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
2002	0	0	0	0	0	0	0	78	1	0	8	30	0	0	0	0	0	0	0	117
2003	0	0	0	0	0	0	32	0	4	7	34	37	0	0	0	0	0	0	0	114
2004	0	0	0	0	0	0	0	61	0	0	0	75	0	0	0	0	0	1	0	137
2005	0	0	0	0	0	0	28	66	2	0	7	51	0	0	0	0	0	0	0	154
2006	0	0	0	0	0	0	40	33	11	1	36	23	0	0	0	0	0	0	0	144
2007	0	0	0	0	0	0	50	67	3	0	15	5	0	0	0	0	0	0	0	140
2008	0	0	0	0	0	0	23	32	0	0	5	48	0	0	0	0	0	0	0	108
2009	0	0	0	0	0	0	28	41	8	3	13	6	0	0	0	0	0	0	0	99
2010	0	0	0	0	0	0	17	40	0	0	0	12	0	0	0	0	0	0	0	69
2011	0	0	0	0	0	0	17	64	0	0	0	1	0	0	0	0	0	0	0	82

	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
Females:																				
1930	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	1	0	0	0	5
1931	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	2	0	0	0	6
1932	0	0	0	5	4	0	7	0	0	0	0	0	0	0	0	1	0	0	0	17
1933	0	0	0	5	4	0	7	1	0	0	0	0	0	1	0	1	0	0	0	19
1934	0	0	0	9	10	0	10	0	0	0	0	0	0	1	0	1	0	0	0	31
1935	0	0	0	8	14	0	10	0	0	0	0	0	0	0	0	1	0	0	0	33
1936	0	0	0	12	13	0	7	0	0	0	0	0	0	0	0	2	0	0	0	34
1937	0	0	0	14	18	0	18	1	0	0	0	0	0	0	0	1	0	0	0	52
1938	0	0	0	18	20	0	22	0	0	0	0	0	0	0	0	1	0	0	0	61
1939	0	0	0	19	23	0	22	0	0	0	0	0	1	0	0	2	0	0	1	68
1940	0	0	0	13	34	0	25	0	0	0	0	0	0	0	0	1	0	0	0	73
1941	0	0	0	64	38	0	18	0	0	0	0	0	0	0	0	2	0	0	0	122
1942	0	0	0	54	66	0	22	0	0	0	0	0	2	0	0	1	0	0	0	145
1943	0	0	0	39	51	0	32	0	0	0	0	0	0	0	0	2	0	0	0	124
1944	0	0	0	38	45	0	25	0	0	0	0	0	0	0	0	1	0	0	0	109
1945	0	0	0	2	3	0	22	1	0	0	0	0	0	0	0	2	0	0	0	30
1946	0	0	0	10	18	10	24	1	0	0	0	0	1	0	0	13	0	0	0	77
1947	0	0	0	18	19	21	27	3	0	0	0	0	0	0	0	23	0	0	0	111
1948	0	0	0	21	25	38	31	0	0	0	0	0	0	0	0	53	0	0	0	168
1949	0	0	0	25	31	30	32	0	0	0	2	0	0	0	4	27	0	1	0	152
1950	0	1	1	29	34	9	25	19	0	0	0	0	0	0	0	32	0	1	0	151
1951	0	0	0	33	42	39	42	2	0	2	1	0	2	0	2	70	0	1	0	236
1952	0	0	1	37	45	43	78	2	0	0	0	0	1	0	0	97	1	0	0	305
1953	0	0	0	39	49	47	56	2	0	0	3	0	0	0	5	57	1	0	0	259
1954	0	1	0	45	55	27	22	15	0	0	3	0	1	0	4	124	0	0	0	297
1955	0	0	0	58	59	15	80	4	0	0	3	0	0	0	7	119	0	2	0	347
1956	0	0	0	62	66	23	97	7	0	0	1	0	1	0	13	108	0	4	0	382
1957	11	1	0	79	68	0	81	12	2	0	3	0	0	0	13	96	1	0	0	367
1958	0	0	0	101	63	0	128	8	0	0	1	0	0	0	0	153	0	0	0	454
1959	0	0	0	126	73	0	70	4	0	0	0	0	0	0	0	83	0	1	0	357
1960	0	0	0	141	57	0	65	4	0	1	1	0	0	0	0	73	0	0	0	342
1961	0	0	0	82	30	0	83	5	0	0	1	0	0	0	0	98	0	0	0	299
1962	0	0	0	117	52	0	47	5	0	0	0	0	0	0	0	85	0	1	0	307
1963	0	0	0	168	52	0	50	4	0	0	0	0	0	0	0	71	0	0	0	345
1964	0	0	0	186	97	6	86	4	0	0	0	0	0	0	0	69	0	0	0	448
1965	0	1	0	110	102	9	99	3	0	0	0	0	0	0	0	94	0	0	0	418
1966	0	1	0	105	88	2	100	15	0	0	0	0	0	0	0	84	0	0	0	395
1967	0	0	0	139	73	8	65	7	0	0	0	0	0	0	3	87	0	0	0	382
1968	0	0	0	124	73	3	81	3	0	0	0	0	0	7	5	56	0	0	0	352
1969	0	0	0	156	96	10	32	1	0	0	0	0	8	0	5	97	0	0	0	405
1970	0	0	0	216	188	2	87	5	1	0	0	0	0	0	4	70	0	0	2	575
1971	0	0	0	250	190	2	67	4	0	0	0	0	0	0	9	52	0	0	0	574
1972	0	0	0	292	286	0	75	22	0	0	0	0	0	0	1	113	0	0	0	789
1973	0	0	0	239	244	2	90	15	0	2	7	0	0	0	6	116	11	27	0	759
1974	0	0	0	267	272	0	51	19	0	3	0	0	0	0	3	79	17	18	0	729
1975	0	0	0	229	288	2	46	22	0	4	0	0	0	2	4	58	23	0	0	678
1976	0	0	0	445	174	0	46	29	0	0	0	0	0	0	11	113	0	0	1	819
1977	0	0	0	269	303	0	28	14	0	0	0	0	0	0	2	43	0	0	0	659
1978	0	0	0	207	356	0	85	22	0	0	0	0	0	0	0	48	0	0	0	718
1979	0	0	0	130	264	0	38	28	0	0	0	0	0	0	7	64	0	0	0	531
1980	0	0	0	272	109	0	70	12	0	0	0	0	0	0	5	82	0	0	0	550
1981	0	0	0	188	192	0	68	11	0	0	0	0	0	0	2	63	0	0	0	524
1982	0	0	0	236	219	2	58	28	0	0	0	0	0	0	6	56	0	0	0	605
1983	0	0	0	98	138	4	69	30	0	0	0	0	0	0	5	42	0	0	0	386
1984	0	0	0	87	114	0	38	55	0	0	0	0	0	0	0	76	0	0	0	370
1985	0	0	0	26	35	4	20	41	0	0	0	0	0	0	5	66	0	0	0	197
1986	0	0	0	0	15	2	35	43	2	0	0	0	0	0	0	54	0	0	0	151
1987	0	0	0	0	0	0	43	30	0	0	0	0	0	0	0	49	0	0	0	122
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Cont.

	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
1995	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	9
1996	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	11	0	0	0	14
1997	0	0	0	0	0	0	0	0	0	0	1	12	0	0	0	0	0	0	0	13
1998	0	0	0	0	0	0	0	0	3	4	4	0	0	0	0	0	0	0	0	11
1999	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	22	0	0	0	29
2000	0	0	0	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	5
2001	0	0	0	0	0	0	0	0	3	0	1	3	0	0	0	0	0	0	0	7
2002	0	0	0	0	0	0	0	31	0	0	0	2	0	0	0	0	0	0	0	33
2003	0	0	0	0	0	0	30	0	1	0	3	2	0	0	0	0	0	0	0	36
2004	0	0	0	0	0	0	0	14	0	0	0	8	0	0	0	0	0	0	0	22
2005	0	0	0	0	0	0	37	19	0	0	7	3	0	0	0	0	0	0	0	66
2006	0	0	0	0	0	0	34	12	1	1	2	1	0	0	0	0	0	0	0	51
2007	0	0	0	0	0	0	45	21	0	0	0	1	0	0	0	0	0	0	0	67
2008	0	0	0	0	0	0	37	18	0	0	0	6	0	0	0	0	0	0	0	61
2009	0	0	0	0	0	0	33	24	0	0	5	1	0	0	0	0	0	0	0	63
2010	0	0	0	0	0	0	28	20	0	0	0	2	0	0	0	0	0	0	0	50
2011	0	0	0	0	0	0	6	37	0	0	0	1	0	0	0	0	0	0	0	44

Table 3

Direct catches in 2012 by sub-area and sex.
These catches were not available when the conditioning was performed but are included here for completeness.

	1E	2C	2R	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13	Total
Males	0	0	0	0	0	0	15	36	1	0	0	0	0	0	0	0	0	0	0	52
Females	0	0	0	0	0	0	50	53	4	0	3	0	0	0	0	0	0	0	0	110

Table 4

The High Catch Series.

The table shows the catches for the years and sub-areas where they differ from the 'best' catch series (1930-31, 1936-45 in sub-areas 7CS, 7CN and 11; 1947-56 in sub-areas 5 and 6W). Numbers from the 'best' catch series are shown for comparison.
The 'high' catch series is identical to the 'best' series for all other areas and years.

Series:	Best	Best	High	High	Best	Best	High	High	Best	Best	High	High
Sub-area:	7CS	7CS	7CS	7CS	7CN	7CN	7CN	7CN	11	11	11	11
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1930	7	4	**14**	**8**	0	0	0	0	1	1	**2**	**2**
1931	7	4	**14**	**8**	1	0	**2**	0	0	2	0	**4**
1932	13	7	13	7	1	0	1	0	0	1	0	1
1933	13	7	13	7	1	1	1	1	0	1	0	1
1934	20	10	20	10	1	0	1	0	0	1	0	1
1935	20	10	20	10	1	0	1	0	1	1	1	1
1936	15	7	**30**	**14**	0	0	0	0	0	2	0	**4**
1937	37	18	**74**	**36**	0	1	0	**2**	1	1	**2**	**2**
1938	44	22	**88**	**44**	0	0	0	0	1	1	**2**	**2**
1939	44	22	**88**	**44**	1	0	**2**	0	0	2	0	**4**
1940	52	25	**104**	**50**	0	0	0	0	1	1	**2**	**2**
1941	37	18	**74**	**36**	1	0	**2**	0	0	2	0	**4**
1942	44	22	**88**	**44**	0	0	0	0	1	1	**2**	**2**
1943	67	32	**134**	**64**	1	0	**2**	0	0	2	0	**4**
1944	52	25	**104**	**50**	0	0	0	0	1	1	**2**	**2**
1945	44	22	44	22	0	1	0	**2**	0	2	0	**4**

Series:	Best	Best	High	High	Best	Best	High	High
Sub-area:	5	5	5	5	6W	6W	6W	6W
	Male	Female	Male	Female	Male	Female	Male	Female
1946	11	10	11	10	21	18	21	18
1947	19	18	**55**	**56**	21	19	**70**	**68**
1948	22	21	**55**	**56**	26	25	**70**	**68**
1949	25	25	**55**	**56**	31	31	**70**	**68**
1950	29	29	**55**	**56**	37	34	**70**	**68**
1951	31	33	**55**	**56**	40	42	**70**	**68**
1952	36	37	**55**	**56**	45	45	**70**	**68**
1953	42	39	**55**	**56**	50	49	**70**	**68**
1954	43	45	**55**	**56**	54	55	**70**	**68**
1955	49	58	**56**	**66**	60	59	**70**	**68**
1956	54	62	**57**	**66**	62	66	**70**	**68**
1957	59	79	59	79	70	68	70	68

Table 5

The catch series for Trials 8 and 9 used to test the sensitivity to the allocation of catches off Korea between sub-areas 5 and 6W. Catches in the other sub-areas are the same as for the 'Best' catch series.

	Trial 8				Trial 9			
Sub-area:	5	5	6W	6W	5	5	6W	6W
	Male	Female	Male	Female	Male	Female	Male	Female
1932	0	5	9	4	0	5	9	4
1933	0	5	8	4	0	5	8	4
1934	1	9	21	10	1	9	21	10
1935	9	12	9	10	7	7	12	14
1936	14	15	13	9	9	10	15	17
1937	17	16	14	15	12	9	21	20
1938	19	22	16	16	14	13	24	22
1939	23	23	20	18	15	15	27	27
1940	21	21	27	26	12	11	37	35
1941	48	72	31	31	38	62	41	41
1942	66	66	53	55	43	43	77	77
1943	51	51	40	41	31	33	59	60
1944	48	48	37	35	31	31	53	53
1945	3	2	2	3	3	2	2	3
1946	14	15	15	16	10	8	22	20
1947	24	21	16	16	15	15	23	24
1948	27	26	20	21	18	18	28	30
1949	30	32	25	25	18	22	36	36
1950	34	38	28	29	23	24	42	40
1951	40	40	33	33	26	26	47	47
1952	46	46	37	34	29	30	51	53
1953	50	51	40	39	31	33	58	58
1954	55	54	43	45	35	35	64	63
1955	62	69	46	49	39	48	70	69
1956	67	74	52	51	42	53	75	74
1957	73	92	56	55	49	66	79	82
1958	80	114	51	51	53	89	77	77
1959	93	141	57	57	63	110	86	89
1960	84	152	46	47	63	131	68	67
1961	44	87	24	24	35	77	33	34
1962	65	128	43	40	49	110	58	59
1963	131	179	43	41	104	149	71	70
1964	159	205	77	76	118	162	119	118
1965	102	131	82	81	68	97	116	115
1966	95	121	70	70	64	91	100	101
1967	125	153	59	57	91	120	93	90
1968	112	139	60	59	82	107	91	90
1969	137	176	75	77	98	138	114	115
1970	223	253	151	151	152	183	221	222
1971	239	286	152	152	165	214	225	225
1972	308	348	229	231	230	267	311	308
1973	251	275	208	208	197	220	262	263
1974	251	302	235	235	188	241	297	297
1975	253	287	235	231	159	196	327	324
1976	389	479	139	139	292	384	235	235
1977	294	331	242	243	192	226	346	346
1978	253	276	283	286	152	175	384	387
1979	164	130	379	264	164	130	379	264
1980	447	272	147	109	447	272	147	109
1981	188	188	192	192	188	188	192	192
1982	236	247	202	209	222	229	217	226
1983	100	98	142	138	100	98	142	138
1984	87	87	105	114	87	87	105	114
1985	23	26	29	35	23	26	29	35
1986	1	0	31	15	1	0	31	15

Bycatches

Recent bycatches (also referred to as incidental catches) are listed in Tables 6 and 7. The numbers of nets are listed in Table 8. The numbers of bycatches are only used in the trials if the number of nets is also known. Thus for Japan the catches from 2007-09 are not used and are shown greyed out in the table.

The bycatch in area 6W by Japan is small (9 whales) (and there are no corresponding set net numbers) so the numbers are added to those for sub-area 6E. The bycatch by Korea in sub-area 1W is very small (2 whales in total) and there are no corresponding set net numbers so the numbers are added to the data for sub-area 5. Similarly the numbers in sub-areas 6E and 10W (3 whales and 1 whale respectively) have been added to those for 6W.

A single series of historical bycatches is used for all of the trials when applying the RMP (i.e. for calculating catch limits), irrespective of the true values of the bycatches, which differ both among trials and simulations within trials. The estimate of the bycatches used by the *CLA* is set to the averages of the predicted bycatches based on the fit to the actual data of the operating model for the six baseline trials (i.e. using the 'best fit' simulation (0)). The series is given in Table 9 and Fig 1.

Table 6

Recent bycatches by Japan. The numbers are taken from the individual records. The catches that are greyed out are not used in the trials.

	1E	2C	6W	6E	7CS	7CN	10E	11	Sum	
2001	1	10	0	25	8	3	4	3	54	Numbers incomplete
2002	7	19	0	45	17	13	3	5	109	
2003	5	17	2	59	18	15	0	8	124	125 in Progress Report
2004	4	19	1	65	14	9	0	3	115	117 in Progress Report
2005	4	33	1	54	17	10	3	6	128	130 in Progress Report
2006	3	28	2	74	21	16	0	3	147	150 in Progress Report
2007	7	42	1	68	20	11	0	6	155	157 in Progress Report
2008	9	23	0	68	17	11	2	3	133	
2009	3	17	2	64	23	3	0	1	113	+ 5 unknown area

Table 7

Recent bycatches by Korea. The numbers are taken from the individual records.

	5	6W	1W	6E	10W	Total
1996	0	128	0	0	0	128
1997	0	80	0	0	1	81
1998	0	45	0	0	0	45
1999	0	62	0	0	0	62
2000	11	69	0	0	0	80
2001	12	148	0	0	0	160
2002	7	82	0	0	0	89
2003	11	80	1	0	0	92
2004	13	55	0	1	0	69
2005	8	99	0	0	0	107
2006	13	67	0	2	0	82
2007	15	64	1	0	0	80
2008	13	68	0	0	0	81
2009	17	70	0	0	0	87

Table 8

Numbers of nets.

	Japan large scale trap nets								Japan salmon trap nets					Korean nets		
	1E	2C	6E	7CS	7CN	10E	11	Total	7CS	7CN	10E	11	Total	5	6W	Total
1946	24	67	103	41	7	9	2	252	3	57	24	44	129	0	0	0
1947	26	73	112	44	7	10	2	275	3	62	26	48	140	2	5	7
1948	29	79	122	48	8	11	2	298	3	68	29	52	152	4	11	15
1949	31	85	131	52	8	12	2	320	4	73	31	56	164	6	16	22
1950	33	91	141	55	9	12	2	343	4	78	33	60	175	8	21	29
1951	35	97	150	59	10	13	2	366	4	83	35	64	187	10	27	36
1952	37	103	159	63	10	14	2	389	4	88	37	68	199	12	32	44
1953	40	109	169	66	11	15	3	412	5	94	40	73	210	14	38	51
1954	42	115	178	70	11	16	3	435	5	99	42	77	222	15	43	58
1955	44	121	187	74	12	17	3	458	5	104	44	81	234	17	48	66
1956	46	127	197	77	13	17	3	481	5	109	46	85	245	19	54	73
1957	48	133	206	81	13	18	3	503	6	114	48	89	257	21	59	80
1958	51	139	216	85	14	19	3	526	6	120	51	93	269	23	64	88
1959	53	145	225	88	14	20	3	549	6	125	53	97	280	25	70	95
1960	55	151	234	92	15	21	4	572	6	130	55	101	292	27	75	102
1961	57	157	244	96	16	22	4	595	7	135	57	105	304	29	80	109
1962	59	164	253	100	16	22	4	618	7	140	59	109	316	31	86	117
1963	62	170	262	103	17	23	4	641	7	146	62	113	327	33	91	124
1964	64	176	272	107	17	24	4	664	7	151	64	117	339	35	97	131
1965	66	182	281	111	18	25	4	687	8	156	66	121	351	37	102	139
1966	68	188	291	114	19	26	4	709	8	161	68	125	362	39	107	146
1967	70	194	300	118	19	27	5	732	8	166	70	129	374	41	113	153
1968	73	200	309	122	20	27	5	755	8	172	73	133	386	43	118	161
1969	75	206	319	125	20	28	5	778	9	177	75	137	397	44	123	168
1970	77	212	328	129	21	29	5	801	9	182	77	141	409	46	129	175
1971	80	209	324	127	21	29	5	795	9	190	81	148	428	48	134	182
1972	83	206	321	124	21	29	5	788	9	199	84	154	447	50	139	190
1973	86	203	317	122	20	28	5	782	10	207	88	161	465	52	145	197
1974	89	200	314	119	20	28	5	775	10	216	91	167	484	54	150	204
1975	92	197	310	117	20	28	5	769	10	224	95	174	503	56	156	212
1976	82	197	320	119	20	33	4	775	11	249	104	196	559	58	161	219
1977	72	197	330	122	20	39	3	781	11	274	113	217	615	60	166	226
1978	61	197	339	124	20	44	1	787	12	299	122	239	671	62	172	233
1979	51	197	349	126	20	50	0	793	12	324	131	260	727	64	177	241
1980	54	200	359	134	20	47	0	814	0	334	125	263	722	66	182	248
1981	56	197	362	137	18	44	0	814	0	327	141	281	749	68	188	255
1982	55	196	375	135	19	44	0	824	0	332	134	277	743	70	193	263

Cont.

	Japan large scale trap nets								Japan salmon trap nets					Korean nets		
	1E	2C	6E	7CS	7CN	10E	11	Total	7CS	7CN	10E	11	Total	5	6W	Total
1983	59	191	379	135	33	43	12	852	0	330	126	278	734	71	198	270
1984	56	184	381	144	52	45	18	880	0	320	151	250	721	73	204	277
1985	52	185	406	144	36	53	11	887	0	348	158	256	762	75	209	285
1986	55	191	401	139	49	53	17	905	0	349	154	255	758	77	215	292
1987	52	190	398	141	48	52	16	897	0	357	158	251	766	79	220	299
1988	51	183	394	135	38	41	15	857	0	362	165	252	779	81	225	306
1989	60	177	384	145	36	38	9	849	0	369	287	230	886	83	231	314
1990	61	176	397	140	34	43	7	858	0	363	293	226	882	85	236	321
1991	66	172	394	139	22	46	0	839	0	373	290	229	892	85	286	371
1992	61	164	385	139	22	42	0	813	0	369	287	231	887	96	305	401
1993	66	177	391	138	22	43	0	837	0	369	290	236	895	96	291	387
1994	59	173	372	134	26	42	0	806	0	350	401	217	968	94	286	380
1995	61	173	365	121	23	39	0	782	0	349	400	216	965	97	292	389
1996	62	169	364	134	22	39	0	790	0	335	390	217	942	103	352	455
1997	58	167	362	135	22	36	0	780	0	335	372	210	917	123	340	463
1998	60	163	361	137	25	36	0	782	0	331	372	211	914	105	338	443
1999	59	165	354	135	27	40	0	780	0	322	386	209	917	120	321	441
2000	59	164	352	134	27	39	0	775	0	322	381	209	912	105	318	423
2001	62	157	344	138	30	39	0	770	0	327	368	219	914	82	311	393
2002	57	159	353	137	34	43	0	783	0	316	367	209	892	88	292	380
2003	53	161	352	143	31	42	0	782	0	315	353	207	875	81	286	367
2004	55	157	341	142	26	38	0	759	0	312	354	211	877	94	267	361
2005	57	156	319	138	24	37	0	731	0	313	356	209	878	81	263	344
2006	50	152	302	137	25	38	0	704	0	324	353	209	886	78	255	333
2007	44	131	291	120	4	13	0	654						77	247	324
2008	43	123	295	122	23	27	0	651						71	230	301
2009														68	219	287

Sources:
Japan 1935-70. Set using linear interpolation, assuming 0 in 1935.
Japan 1970-79. Set using linear interpolation between the numbers for 1970 and 1975 from Tobayama *et al*. (1992).
Japan 1979-2006. Hakamada (2010)
Japan 2007-08, large scale. Hakamada, pers. comm.
Korea 1946-89. Set using linear interpolation, assuming 0 in 1946.
Korea 1990-2009. An, pers. comm.
Missing data: where the numbers of nets between 2007-12 are unknown, the numbers from the last known year are used.

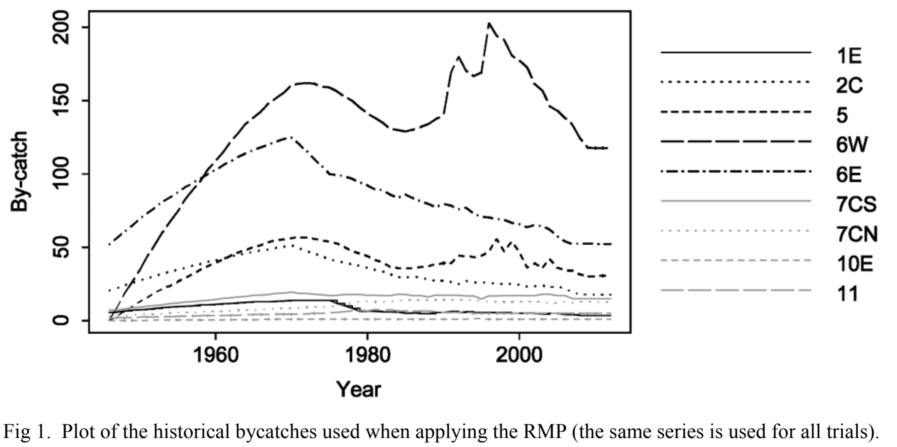

Fig 1. Plot of the historical bycatches used when applying the RMP (the same series is used for all trials).

Table 9

The single series of historical bycatches used in all trials when applying the RMP (i.e. for calculating catch limits). The series is the average of the predicted bycatches based on the fit to the actual data of the operating model for the six baseline trials (i.e. using the 'best fit' simulation (0)).

Year	1E	2C	5	6W	6E	7CS	7CN	10E	11
1946	5.50	20.50	0.00	0.00	52.00	7.00	3.00	0.00	1.67
1947	6.00	22.17	3.17	8.50	56.33	7.33	3.50	0.00	2.00
1948	6.67	24.00	6.33	18.17	60.83	8.00	3.50	0.00	2.00
1949	7.17	25.50	9.67	26.17	64.83	8.83	3.67	0.00	2.00
1950	7.50	27.50	12.83	34.17	69.50	9.17	4.33	0.00	2.33
1951	7.83	28.83	16.00	43.83	73.50	9.83	4.50	0.17	2.50
1952	8.33	30.33	19.00	51.50	77.00	10.33	4.50	0.33	2.50
1953	9.00	32.00	22.00	60.00	81.17	10.83	4.67	0.50	2.67
1954	9.33	33.50	23.67	67.33	84.00	11.67	5.33	0.50	2.67
1955	9.67	34.67	26.50	74.33	87.50	12.00	5.33	0.50	3.00
1956	9.83	36.00	29.00	82.67	91.00	12.67	5.50	0.50	3.17
1957	10.17	37.50	32.00	89.00	93.83	13.00	5.50	0.50	3.33
1958	10.83	38.67	34.67	95.00	97.00	13.50	6.17	0.50	3.33
1959	10.83	40.00	37.17	102.83	100.00	13.83	6.33	0.50	3.50
1960	11.17	41.17	39.50	109.00	102.83	14.50	6.33	0.50	3.50
1961	11.67	42.17	41.67	114.83	106.17	15.17	6.33	0.50	3.50
1962	11.83	43.83	44.17	122.17	108.83	15.50	6.83	0.67	3.67
1963	12.17	45.00	46.50	127.83	111.83	16.17	7.33	0.67	3.67
1964	12.50	46.00	48.33	134.33	114.33	16.50	7.33	0.67	4.00
1965	12.83	47.00	50.00	138.67	116.17	17.33	7.33	0.67	4.17
1966	12.83	48.00	51.67	142.83	118.33	17.50	7.50	0.67	4.33
1967	13.00	48.67	53.50	148.17	120.00	17.83	8.00	1.00	4.33
1968	13.33	49.67	55.00	152.17	122.00	18.50	8.33	1.00	4.50
1969	13.50	50.50	55.33	155.67	123.83	18.83	8.33	1.00	4.50
1970	13.83	51.33	56.33	160.50	125.00	19.50	8.33	1.00	4.50
1971	13.83	49.33	56.67	161.50	120.33	18.67	8.67	1.00	4.50
1972	13.83	47.50	56.67	162.00	115.83	18.67	9.33	1.00	4.67
1973	13.83	45.83	55.67	161.50	110.17	18.00	9.33	1.00	5.00
1974	13.83	43.83	54.83	159.83	105.50	17.67	9.33	1.00	5.00
1975	13.83	42.00	53.67	159.00	100.00	17.00	9.50	1.00	5.33
1976	11.83	40.67	52.67	156.33	99.17	17.17	10.33	1.00	5.50
1977	10.00	39.50	50.00	152.83	98.33	17.83	11.33	1.00	6.33
1978	8.33	38.50	47.67	150.00	96.67	17.83	12.33	1.00	6.50
1979	6.33	37.17	45.67	145.33	94.33	17.83	13.17	1.00	6.83
1980	6.50	36.17	44.00	141.17	92.33	17.17	13.33	1.00	6.67
1981	6.33	34.67	41.33	138.33	89.50	17.33	13.00	1.00	7.50
1982	6.00	33.67	39.67	135.00	89.17	17.00	13.00	1.00	7.17
1983	6.00	31.83	36.83	131.00	86.00	17.00	13.17	0.83	7.50
1984	5.83	29.67	35.67	130.00	83.67	18.00	13.33	1.00	6.50
1985	5.00	29.50	35.50	129.17	86.33	17.83	14.00	1.00	6.50
1986	5.33	30.00	35.67	130.33	83.50	17.00	14.00	1.00	6.50
1987	4.83	29.33	36.50	132.00	81.33	17.00	14.00	1.00	6.50
1988	4.83	28.00	37.17	134.17	79.67	16.17	14.00	1.00	6.50
1989	5.50	27.33	38.33	137.50	77.50	17.50	14.33	1.00	6.00
1990	5.50	27.17	39.33	140.17	79.50	17.17	14.17	1.00	5.67
1991	6.33	26.33	39.33	169.33	78.67	17.17	14.17	1.00	5.50
1992	5.50	25.00	44.33	180.00	76.00	17.17	14.17	1.00	5.67
1993	6.17	27.00	44.00	170.50	77.00	16.83	14.17	1.00	6.00
1994	5.50	26.17	43.33	166.67	72.83	16.83	13.83	1.50	5.00
1995	5.50	26.33	44.33	169.17	70.83	14.83	13.67	1.50	5.00
1996	5.50	25.50	46.83	202.83	70.33	16.83	12.83	1.00	5.00
1997	5.33	25.33	55.83	194.50	69.33	16.83	13.00	1.00	5.00
1998	5.50	24.67	47.33	191.67	68.50	17.00	13.00	1.00	5.00
1999	5.00	24.83	53.83	180.83	66.67	17.00	13.00	1.00	5.00
2000	5.00	24.67	46.83	177.50	65.67	17.00	13.00	1.00	5.00
2001	5.17	23.33	36.33	172.67	63.67	17.00	13.00	1.00	5.00
2002	5.00	23.50	39.17	161.33	65.00	17.00	13.00	1.00	5.00
2003	4.50	24.00	35.67	157.00	64.50	18.00	13.00	1.00	5.00
2004	5.00	23.00	42.00	146.17	62.00	18.00	12.00	1.00	5.00
2005	5.00	23.00	36.00	143.33	57.50	17.00	12.00	1.00	5.00
2006	4.00	22.17	34.50	138.33	54.00	17.00	13.00	1.00	5.00
2007	4.00	19.17	34.00	133.67	52.00	15.00	12.00	1.00	5.00
2008	3.50	17.83	31.50	124.17	52.67	15.00	12.83	1.00	5.00
2009	3.50	17.83	30.17	118.00	52.50	15.00	12.83	1.00	5.00
2010	3.50	17.67	30.17	117.83	52.33	15.00	12.83	1.00	5.00
2011	3.50	17.67	30.67	117.83	52.33	15.00	12.67	1.00	5.00
2012	3.50	17.67	30.67	117.83	52.33	15.00	12.67	1.00	5.00

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Adjunct 2

Mixing matrices

An initial description of the information used to inform the parameters used is given in Allison and De Moor (2010).

Hypothesis A Baseline

J Stock Baseline A (Matrix J-A)

Age/		Sub-Area																					
sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	0	0
	May	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_2$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	0	0
	Jun.	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	Jul.	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	Aug.	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	Sep.	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	O-D	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	0	0	0
Ad.M	J-M	2	2	1	0	0	0	2	4	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$4\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	$2\gamma_7$	γ_8	γ_8	0	0
	May	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$4\gamma_2$	$2\gamma_4$	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$	0	0
	Jun.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_4$	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$	0	0
	Jul.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	0	0
	Aug.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	0	0
	Sep.	2	2	1	0	0	0	2	4	$4\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	O-D	4	4	1	0	0	0	2	2	0	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	2	2	1	0	0	0	2	4	$4\gamma_{29}$	γ_1	γ_4	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_1$	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}	0	0
	May	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_2$	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$	0	0
	Jun.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	γ_3	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$	0	0
	Jul.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	0	0
	Aug.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	0	0
	Sep.	2	2	1	0	0	0	2	4	$4\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	O-D	4	4	1	0	0	0	2	2	0	γ_3	γ_5	0	0	0	0	0	0	0	0	0	0	0

O Stock Baseline A (Matrix O-AB)

Age/	Mon	Sub-Area																					
sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	γ_{13}	4	4	4	0	0	0	4	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	May	0	0	γ_{14}	2	2	2	0	0	0	8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jun.	0	0	γ_{14}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jul.	0	0	γ_{15}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Aug.	0	0	γ_{15}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Sep.	0	0	γ_{15}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	4	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	γ_{13}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	γ_{13}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	1	γ_{16}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	1	γ_{16}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0

Hypothesis B Baseline

Y Stock Baseline B (Matrix Y-BC)

Age/	Mon	Sub-Area																					
sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	4	0	0	0	0	0	4	γ_{25}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	May	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jun.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jul.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Aug.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sep.	2	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	O-D	4	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AdM	J-M	4	0	0	0	0	0	4	γ_{25}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	May	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jun.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jul.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Aug.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sep.	2	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	O-D	4	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AdF	J-M	4	0	0	0	0	0	4	γ_{25}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	May	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jun.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jul.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Aug.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sep.	2	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	O-D	4	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0

J Stock Baseline B (Matrix J-B)

Age/	Mon	Sub-Area																					
sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	0	0
	May	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_2$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	0	0
	Jun.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	Jul.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	Aug.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	Sep.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	O-D	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	0	0	0
Ad.M	J-M	0	2	1	0	0	0	0	4	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	$2\gamma_7$	γ_8	γ_8	0	0
	May	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_2$	$2\gamma_4$	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$	0	0
	Jun.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_4$	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$	0	0
	Jul.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	0	0
	Aug.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	0	0
	Sep.	0	2	1	0	0	0	0	4	$4\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	O-D	0	4	1	0	0	0	0	2	0	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	2	1	0	0	0	0	4	$4\gamma_{29}$	γ_1	γ_4	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_1$	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}	0	0
	May	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_2$	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$	0	0
	Jun.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	γ_3	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$	0	0
	Jul.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	0	0
	Aug.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	0	0
	Sep.	0	2	1	0	0	0	0	4	$4\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	O-D	0	4	1	0	0	0	0	2	0	γ_3	γ_5	0	0	0	0	0	0	0	0	0	0	0

Hypothesis B Baseline continued
O Stock Baseline B = O Stock Baseline A (Matrix O-AB)

Age/	Mon	Sub-Area																					
sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	γ_{13}	4	4	4	0	0	0	4	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	May	0	0	γ_{14}	2	2	2	0	0	0	8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jun.	0	0	γ_{14}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jul.	0	0	γ_{15}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Aug.	0	0	γ_{15}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Sep.	0	0	γ_{15}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	4	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	γ_{13}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	γ_{13}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	1	γ_{16}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	1	γ_{16}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0

Hypothesis C Baseline
Y Stock Baseline C = Y Baseline B (Matrix Y-BC)

Age/	Mon	Sub-Area																					
sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	4	0	0	0	0	0	4	γ_{25}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	May	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jun.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jul.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Aug.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sep.	2	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	O-D	4	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AdM	J-M	4	0	0	0	0	0	4	γ_{25}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	May	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jun.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jul.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Aug.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sep.	2	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	O-D	4	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AdF	J-M	4	0	0	0	0	0	4	γ_{25}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	May	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jun.	1	0	0	0	0	0	4	γ_{26}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Jul.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Aug.	1	0	0	0	0	0	4	γ_{27}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Sep.	2	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	O-D	4	0	0	0	0	0	4	γ_{28}	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Hypothesis C Baseline continued
JW Stock Baseline C (Matrix JW-C)

Age/	Mon	Sub-Area																					
sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
0	J-M	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	0	0
	May	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	0	0
	Jun.	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	Jul.	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	Aug.	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	Sep.	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	0	0
	O-D	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	0	0	0
Ad.M	J-M	0	2	0	0	0	0	0	4	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	γ_6	$2\gamma_7$	γ_8	γ_8	0	0
	May	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$	0	0
	Jun.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$	0	0
	Jul.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	0	0
	Aug.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	0	0
	Sep.	0	2	0	0	0	0	0	4	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	O-D	0	4	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	2	0	0	0	0	0	4	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}	0	0
	May	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$	0	0
	Jun.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$	0	0
	Jul.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	0	0
	Aug.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	0	0
	Sep.	0	2	0	0	0	0	0	4	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	γ_{12}	0	0	0
	O-D	0	4	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

JE Stock Baseline C (Matrix JE-C)

Age/	Mon	Sub-Area																					
sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	2	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	2	0	0	0	0	0	0	$2\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	May	0	0	2	0	0	0	0	0	0	$2\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jun.	0	0	2	0	0	0	0	0	0	$2\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jul.	0	0	2	0	0	0	0	0	0	$2\gamma_{31}$	$6\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Aug.	0	0	2	0	0	0	0	0	0	$2\gamma_{31}$	$6\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Sep.	0	0	2	0	0	0	0	0	0	$2\gamma_{31}$	$6\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	O-D	0	0	2	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	1	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	May	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jun.	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jul.	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Aug.	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Sep.	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	O-D	0	0	1	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	1	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	May	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jun.	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jul.	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Aug.	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Sep.	0	0	1	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	O-D	0	0	1	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0

Note: γ_2 not used for Hypothesis III.

Hypothesis C Baseline continued

OW Stock Baseline C (Matrix OW-C)

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	γ_{13}	4	0	0	0	0	0	$4\gamma_1$	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	0	0	0	0	0	$8\gamma_1$	γ_4	γ_{32}	0	0	0	0	0	0	γ_{33}	0	0	0
	May	0	0	γ_{14}	0	0	0	0	0	0	$8\gamma_1$	γ_4	γ_{32}	0	0	0	0	0	0	γ_{33}	γ_{34}	0	0
	Jun.	0	0	γ_{14}	0	0	0	0	0	0	$4\gamma_3$	$2\gamma_4$	γ_{32}	0	0	0	0	0	0	γ_{33}	γ_{34}	0	0
	Jul.	0	0	0	0	0	0	0	0	0	$4\gamma_3$	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	γ_{33}	γ_{34}	0	0
	Aug.	0	0	0	0	0	0	0	0	0	$4\gamma_3$	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	γ_{33}	γ_{34}	0	0
	Sep.	0	0	0	0	0	0	0	0	0	$4\gamma_3$	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	γ_{33}	γ_{34}	0	0
	O-D	0	0	0	4	0	0	0	0	0	$4\gamma_3$	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	γ_{13}	4	0	0	0	0	0	γ_1	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	0	0	0	0	0	$2\gamma_1$	γ_4	$4\gamma_{32}$	0	0	0	0	0	0	γ_{33}	0	0	0
	May	0	0	0	0	0	0	0	0	0	$2\gamma_1$	γ_4	$4\gamma_{32}$	0	0	0	0	0	0	γ_{33}	γ_{34}	0	0
	Jun.	0	0	0	0	0	0	0	0	0	$2\gamma_3$	$2\gamma_4$	$4\gamma_{32}$	0	0	0	0	0	0	γ_{33}	γ_{34}	0	0
	Jul.	0	0	0	0	0	0	0	0	0	$2\gamma_3$	$2\gamma_5$	$4\gamma_{32}$	0	0	0	0	0	0	γ_{33}	γ_{34}	0	0
	Aug.	0	0	0	0	0	0	0	0	0	$2\gamma_3$	$2\gamma_5$	$4\gamma_{32}$	0	0	0	0	0	0	γ_{33}	γ_{34}	0	0
	Sep.	0	0	0	0	0	0	0	0	0	γ_3	$2\gamma_5$	$4\gamma_{32}$	0	0	0	0	0	0	γ_{33}	γ_{34}	0	0
	O-D	0	0	0	4	0	0	0	0	0	γ_3	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	γ_{13}	4	0	0	0	0	0	γ_1	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	0	0	0	0	0	γ_1	γ_4	$2\gamma_{32}$	0	0	0	0	0	0	γ_{33}	γ_{34}	0	0
	May	0	0	0	0	0	0	0	0	0	γ_1	γ_4	γ_{32}	0	0	0	0	0	0	$2\gamma_{33}$	$2\gamma_{34}$	0	0
	Jun.	0	0	0	0	0	0	0	0	0	γ_3	$2\gamma_4$	γ_{32}	0	0	0	0	0	0	$2\gamma_{33}$	$2\gamma_{34}$	0	0
	Jul.	0	0	0	0	0	0	0	0	0	γ_3	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	$2\gamma_{33}$	$2\gamma_{34}$	0	0
	Aug.	0	0	0	0	0	0	0	0	0	γ_3	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	$2\gamma_{33}$	$2\gamma_{34}$	0	0
	Sep.	0	0	0	0	0	0	0	0	0	γ_3	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	$2\gamma_{33}$	$2\gamma_{34}$	0	0
	O-D	0	0	0	4	0	0	0	0	0	γ_3	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0

OE Stock Baseline C (Matrix OE-C)

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	May	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jun.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jul.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Aug.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Sep.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	γ_{22}	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note γ_{15} not used in Hypothesis III.

MIXING MATRICES FOR SENSITIVITY TRIALS (JUNE 2012)

Trial 02 (With a 'C' stock): Hypothesis A

J Stock and O stock: As for Baseline A (Matrix J-A and O-AB)

C Stock Trial A02 (Matrix C-A2)

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Apr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Jun.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Jul.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Sep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	O-D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ad.M	J-M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Apr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	0	0	0	0	0	0	6
	May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	0	5
	Jun.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	0	4
	Jul.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	0	4
	Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	0	4
	Sep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	0	3
	O-D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ad.F	J-M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Apr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$2\gamma_{36}$	0	0	0	0	0	0	6
	May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	0	3
	Jun.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	0	1
	Jul.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	0	1
	Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	0	1
	Sep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	0	1
	O-D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Trial 02 (With a 'C' stock): Hypothesis C

Y Stock, JW Stock, JE Stock, OW Stock and OE Stock: as for Baseline C (Matrix Y-BC, JW-C, JE-C, OW-C & OE-C)

C Stock Trial C02 (Matrix C-C2)

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Apr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Jun.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Jul.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Sep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	O-D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ad.M	J-M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Apr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	0	0	0	0	0	0	2
	May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	γ_{35}	1
	Jun.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	γ_{35}	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	γ_{35}	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	γ_{35}	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	γ_{35}	0
	O-D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ad.F	J-M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Apr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$2\gamma_{36}$	0	0	0	0	0	0	2
	May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	$3\gamma_{35}$	1
	Jun.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	$3\gamma_{35}$	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	$3\gamma_{35}$	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	$3\gamma_{35}$	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	$3\gamma_{35}$	0
	O-D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Trial 05 (Some 'O'/'OW' animals in sub-area 10E): Hypothesis A
J Stock as for Baseline A (Matrix J-A)
O Stock Trial A05 (Matrix O-AB5) Differences from the Baseline trial are highlighted.

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	γ_{13}	4	4	4	0	0	0	4	$3\gamma_{16}$	0	0	0	0	0	0	γ_{16}	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	8	$6\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0	0	$2\gamma_{16}$	γ_{22}	γ_{23}	γ_{24}	0
	May	0	0	γ_{14}	2	2	2	0	0	0	8	$6\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	$2\gamma_{16}$	γ_{22}	γ_{23}	γ_{24}	0
	Jun.	0	0	γ_{14}	2	2	2	0	0	0	4	$12\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	$4\gamma_{16}$	γ_{22}	γ_{23}	γ_{24}	0
	Jul.	0	0	γ_{15}	2	2	2	0	0	0	4	$12\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	$4\gamma_{16}$	γ_{22}	γ_{23}	γ_{24}	0
	Aug.	0	0	γ_{15}	2	2	2	0	0	0	4	$12\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	$4\gamma_{16}$	γ_{22}	γ_{23}	γ_{24}	0
	Sep.	0	0	γ_{15}	2	2	2	0	0	0	4	$12\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	$4\gamma_{16}$	γ_{22}	γ_{23}	γ_{24}	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	4	$6\gamma_{16}$	0	0	0	0	0	0	$2\gamma_{16}$	0	0	0	0
Ad.M	J-M	0	0	γ_{13}	4	4	4	0	0	0	1	$3\gamma_{16}$	0	0	0	0	0	0	γ_{16}	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	2	$6\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0	0	$2\gamma_{16}$	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	2	$6\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	$2\gamma_{16}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	2	$12\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	$4\gamma_{16}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	2	$12\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	$4\gamma_{16}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	2	$12\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	$4\gamma_{16}$	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	2	$12\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}	0	$4\gamma_{16}$	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	1	$3\gamma_{16}$	0	0	0	0	0	0	γ_{16}	0	0	0	0
Ad.F	J-M	0	0	γ_{13}	4	4	4	0	0	0	1	$3\gamma_{16}$	0	0	0	0	0	0	γ_{16}	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	1	$3\gamma_{16}$	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0	0	γ_{16}	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	1	$3\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	γ_{16}	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	1	$6\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	$2\gamma_{16}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	1	$6\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	$2\gamma_{16}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	1	$6\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	$2\gamma_{16}$	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	1	$6\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$	0	$2\gamma_{16}$	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	1	$3\gamma_{16}$	0	0	0	0	0	0	γ_{16}	0	0	0	0

Trial 05 (Some 'O'/'OW' animals in sub-area 10E): Hypothesis B
Y Stock and J stock: As for Baseline B (Matrix Y-BC and J-B)
O Stock Trial B05 (Matrix O-AB5) as above

Trial 05 (Some 'O'/'OW' animals in sub-area 10E): Hypothesis C
Y Stock, JW Stock, JE Stock and OE Stock: as for Baseline C (Matrix Y-BC, JW-C, JE-C & OE-C)
OW Stock Trial C05 (Matrix OW-C5) Differences from the Baseline trial are highlighted.

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	γ_{13}	4	0	0	0	0	0	$4\gamma_1$	$3\gamma_5$	γ_{32}	0	0	0	0	0	γ_5	0	0	0	0
	Apr.	0	0	γ_{14}	2	0	0	0	0	0	$8\gamma_1$	$3\gamma_4$	γ_{32}	0	0	0	0	0	γ_4	γ_{33}	0	0	0
	May	0	0	γ_{14}	0	0	0	0	0	0	$8\gamma_1$	$3\gamma_4$	γ_{32}	0	0	0	0	0	γ_4	γ_{33}	γ_{34}	0	0
	Jun.	0	0	γ_{14}	0	0	0	0	0	0	$4\gamma_3$	$6\gamma_4$	γ_{32}	0	0	0	0	0	$2\gamma_4$	γ_{33}	γ_{34}	0	0
	Jul.	0	0	0	0	0	0	0	0	0	$4\gamma_3$	$6\gamma_5$	γ_{32}	0	0	0	0	0	$2\gamma_5$	γ_{33}	γ_{34}	0	0
	Aug.	0	0	0	0	0	0	0	0	0	$4\gamma_3$	$6\gamma_5$	γ_{32}	0	0	0	0	0	$2\gamma_5$	γ_{33}	γ_{34}	0	0
	Sep.	0	0	0	0	0	0	0	0	0	$4\gamma_3$	$6\gamma_5$	γ_{32}	0	0	0	0	0	$2\gamma_5$	γ_{33}	γ_{34}	0	0
	O-D	0	0	0	4	0	0	0	0	0	$4\gamma_3$	$3\gamma_5$	γ_{32}	0	0	0	0	0	γ_5	0	0	0	0
Ad.M	J-M	0	0	γ_{13}	4	0	0	0	0	0	γ_1	$3\gamma_5$	γ_{32}	0	0	0	0	0	γ_5	0	0	0	0
	Apr.	0	0	γ_{14}	2	0	0	0	0	0	$2\gamma_1$	$3\gamma_4$	$4\gamma_{32}$	0	0	0	0	0	γ_4	γ_{33}	0	0	0
	May	0	0	0	0	0	0	0	0	0	$2\gamma_1$	$3\gamma_4$	$4\gamma_{32}$	0	0	0	0	0	γ_4	γ_{33}	γ_{34}	0	0
	Jun.	0	0	0	0	0	0	0	0	0	$2\gamma_3$	$6\gamma_4$	$4\gamma_{32}$	0	0	0	0	0	$2\gamma_4$	γ_{33}	γ_{34}	0	0
	Jul.	0	0	0	0	0	0	0	0	0	$2\gamma_3$	$6\gamma_5$	$4\gamma_{32}$	0	0	0	0	0	$2\gamma_5$	γ_{33}	γ_{34}	0	0
	Aug.	0	0	0	0	0	0	0	0	0	$2\gamma_3$	$6\gamma_5$	$4\gamma_{32}$	0	0	0	0	0	$2\gamma_5$	γ_{33}	γ_{34}	0	0
	Sep.	0	0	0	0	0	0	0	0	0	γ_3	$6\gamma_5$	$4\gamma_{32}$	0	0	0	0	0	$2\gamma_5$	γ_{33}	γ_{34}	0	0
	O-D	0	0	0	4	0	0	0	0	0	γ_3	$3\gamma_5$	γ_{32}	0	0	0	0	0	γ_5	0	0	0	0
Ad.F	J-M	0	0	γ_{13}	4	0	0	0	0	0	γ_1	$3\gamma_5$	γ_{32}	0	0	0	0	0	γ_5	0	0	0	0
	Apr.	0	0	γ_{14}	2	0	0	0	0	0	γ_1	$3\gamma_4$	$2\gamma_{32}$	0	0	0	0	0	γ_4	γ_{33}	γ_{34}	0	0
	May	0	0	0	0	0	0	0	0	0	γ_1	$3\gamma_4$	γ_{32}	0	0	0	0	0	γ_4	$2\gamma_{33}$	$2\gamma_{34}$	0	0
	Jun.	0	0	0	0	0	0	0	0	0	γ_3	$6\gamma_4$	γ_{32}	0	0	0	0	0	$2\gamma_4$	$2\gamma_{33}$	$2\gamma_{34}$	0	0
	Jul.	0	0	0	0	0	0	0	0	0	γ_3	$6\gamma_5$	γ_{32}	0	0	0	0	0	$2\gamma_5$	$2\gamma_{33}$	$2\gamma_{34}$	0	0
	Aug.	0	0	0	0	0	0	0	0	0	γ_3	$6\gamma_5$	γ_{32}	0	0	0	0	0	$2\gamma_5$	$2\gamma_{33}$	$2\gamma_{34}$	0	0
	Sep.	0	0	0	0	0	0	0	0	0	γ_3	$6\gamma_5$	γ_{32}	0	0	0	0	0	$2\gamma_5$	$2\gamma_{33}$	$2\gamma_{34}$	0	0
	O-D	0	0	0	4	0	0	0	0	0	γ_3	$3\gamma_5$	γ_{32}	0	0	0	0	0	γ_5	0	0	0	0

Trial 11 (37.5% J/JW-stock in sub-area 12SW in June, with 10% J/JW-stock in 12NE): Hypothesis A
O Stock: as for Baseline A (Matrix O-AB)
J Stock Trial A11 (Matrix J-A11) Differences from the Baseline trial are highlighted.

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	$2\gamma_{37}$	0
	May	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_2$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	$2\gamma_{37}$	0
	Jun.	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	Jul.	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	Aug.	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	Sep.	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	O-D	2	2	2	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	0	0	0
Ad.M	J-M	2	2	1	0	0	0	2	4	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$4\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	$2\gamma_7$	γ_8	γ_8	γ_{37}	0
	May	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$4\gamma_2$	$2\gamma_4$	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$	$2\gamma_{37}$	0
	Jun.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_4$	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$	$2\gamma_{37}$	0
	Jul.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	$2\gamma_{37}$	0
	Aug.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	$2\gamma_{37}$	0
	Sep.	2	2	1	0	0	0	2	4	$4\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	O-D	4	4	1	0	0	0	2	2	0	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	2	2	1	0	0	0	2	4	$4\gamma_{29}$	γ_1	γ_4	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_1$	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}	γ_{37}	0
	May	0	0	1	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_2$	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$	$2\gamma_{37}$	0
	Jun.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	γ_3	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$	$2\gamma_{37}$	0
	Jul.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	$2\gamma_{37}$	0
	Aug.	0	0	1	0	0	0	2	2	$2\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	$2\gamma_{37}$	0
	Sep.	2	2	1	0	0	0	2	4	$4\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	O-D	4	4	1	0	0	0	2	2	0	γ_3	γ_5	0	0	0	0	0	0	0	0	0	0	0

Trial 11 (37.5% J/JW-stock in sub-area 12SW in June): Hypothesis B
Y Stock, O Stock: as for Baseline B (Matrix Y-BC, O-AB)
J Stock Trial B11 (Matrix J-B11) Differences from the Baseline trial are highlighted.

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	$2\gamma_{37}$	0
	May	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_2$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	$2\gamma_{37}$	0
	Jun.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	Jul.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	Aug.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	Sep.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	O-D	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	0	0	0
Ad.M	J-M	0	2	1	0	0	0	0	4	$4\gamma_{29}$	$2\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_1$	$2\gamma_4$	0	0	0	0	0	γ_6	$2\gamma_7$	γ_8	γ_8	γ_{37}	0
	May	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_2$	$2\gamma_4$	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$	$2\gamma_{37}$	0
	Jun.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_4$	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$	$2\gamma_{37}$	0
	Jul.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	$2\gamma_{37}$	0
	Aug.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	$2\gamma_{37}$	0
	Sep.	0	2	1	0	0	0	0	4	$4\gamma_{29}$	$2\gamma_3$	$4\gamma_5$	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	O-D	0	4	1	0	0	0	0	2	0	$2\gamma_3$	$2\gamma_5$	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	2	1	0	0	0	0	4	$4\gamma_{29}$	γ_1	γ_4	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_1$	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}	γ_{37}	0
	May	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_2$	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$	$2\gamma_{37}$	0
	Jun.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	γ_3	γ_4	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$	$2\gamma_{37}$	0
	Jul.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	$2\gamma_{37}$	0
	Aug.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	$2\gamma_{37}$	0
	Sep.	0	2	1	0	0	0	0	4	$4\gamma_{29}$	γ_3	γ_5	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	O-D	0	4	1	0	0	0	0	2	0	γ_3	γ_5	0	0	0	0	0	0	0	0	0	0	0

Trial 11 (37.5% J/JW-stock in sub-area 12SW in June): Hypothesis C
Y Stock, JE Stock, OW Stock and OE Stock: as for Baseline C (Matrix Y-BC, JE-C, OW-C, OE-C)
JW Stock Trial C11 (Matrix JW-C11) Differences from the Baseline trial are highlighted.

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
0	J-M	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	$2\gamma_{37}$	0
	May	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_8$	$2\gamma_8$	$2\gamma_{37}$	0
	Jun.	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	Jul.	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	Aug.	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	Sep.	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	$2\gamma_9$	$2\gamma_{37}$	0
	O-D	0	2	0	0	0	0	0	2	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	$2\gamma_9$	0	0	0
Ad.M	J-M	0	2	0	0	0	0	0	4	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	γ_6	$2\gamma_7$	γ_8	γ_8	γ_{37}	0
	May	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_8	$2\gamma_8$	$2\gamma_{37}$	0
	Jun.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_9	$2\gamma_9$	$2\gamma_{37}$	0
	Jul.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	$2\gamma_{37}$	0
	Aug.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	γ_9	$2\gamma_9$	$2\gamma_{37}$	0
	Sep.	0	2	0	0	0	0	0	4	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	O-D	0	4	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	2	0	0	0	0	0	4	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	0	0	0	0
	Apr.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{10}	γ_{10}	γ_{37}	0
	May	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{11}	$2\gamma_{11}$	$2\gamma_{37}$	0
	Jun.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	$2\gamma_6$	$2\gamma_7$	γ_{12}	$2\gamma_{12}$	$2\gamma_{37}$	0
	Jul.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	$2\gamma_{37}$	0
	Aug.	0	0	0	0	0	0	0	2	$2\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	γ_{12}	$2\gamma_{12}$	$2\gamma_{37}$	0
	Sep.	0	2	0	0	0	0	0	4	$4\gamma_{29}$	0	0	0	0	0	0	0	γ_6	γ_7	γ_{12}	0	0	0
	O-D	0	4	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Trial 12 (No 'C' animals in sub-area 12NE): Hypothesis C
Y Stock, JW Stock, JE Stock, OW Stock and OE Stock: as for Baseline C (Matrix Y-BC, JW-C, JE-C, OW-C & OE-C)
C Stock Trial C12 (Matrix C-C12) outline shows the difference from Trial02

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Apr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Jun.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Jul.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Sep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	O-D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ad.M	J-M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Apr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	0	0	0	0	0	0	2
	May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	0	1
	Jun.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	0	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	0	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	0	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	γ_{30}	0	0	0	0	0	0
	O-D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Ad.F	J-M	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	Apr.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$2\gamma_{36}$	0	0	0	0	0	0	2
	May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	0	1
	Jun.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	0	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	0	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	0	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	γ_{36}	$3\gamma_{30}$	0	0	0	0	0	0
	O-D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Trial 13 (No 'OW' in 11 or 12 SW): Hypothesis C
Y Stock, JW Stock, JE Stock and OE Stock: as for Baseline C (Matrix Y-BC, JW-C, JE-C & OE-C)
OW Stock Trial C13 (Matrix OW-C13) Differences from the Baseline trial are highlighted.

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	γ_{13}	4	0	0	0	0	0	$4\gamma_1$	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	0	0	0	0	0	$8\gamma_1$	γ_4	γ_{32}	0	0	0	0	0	0	0	0	0	0
	May	0	0	γ_{14}	0	0	0	0	0	0	$8\gamma_1$	γ_4	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Jun.	0	0	γ_{14}	0	0	0	0	0	0	$4\gamma_3$	$2\gamma_4$	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Jul.	0	0	0	0	0	0	0	0	0	$4\gamma_3$	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Aug.	0	0	0	0	0	0	0	0	0	$4\gamma_3$	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Sep.	0	0	0	0	0	0	0	0	0	$4\gamma_3$	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	0	0	0	0
	O-D	0	0	0	4	0	0	0	0	0	$4\gamma_3$	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	γ_{13}	4	0	0	0	0	0	γ_1	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	0	0	0	0	0	$2\gamma_1$	γ_4	$4\gamma_{32}$	0	0	0	0	0	0	0	0	0	0
	May	0	0	0	0	0	0	0	0	0	$2\gamma_1$	γ_4	$4\gamma_{32}$	0	0	0	0	0	0	0	0	0	0
	Jun.	0	0	0	0	0	0	0	0	0	$2\gamma_3$	$2\gamma_4$	$4\gamma_{32}$	0	0	0	0	0	0	0	0	0	0
	Jul.	0	0	0	0	0	0	0	0	0	$2\gamma_3$	$2\gamma_5$	$4\gamma_{32}$	0	0	0	0	0	0	0	0	0	0
	Aug.	0	0	0	0	0	0	0	0	0	$2\gamma_3$	$2\gamma_5$	$4\gamma_{32}$	0	0	0	0	0	0	0	0	0	0
	Sep.	0	0	0	0	0	0	0	0	0	γ_3	$2\gamma_5$	$4\gamma_{32}$	0	0	0	0	0	0	0	0	0	0
	O-D	0	0	0	4	0	0	0	0	0	γ_3	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	γ_{13}	4	0	0	0	0	0	γ_1	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	0	0	0	0	0	γ_1	γ_4	$2\gamma_{32}$	0	0	0	0	0	0	0	0	0	0
	May	0	0	0	0	0	0	0	0	0	γ_1	γ_4	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Jun.	0	0	0	0	0	0	0	0	0	γ_3	$2\gamma_4$	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Jul.	0	0	0	0	0	0	0	0	0	γ_3	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Aug.	0	0	0	0	0	0	0	0	0	γ_3	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	0	0	0	0
	Sep.	0	0	0	0	0	0	0	0	0	γ_3	$2\gamma_5$	γ_{32}	0	0	0	0	0	0	0	0	0	0
	O-D	0	0	0	4	0	0	0	0	0	γ_3	γ_5	γ_{32}	0	0	0	0	0	0	0	0	0	0

Trial 14 (No 'OE' in 11 or 12 SW): Hypothesis C
Y Stock, JW Stock, JE Stock and OW Stock: as for Baseline C (Matrix Y-BC, JW-C, JE-C & OW-C)
OE Stock Trial C14 (Matrix OE-C14) Differences from the Baseline trial are highlighted .

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0	0	0	0	0	γ_{24}	0
	May	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	0	0	γ_{24}	0
	Jun.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	0	0	γ_{24}	0
	Jul.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	0	0	γ_{24}	0
	Aug.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	0	0	γ_{24}	0
	Sep.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	0	0	γ_{24}	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0	0	0	0	0	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	0	0	$6\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	0	0	$6\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	0	0	$6\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	0	0	$6\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}	0	0	0	0	$3\gamma_{24}$	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0	0	0	0	0	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	0	0	$9\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	0	0	$9\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	0	0	$9\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	0	0	$9\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$	0	0	0	0	$3\gamma_{24}$	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Trial 15 (No 'OE' in 7WR): Hypothesis C
Y Stock, JW Stock, JE Stock and OW Stock: as for Baseline C (Matrix Y-BC, JW-C, JE-C & OW-C)
OE Stock Trial C15 (Matrix OE-C15) Differences from the Baseline trial are highlighted .

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	0	γ_{18}	γ_{19}	γ_{20}	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	May	0	0	0	2	2	2	0	0	0	0	0	0	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jun.	0	0	0	2	2	2	0	0	0	0	0	0	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jul.	0	0	0	2	2	2	0	0	0	0	0	0	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Aug.	0	0	0	2	2	2	0	0	0	0	0	0	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Sep.	0	0	0	2	2	2	0	0	0	0	0	0	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	0	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	0	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	0	0	0	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	γ_{22}	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	0	0	0	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	0	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	0	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	0	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Hypothesis A Trials 21 (Abundance estimate in 5 = 'minimum'),
22 (Abundance estimate in 5 = 'maximum'),
29 (Abundance estimate in 6W = 'minimum') and
30 (Abundance estimate in 6W = 'maximum'):
O Stock: as for Baseline A (Matrix O-AB)
J Stock Trial A11 (Matrix J-Am) Differences from the Baseline trial are highlighted.

Age/ Sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	2	2	2	0	0	0	$2\gamma_{39}$	2	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	2	2	2	0	0	0	$2\gamma_{39}$	2	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	0	0
	May	2	2	2	0	0	0	$2\gamma_{39}$	2	$4\gamma_{29}$	$2\gamma_{2}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	0	0
	Jun.	2	2	2	0	0	0	$2\gamma_{39}$	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Jul.	2	2	2	0	0	0	$2\gamma_{39}$	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Aug.	2	2	2	0	0	0	$2\gamma_{39}$	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Sep.	2	2	2	0	0	0	$2\gamma_{39}$	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	O-D	2	2	2	0	0	0	$2\gamma_{39}$	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	0	0	0
Ad.M	J-M	2	2	1	0	0	0	$2\gamma_{39}$	4	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	0	0	1	0	0	0	$2\gamma_{39}$	2	$2\gamma_{29}$	$4\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	$2\gamma_{7}$	γ_{8}	γ_{8}	0	0
	May	0	0	1	0	0	0	$2\gamma_{39}$	2	$2\gamma_{29}$	$4\gamma_{2}$	$2\gamma_{4}$	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{8}	$2\gamma_{8}$	0	0
	Jun.	0	0	1	0	0	0	$2\gamma_{39}$	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{4}$	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{9}	$2\gamma_{9}$	0	0
	Jul.	0	0	1	0	0	0	$2\gamma_{39}$	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	0	0
	Aug.	0	0	1	0	0	0	$2\gamma_{39}$	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	0	0
	Sep.	2	2	1	0	0	0	$2\gamma_{39}$	4	$4\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	O-D	4	4	1	0	0	0	$2\gamma_{39}$	2	0	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	2	2	1	0	0	0	$2\gamma_{39}$	4	$4\gamma_{29}$	γ_{1}	γ_{4}	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	0	0	1	0	0	0	$2\gamma_{39}$	2	$2\gamma_{29}$	$2\gamma_{1}$	γ_{4}	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{10}	γ_{10}	0	0
	May	0	0	1	0	0	0	$2\gamma_{39}$	2	$2\gamma_{29}$	$2\gamma_{2}$	γ_{4}	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{11}	$2\gamma_{11}$	0	0
	Jun.	0	0	1	0	0	0	$2\gamma_{39}$	2	$2\gamma_{29}$	γ_{3}	γ_{4}	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{12}	$2\gamma_{12}$	0	0
	Jul.	0	0	1	0	0	0	$2\gamma_{39}$	2	$2\gamma_{29}$	γ_{3}	γ_{5}	0	0	0	0	0	γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	0	0
	Aug.	0	0	1	0	0	0	$2\gamma_{39}$	2	$2\gamma_{29}$	γ_{3}	γ_{5}	0	0	0	0	0	γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	0	0
	Sep.	2	2	1	0	0	0	$2\gamma_{39}$	4	$4\gamma_{29}$	γ_{3}	γ_{5}	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	O-D	4	4	1	0	0	0	$2\gamma_{39}$	2	0	γ_{3}	γ_{5}	0	0	0	0	0	0	0	0	0	0	0

Trial 23 (Single J-stock): Hypothesis C
Y Stock, OW Stock and OE Stock: as for Baseline C (Matrix Y-BC, OW-C & OE-C)
J Stock Trial C23 (Matrix J-C23) the highlighted cells correspond to the only difference with the J-stock matrix, Hyp. B

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
0	J-M	0	2	2	0	0	0	0	2	$4\gamma_{29}$	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	0	0
	May	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	0	0
	Jun.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Jul.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{31}$	$6\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Aug.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{31}$	$6\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Sep.	0	2	2	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{31}$	$6\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	O-D	0	2	2	0	0	0	0	2	$4\gamma_{29}$	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	0	0	0
Ad.M	J-M	0	2	1	0	0	0	0	4	$4\gamma_{29}$	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	γ_{6}	$2\gamma_{7}$	γ_{8}	γ_{8}	0	0
	May	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{8}	$2\gamma_{8}$	0	0
	Jun.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{9}	$2\gamma_{9}$	0	0
	Jul.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	0	0
	Aug.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	0	0
	Sep.	0	2	1	0	0	0	0	4	$4\gamma_{29}$	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	O-D	0	4	1	0	0	0	0	2	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	2	1	0	0	0	0	4	$4\gamma_{29}$	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{10}	γ_{10}	0	0
	May	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{11}	$2\gamma_{11}$	0	0
	Jun.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{12}	$2\gamma_{12}$	0	0
	Jul.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	0	0
	Aug.	0	0	1	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	0	0
	Sep.	0	2	1	0	0	0	0	4	$4\gamma_{29}$	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	γ_{6}	γ_{7}	γ_{12}	0	0	0
	O-D	0	4	1	0	0	0	0	2	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0

Trial 24 (Single O-stock): Hypothesis C
Y Stock, JW Stock & JE Stock: as for Baseline C (Matrix Y-BC, JW-C & JE-C)
O Stock Trial C24 (Matrix O-C24) (Based primarily on OE, with some additions from OW in sub-areas where OW occurs without OE. Highlight shows the difference from the O-stock matrix of Hypothesis B. Note: this is a starting point which may need to be revised after inspection of the results.

Age/ sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	γ_{13}	4	4	4	0	0	0	$4\gamma_{1}$	γ_{5}	γ_{17}	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	$8\gamma_{1}$	γ_{4}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	May	0	0	γ_{14}	2	2	2	0	0	0	$8\gamma_{1}$	γ_{4}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jun.	0	0	γ_{14}	2	2	2	0	0	0	$4\gamma_{3}$	$2\gamma_{4}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jul.	0	0	0	2	2	2	0	0	0	$4\gamma_{3}$	$2\gamma_{5}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Aug.	0	0	0	2	2	2	0	0	0	$4\gamma_{3}$	$2\gamma_{5}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Sep.	0	0	0	2	2	2	0	0	0	$4\gamma_{3}$	$2\gamma_{5}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	O-D	0	0	0	4	4	4	0	0	0	$4\gamma_{3}$	γ_{5}	γ_{17}	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	γ_{13}	4	4	4	0	0	0	γ_{1}	γ_{5}	γ_{17}	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	$2\gamma_{1}$	γ_{4}	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	$2\gamma_{1}$	γ_{4}	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	$2\gamma_{3}$	$2\gamma_{4}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	$2\gamma_{3}$	$2\gamma_{5}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	$2\gamma_{3}$	$2\gamma_{5}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	γ_{3}	$2\gamma_{5}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D	0	0	0	4	4	4	0	0	0	γ_{3}	γ_{5}	γ_{17}	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	γ_{13}	4	4	4	0	0	0	γ_{1}	γ_{5}	γ_{17}	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	γ_{1}	γ_{4}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	γ_{1}	γ_{4}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	γ_{3}	$2\gamma_{4}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	γ_{3}	$2\gamma_{5}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	γ_{3}	$2\gamma_{5}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	γ_{3}	$2\gamma_{5}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D	0	0	0	4	4	4	0	0	0	γ_{3}	γ_{5}	γ_{17}	0	0	0	0	0	0	0	0	0	0

Trial 26 (Substantially more O-/OE-stock ages 1-4 are found in sub-areas 2R, 3 & 4 year-round): Hypothesis A
J Stock as for Baseline A (Matrix J-A)
O Stock Trial A26 (Matrix O-AB26) Differences from the Baseline trial are highlighted.

Age/	Mon	Sub-Area																					
sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	γ_{13}	4	4	4	0	0	0	4	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	44	44	44	0	0	0	8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	May	0	0	γ_{14}	44	44	44	0	0	0	8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jun.	0	0	γ_{14}	44	44	44	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jul.	0	0	γ_{15}	44	44	44	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Aug.	0	0	γ_{15}	44	44	44	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Sep.	0	0	γ_{15}	44	44	44	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	4	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	γ_{13}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	γ_{13}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	1	γ_{16}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	1	γ_{16}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0

Trial 26 (Substantially more O-/OE-stock ages 1-4 are found in sub-areas 2R, 3 & 4 year-round): Hypothesis B
Y Stock and J stock: As for Baseline B (Matrix Y-BC and J-B)
O Stock Trial B26 (Matrix O-AB26) as above

Trial 26 (Substantially more O-/OE-stock ages 1-4 are found in sub-areas 2R, 3 & 4 year-round): Hypothesis C
Y Stock, JW Stock, JE Stock and OW Stock: as for Baseline C (Matrix Y-BC, JW-C, JE-C & OW-C)
OE Stock Trial C26 (Matrix OE-C26) Differences from the Baseline trial are highlighted.

Age/	Mon	Sub-Area																					
sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	44	44	44	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	May	0	0	0	44	44	44	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jun.	0	0	0	44	44	44	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jul.	0	0	0	44	44	44	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Aug.	0	0	0	44	44	44	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Sep.	0	0	0	44	44	44	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	γ_{21}	0	0	γ_{22}	γ_{23}	γ_{24}	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	γ_{22}	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Trial 27 (no age 1-4 whales in sub-area 9 / 9N): Hypothesis A
J Stock as for Baseline A (Matrix J-A)
O Stock Trial A27 (Matrix O-AB27) Differences from the Baseline trial are highlighted.

Age/	Mon	Sub-Area																					
sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	γ_{13}	4	4	4	0	0	0	4	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	May	0	0	γ_{14}	2	2	2	0	0	0	8	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jun.	0	0	γ_{14}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jul.	0	0	γ_{15}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Aug.	0	0	γ_{15}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Sep.	0	0	γ_{15}	2	2	2	0	0	0	4	$4\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	4	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	γ_{13}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	2	$2\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	2	$4\gamma_{16}$	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	γ_{13}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{14}	2	2	2	0	0	0	1	γ_{16}	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	1	γ_{16}	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	1	$2\gamma_{16}$	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D	0	0	γ_{15}	4	4	4	0	0	0	1	γ_{16}	0	0	0	0	0	0	0	0	0	0	0

Trial 27 (no age 1-4 whales in sub-area 9/9N): Hypothesis B
Y Stock and J stock: As for Baseline B (Matrix Y-BC and J-B)
O Stock Trial B27 (Matrix O-AB27) as above

Trial 27 (no age 1-4 whales in sub-area 9/9N): Hypothesis C
Y Stock, JW Stock, JE Stock and OW Stock: as for Baseline C (Matrix Y-BC, JW-C, JE-C & OW-C)
OE Stock Trial C27 (Matrix OE-C27) Differences from the Baseline trial are highlighted.

Age/	Mon	Sub-Area																					
sex		1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	May	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jun.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Jul.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Aug.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	Sep.	0	0	0	2	2	2	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	0	0	0	0	γ_{22}	γ_{23}	γ_{24}	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	$2\gamma_{21}$	0	0	γ_{22}	γ_{23}	$6\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	$4\gamma_{17}$	$4\gamma_{18}$	$4\gamma_{19}$	$4\gamma_{20}$	γ_{21}	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	0	2	2	2	0	0	0	0	0	$2\gamma_{17}$	$2\gamma_{18}$	$2\gamma_{19}$	$2\gamma_{20}$	0	0	0	γ_{22}	γ_{23}	$3\gamma_{24}$	0
	May	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	γ_{22}	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jun.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Jul.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Aug.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$4\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$9\gamma_{24}$	0
	Sep.	0	0	0	0	0	0	0	0	0	0	0	γ_{17}	γ_{18}	γ_{19}	γ_{20}	$2\gamma_{21}$	0	0	$2\gamma_{22}$	$2\gamma_{23}$	$3\gamma_{24}$	0
	O-D	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Trial 28 (Number of 1+ whales in 2009 in sub-area 2C in any month <200): Hypothesis A
O Stock: as for Baseline A (Matrix O-AB)
J Stock Trial A28 (Matrix J-A28) Differences from the Baseline trial are highlighted.

Age/sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	2	2	$2\gamma_{38}$	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	2	2	$2\gamma_{38}$	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	0	0
	May	2	2	$2\gamma_{38}$	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_{2}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	0	0
	Jun.	2	2	$2\gamma_{38}$	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Jul.	2	2	$2\gamma_{38}$	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Aug.	2	2	$2\gamma_{38}$	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Sep.	2	2	$2\gamma_{38}$	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	O-D	2	2	$2\gamma_{38}$	0	0	0	2	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	0	0	0
Ad.M	J-M	2	2	γ_{38}	0	0	0	2	4	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	0	0	γ_{38}	0	0	0	2	2	$2\gamma_{29}$	$4\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	$2\gamma_{7}$	γ_{8}	γ_{8}	0	0
	May	0	0	γ_{38}	0	0	0	2	2	$2\gamma_{29}$	$4\gamma_{2}$	$2\gamma_{4}$	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{8}	$2\gamma_{8}$	0	0
	Jun.	0	0	γ_{38}	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{4}$	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{9}	$2\gamma_{9}$	0	0
	Jul.	0	0	γ_{38}	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	0	0
	Aug.	0	0	γ_{38}	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	0	0
	Sep.	2	2	γ_{38}	0	0	0	2	4	$4\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	O-D	4	4	γ_{38}	0	0	0	2	2	0	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	2	2	γ_{38}	0	0	0	2	4	$4\gamma_{29}$	γ_{1}	γ_{4}	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	0	0	γ_{38}	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_{1}$	γ_{4}	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{10}	γ_{10}	0	0
	May	0	0	γ_{38}	0	0	0	2	2	$2\gamma_{29}$	$2\gamma_{2}$	γ_{4}	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{11}	$2\gamma_{11}$	0	0
	Jun.	0	0	γ_{38}	0	0	0	2	2	$2\gamma_{29}$	γ_{3}	γ_{4}	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{12}	$2\gamma_{12}$	0	0
	Jul.	0	0	γ_{38}	0	0	0	2	2	$2\gamma_{29}$	γ_{3}	γ_{5}	0	0	0	0	0	γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	0	0
	Aug.	0	0	γ_{38}	0	0	0	2	2	$2\gamma_{29}$	γ_{3}	γ_{5}	0	0	0	0	0	γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	0	0
	Sep.	2	2	γ_{38}	0	0	0	2	4	$4\gamma_{29}$	γ_{3}	γ_{5}	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	O-D	4	4	γ_{38}	0	0	0	2	2	0	γ_{3}	γ_{5}	0	0	0	0	0	0	0	0	0	0	0

Trial 28 (Number of 1+ whales in 2009 in sub-area 2C in any month <200): Hypothesis B
Y Stock, O Stock: as for Baseline B (Matrix Y-BC, O-AB)
J Stock Trial B28 (Matrix J-B28) Differences from the Baseline trial are highlighted.

Age/sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	2	$2\gamma_{38}$	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	0	2	$2\gamma_{38}$	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	0	0
	May	0	2	$2\gamma_{38}$	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{2}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{8}$	$2\gamma_{8}$	0	0
	Jun.	0	2	$2\gamma_{38}$	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Jul.	0	2	$2\gamma_{38}$	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Aug.	0	2	$2\gamma_{38}$	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	Sep.	0	2	$2\gamma_{38}$	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	$2\gamma_{9}$	0	0
	O-D	0	2	$2\gamma_{38}$	0	0	0	0	2	$4\gamma_{29}$	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	$2\gamma_{9}$	0	0	0
Ad.M	J-M	0	2	γ_{38}	0	0	0	0	4	$4\gamma_{29}$	$2\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	0	0	γ_{38}	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{1}$	$2\gamma_{4}$	0	0	0	0	0	γ_{6}	$2\gamma_{7}$	γ_{8}	γ_{8}	0	0
	May	0	0	γ_{38}	0	0	0	0	2	$2\gamma_{29}$	$4\gamma_{2}$	$2\gamma_{4}$	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{8}	$2\gamma_{8}$	0	0
	Jun.	0	0	γ_{38}	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{4}$	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{9}	$2\gamma_{9}$	0	0
	Jul.	0	0	γ_{38}	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	0	0
	Aug.	0	0	γ_{38}	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	γ_{9}	$2\gamma_{9}$	0	0
	Sep.	0	2	γ_{38}	0	0	0	0	4	$4\gamma_{29}$	$2\gamma_{3}$	$4\gamma_{5}$	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	O-D	0	4	γ_{38}	0	0	0	0	2	0	$2\gamma_{3}$	$2\gamma_{5}$	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	2	γ_{38}	0	0	0	0	4	$4\gamma_{29}$	γ_{1}	γ_{4}	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	Apr.	0	0	γ_{38}	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_{1}$	γ_{4}	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{10}	γ_{10}	0	0
	May	0	0	γ_{38}	0	0	0	0	2	$2\gamma_{29}$	$2\gamma_{2}$	γ_{4}	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{11}	$2\gamma_{11}$	0	0
	Jun.	0	0	γ_{38}	0	0	0	0	2	$2\gamma_{29}$	γ_{3}	γ_{4}	0	0	0	0	0	$2\gamma_{6}$	$2\gamma_{7}$	γ_{12}	$2\gamma_{12}$	0	0
	Jul.	0	0	γ_{38}	0	0	0	0	2	$2\gamma_{29}$	γ_{3}	γ_{5}	0	0	0	0	0	γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	0	0
	Aug.	0	0	γ_{38}	0	0	0	0	2	$2\gamma_{29}$	γ_{3}	γ_{5}	0	0	0	0	0	γ_{6}	γ_{7}	γ_{12}	$2\gamma_{12}$	0	0
	Sep.	0	2	γ_{38}	0	0	0	0	4	$4\gamma_{29}$	γ_{3}	γ_{5}	0	0	0	0	0	γ_{6}	γ_{7}	0	0	0	0
	O-D	0	4	γ_{38}	0	0	0	0	2	0	γ_{3}	γ_{5}	0	0	0	0	0	0	0	0	0	0	0

Trial 28 (Number of 1+ whales in 2009 in sub-area 2C in any month <200): Hypothesis C
Y Stock, JW Stock, OW Stock and OE Stock: as for Baseline C (Matrix Y-BC, JW-C, OW-C, OE-C)
JE Stock Trial C28 (Matrix JE-C28) Differences from the Baseline trial are highlighted.

Age/sex	Mon	1W	1E	2C	2R	3	4	5	6W	6E	7CS	7CN	7WR	7E	8	9	9N	10W	10E	11	12SW	12NE	13
Juv	J-M	0	0	$2\gamma_{38}$	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	$2\gamma_{38}$	0	0	0	0	0	0	$2\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	May	0	0	$2\gamma_{38}$	0	0	0	0	0	0	$2\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jun.	0	0	$2\gamma_{38}$	0	0	0	0	0	0	$2\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jul.	0	0	$2\gamma_{38}$	0	0	0	0	0	0	$2\gamma_{31}$	$6\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Aug.	0	0	$2\gamma_{38}$	0	0	0	0	0	0	$2\gamma_{31}$	$6\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Sep.	0	0	$2\gamma_{38}$	0	0	0	0	0	0	$2\gamma_{31}$	$6\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	O-D	0	0	$2\gamma_{38}$	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
Ad.M	J-M	0	0	γ_{38}	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	May	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jun.	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jul.	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Aug.	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Sep.	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	O-D	0	0	γ_{38}	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
Ad.F	J-M	0	0	γ_{38}	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Apr.	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	May	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$3\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jun.	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Jul.	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Aug.	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	Sep.	0	0	γ_{38}	0	0	0	0	0	0	$4\gamma_{31}$	$8\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0
	O-D	0	0	γ_{38}	0	0	0	0	0	0	γ_{31}	$2\gamma_{16}$	0	0	0	0	0	0	0	0	0	0	0

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Adjunct 3

Calculation of stock mixing proportions, including correction for 'missing alleles': unpooled results

C.L. de Moor

This document details the stock mixing proportions by month and sex as circulated to the Steering Group for the *Implementation Review* of western North Pacific common minke whales on 26th August 2011 together with an update to those circulated results for sub-area 6W following comments from the 'G3 Review Group'.

In anticipation of sensitivity tests to Hypothesis C assuming a single J-stock with Y-, OW- and OE-stocks, and a single O-stock with Y-, JW- and JE-stocks, mixing proportions in sub-areas affected by this alternative have been included at the end of the document.

This adjunct is a cut down version of De Moor (2011)(rev). Details of an alternative O-stock (the O2 stock) are given in De Moor (2011)(rev) but are not included here because the results for the two O-stock definitions were essentially identical, trials would only be conducted using the original definition of the O-stock (IWC, 2013).

PURE STOCK DEFINITIONS

Table 1

The nomination of samples representative of 'pure' stocks for the purpose of estimating mixing proportions.

Hypotheses A and B		Hypothesis C	
Stock	Location/months to define pure sample	Stock	Location/months to define pure sample
Y-stock	5 (all months)	Y-stock	5 (all months)
J-stock	6E (all months)	JW-stock	6E (all months)
O-stock	7WR, 7E, 8 (all months)	JE-stock	2C (Jul.-Dec.)
		OW-stock	7CN [Jun.] [>8.8NM]
		OE-stock	8 and 9 (all months) [excluding 9 in 1995]

Table 2

Pure stock sample sizes.

Stock	Sample size Haplotypes	Sample size Loci
Pure Y	58	58 58 58 58 58 58 56 58 58 58 54
Pure J	392	392 392 392 392 392 392 392 392 392 392 392 (392 391 392 392 392)
Pure O	341	342 342 342 342 342 341 342 342 342 342 342 342 342 342 342 342
Pure JW	392	392 392 392 392 392 392 392 392 392 392 392 (392 391 392 392 392)
Pure JE	83	83 83 83 83 83 83 83 83 83 83 83 83 83 83 83 83
Pure OW	99	99 99 99 99 99 99 99 99 99 99 99 99 99 99 99 99
Pure OE	590	589 590 589 589 589 590 590 590 589 589 589 589 589 589 589 589

Notation in this document:

(1) In most cases samples are obtained from 16 loci. In sub-areas 5 and 6W samples from the first 11 loci only are available. In each table a (x16) or (x11) is given next to the Loci Sample Size indicating the number of loci used in the calculation of the mixing proportion. In some cases there was a missing value in a sample at a particular loci. Thus, for example if the total sample size were 50, for one of the loci (the 10th) the sample size is 49. This is noted by saying eg '50 with 49 at 10th')

(2) In cases where a mixing proportion should indicate a pure stock, it is given in ***bold italic***. A one-sided t-test has been carried out on all of these cases. If the hypothesis of a pure stock (proportion = 1 or 0) is rejected with α=0.05, then the proportion is underlined. For sub-areas where the mixing matrix assumes only a single stock, even though the sub-area is not used in the definition of a pure stock, similar tests are carried out and given in grey highlight. The one-sided t-test is not conducted if the sample size is 1 or if SE<0.001, but if the mixing proportion is 1.000 or 0.000 as expected the hypothesis of a pure stock is taken to not be rejected.

(3) In cases where a pooled mixing proportion is directly comparable to that in Working Paper 2 from SC/63, a '&' is used to denote cases where the updated mixing proportion differs from that previously used in conditioning by more than 0.05.

SUB-AREA 5 (bycatch data only, 58 samples)

Pure Y defined in sub-area 5 in all months for Hypotheses B and C

Mixing matrices assume J-stock present in all months in sub-area 5 for Hypothesis A

Hyp A: Proportion of J mixing with O		Sample size	Proportion Haplotypes	SE	Sample size (x11)	Proportion Loci	SE
Jan-Mar	Males	5	1.000	0.005	5 with 4 at 7th and 11th	1.000	0.000
Apr		1	1.000	0.009	1	0.981	0.267
May		9	1.000	0.001	9	0.943	0.052
Jun		12	1.000	0.001	12 with 11 and 11th	0.950	0.042
Jul		6	1.000	0.004	6	0.904	0.076
Aug		4	1.000	0.005	4	0.857	0.087
Sep		3	1.000	0.025	3 with 2 at 11th	0.303	0.164
Oct-Dec		11	1.000	0.001	11 with 10 at 7th &11th	0.939	0.054
Jan-Mar	Females	3	1.000	0.005	3	0.999	0.000
Apr		0			0		
May		1	1.000	0.010	1	0.999	0.000
Jun		1	1.000	0.009	1	1.000	0.000
Jul		0			0		
Aug		0			0		
Sep		0			0		
Oct-Dec		2	1.000	0.007	2	1.000	0.000
Summary: all data		58	1.000	0.000	58 with 56 at 7th and 54 at 11th	0.919	0.023

Hyp B & C: Proportion of J/JW mixing with Y		Sample size	Proportion Haplotypes	SE	Sample size (x11)	Proportion Loci	SE
Jan.-Mar.	Males	5	***0.000***	0.007	5 with 4 at 7th and 11th	0.001	0.000
Apr.		1	0.990	8.911	1	0.001	0.000
May		9	***0.000***	0.007	9	***0.447***	0.210
Jun.		12	***0.268***	0.398	12 with 11 and 11th	0.001	0.000
Jul.		6	***0.000***	0.007	6	0.001	0.000
Aug.		4	***0.000***	0.009	4	***0.027***	0.287
Sep.		3	***0.000***	0.027	3 with 2 at 11th	0.001	0.000
Oct.-Dec.		11	***0.000***	0.026	11 with 10 at 7th &11th	0.001	0.000
Jan.-Mar.	Females	3	***0.000***	0.010	3	***0.445***	0.425
Apr.		0			0		
May		1	**0.000**	0.041	1	0.001	0.000
Jun.		1	0.998	0.208	1	0.052	0.531
Jul.		0			0		
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		2	***0.000***	0.056	2	***0.000***	0.000
Summary: all data		58	***0.000***	0.004	58 with 56 at 7th and 54 at 11th	**0.000**	0.000

SUB-AREA 1E (bycatch data only, 22 samples)
Not used for definition of a pure stock
Mixing matrices assume no mixing in this sub-area - only J/JW
Comments: Low sample size, but some mixing in Apr./May.

Hyp A: Proportion of J mixing with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	4	1.000	0.005	4	0.977	0.076
Apr.		4	0.750	0.212	4	0.652	0.107
May		0			0		
Jun.		1	1.000	0.009	1	0.999	0.000
Jul.		0			0		
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Mar.	Females	7	1.000	0.002	7	0.999	0.000
Apr.		1	1.000	0.009	1	0.999	0.000
May		3	1.000	0.005	3	0.999	0.000
Jun.		0			0		
Jul.		0			0		
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		2	1.000	0.007	2	0.999	0.000
Summary: all data		22	0.954	0.045	22	0.930	0.030

Hyp B & C: Proportion of J mixing with Y		Sample size	Proportion Haplotypes	SE	Sample size (x11)	Proportion Loci	SE
Jan.-Mar.	Males	4	0.000	0.010	4	0.999	0.000
Apr.		4	0.464	0.380	4	0.600	0.216
May		0			0		
Jun.		1	0.000	0.031	1	0.999	0.000
Jul.		0			0		
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Mar.	Females	7	1.000	0.022	7	0.559	0.253
Apr.		1	0.998	0.208	1	1.000	0.000
May		3	0.755	0.954	3	0.397	0.336
Jun.		0			0		
Jul.		0			0		
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		2	1.000	0.032	2	1.000	0.000
Summary: all data		22	0.655	0.268	22	0.776	0.109

Hyp C: Proportion of JW mixing with JE		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	4	1.000	0.01	4	1.000	0.000
Apr.		4	0.469	0.308	4	0.432	0.250
May		0			0		
Jun.		1	1.000	0.033	1	0.000	0.000
Jul.		0			0		
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Mar.	Females	7	0.980	0.581	7	0.444	0.274
Apr.		1	1.000	0.011	1	0.000	0.000
May		3	0.000	0.030	3	0.184	0.526
Jun.		0			0		
Jul.		0			0		
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		2	1.000	0.029	2	1.000	0.000
Summary: all data		22	0.708	0.206	22	0.598	0.124

SUB-AREA 6W (bycatch data only, 415 samples)
Not used for definition of a pure stock.
Mixing matrices assume only J stock for Hyp A.
Mixing matrices assume mixing in this sub-area between J/JW and Y year round for Hyp B and C.
Comments: Some mixing from Oct.-Jun.

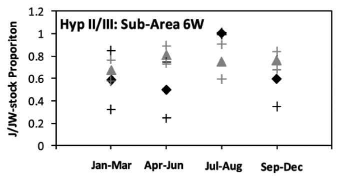
Hyp A: Proportion of J mixing with O		Sample size	Proportion Haplotypes	SE	Sample size (x11)	Proportion Loci	SE
Jan.-Mar.	Males	83	0.993	0.013	83 with 81 in 11th	0.937	0.018
Apr.		37	1.000	0.001	37 with 36 in 1st	0.978	0.019
May		41	1.000	0.001	41 with 40 in 8th	0.982	0.017
Jun.		43	1.000	0.001	43	0.966	0.022
Jul.		21	1.000	0.001	21	0.898	0.049
Aug.		16	1.000	0.001	16 with 15 in 11th	0.999	0.000
Sep.		20	1.000	0.001	20 with 18 in 11th	0.793	0.053
Oct.-Dec.		97	1.000	0.000	97 with 96 in 7th and 94 in 11th	0.971	0.015
Jan.-Mar.	Females	13	0.921	0.077	13 with 12 in 6th	0.778	0.061
Apr.		3	1.000	0.005	3	0.931	0.072
May		7	1.000	0.004	7	0.860	0.083
Jun.		10	1.000	0.003	10	0.820	0.072
Jul.		1	1.000	0.009	1	0.959	0.338
Aug.		4	1.000	0.005	4	0.958	0.049
Sep.		6	1.000	0.004	6 with 5 in 9th	0.872	0.078
Oct.-Dec.		13	1.000	0.003	13 with 12 in 11th	1.000	0.000
Summary: all data		415	0.997	0.003	415 with 414 in 1st, 6-9th and 406 in 11th	0.937	0.008

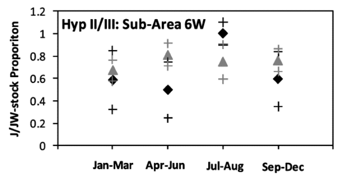
Hyp B and C: Proportion of J/JW mixing with Y		Sample size	Proportion Haplotypes	SE	Sample size (x11)	Proportion Loci	SE
Jan.-Mar.	Males	83	0.555	0.142	83 with 81 in 11th	0.745	0.050
Apr.		37	0.449	0.253	37 with 36 in 1st	0.963	0.083
May		41	0.749	0.243	41 with 40 in 8th	0.926	0.062
Jun.		43	0.534	0.245	43	0.787	0.080
Jul.		21	0.830	0.38	21	0.788	0.089
Aug.		16	1.000	0.004	16 with 15 in 11th	0.726	0.137
Sep.		20	0.533	0.335	20 with 18 in 11th	0.475	0.107
Oct.-Dec.		97	0.629	0.140	97 with 96 in 7th and 94 in 11th	0.859	0.049
Jan.-Mar.	Females	13	0.730	0.314	13 with 12 in 6th	0.284	0.128
Apr.		3	0.002	0.139	3	0.751	0.301
May		7	0.000	0.006	7	0.529	0.148
Jun.		10	0.364	0.309	10	0.583	0.167
Jul.		1	1.000	0.009	1	0.999	0.000
Aug.		4	1.000	0.024	4	0.457	0.323
Sep.		6	0.415	0.636	6 with 5 in 9th	0.773	0.143
Oct.-Dec.		13	0.409	0.455	13 with 12 in 11th	0.806	0.130
Summary: all data		415	0.625	0.069	415 with 414 in 1st, 6-9th and 406 in 11th	0.776	0.109

Pooling for input to conditioning:

Hyp B and C: Proportion of J/JW mixing with Y		Sample size	Proportion Haplotypes	SE	Sample size (x11)	Proportion Loci	SE
Jan.-Mar.	M F	96	0.584	0.131	96 with 95 in 6th, 94 in 11th	0.672	0.047
Apr.-Jun.	M F	141	0.496	0.126	141 with 140 in 1st, 8th	0.812	0.04
Jul.-Aug.	M F	42	1.000	0.004	42 with 41 in 11th	0.749	0.077
Sep.-Dec.	M F	136	0.593	0.123	136 with 135 in 7th, 9th, 130 in 11th	0.761	0.04

Plots of pooled mixing proportions for J/JW-stock with O/Y-stock. RH plots are with a minimum 0.05 SE:





SUB-AREA 6E (bycatch data only, 392 samples)
Pure J/JW-stock defined in sub-area 6E in all months for all Hypotheses

Hyp A & B: Proportion of J mixing with O	Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar. Males	63	***1.000***	0.000	63	***1.000***	0.000
Apr.	24	***1.000***	0.001	24	***1.000***	0.000
May	23	***1.000***	0.001	23	***1.000***	0.000
Jun.	9	***1.000***	0.005	9	0.999	0.000
Jul.	9	***1.000***	0.001	9	***1.000***	0.000
Aug.	12	***1.000***	0.001	12	***1.000***	0.000
Sep.	9	***1.000***	0.001	9	***1.000***	0.000
Oct.-Dec.	39	***1.000***	0.001	39	0.999	0.000
Jan.-Mar. Females	64	***1.000***	0.008	64	0.999	0.000
Apr.	31	***1.000***	0.001	31	0.999	0.000
May	22	***1.000***	0.001	22	0.999	0.000
Jun.	16	***1.000***	0.001	16	0.999	0.000
Jul.	7	***1.000***	0.002	7	***1.000***	0.000
Aug.	12	***1.000***	0.001	12	***1.000***	0.000
Sep.	4	***1.000***	0.002	4	0.999	0.000
Oct.-Dec.	48	***1.000***	0.001	48	***1.000***	0.000
Jan.-Dec. M+F	392	***1.000***	0.000	392, 391 in 13th	***1.000***	0.000

Hyp B & C: Proportion of J/JW mixing with Y	Sample size	Proportion Haplotypes	SE	Sample size (x11)	Proportion Loci	SE
Jan.-Mar. Males	63	***1.000***	0.003	63	0.999	0.000
Apr.	24	***1.000***	0.015	24	***0.956***	0.143
May	23	***1.000***	0.004	23	0.999	0.000
Jun.	9	***0.720***	0.609	9	***0.967***	0.230
Jul.	9	***1.000***	0.031	9	0.999	0.000
Aug.	12	***1.000***	0.006	12	0.999	0.000
Sep.	9	***1.000***	0.019	9	0.999	0.000
Oct.-Dec.	39	***1.000***	0.005	39	0.999	0.000
Jan.-Mar. Females	64	***1.000***	0.003	64	***1.000***	0.000
Apr.	31	***0.927***	0.261	31	0.999	0.000
May	22	***0.950***	0.326	22	0.999	0.000
Jun.	16	***0.506***	0.535	16	0.999	0.000
Jul.	7	***1.000***	0.027	7	***1.000***	0.000
Aug.	12	***1.000***	0.007	12	***0.991***	0.172
Sep.	4	***0.000***	0.028	4	0.999	0.000
Oct.-Dec.	48	***0.893***	0.197	48	0.999	0.000
Jan.-Dec. M+F	392	***1.000***	0.002	392	***1.000***	0.000

Hyp C: Proportion of JW mixing with JE	Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar. Males	63	***1.000***	0.002	63	***1.000***	0.000
Apr.	24	***1.000***	0.003	24	0.999	0.000
May	23	***1.000***	0.004	23	***1.000***	0.000
Jun.	9	***0.859***	0.375	9	***0.562***	0.302
Jul.	9	***0.734***	0.429	9	***1.000***	0.000
Aug.	12	***1.000***	0.007	12	***1.000***	0.000
Sep.	9	***1.000***	0.032	9	***0.494***	0.308
Oct.-Dec.	39	***1.000***	0.004	39	***1.000***	0.000
Jan.-Mar. Females	64	***0.993***	0.099	64	0.999	0.000
Apr.	31	***0.906***	0.204	31	0.999	0.000
May	22	***0.856***	0.227	22	0.999	0.000
Jun.	16	***0.264***	0.472	16	***1.000***	0.000
Jul.	7	***<u>0.000</u>***	0.032	7	0.999	0.000
Aug.	12	***0.317***	0.554	12	***0.983***	0.191
Sep.	4	***1.000***	0.009	4	0.999	0.000
Oct.-Dec.	48	***1.000***	0.004	48	0.999	0.000
Jan.-Dec. M+F	392	***1.000***	0.002	392, 391 in 13th	***0.999***	0.000

SUB-AREA 10E (bycatch data only, 9 samples)
Not used for definition of a pure stock.
Mixing matrices assume no mixing in this sub-area - only J/JW-stock year-round.

Hyp A & B: Proportion of J mixing with O	Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar. Males	0					
Apr.	0					
May	0					
Jun.	0					
Jul.	0					
Aug.	0					
Sep.	0					
Oct.-Dec.	5	1.000	0.004	5	0.999	0.000
Jan.-Mar. Females	0					
Apr.	0					
May	0					
Jun.	0					
Jul.	0					
Aug.	0					
Sep.	0					
Oct.-Dec.	4	1.000	0.005	4	0.886	0.098
Jan.-Dec. M+F	9	1.000	0.001	9	0.985	0.051

Hyp C: Proportion of JW mixing with JE	Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar. Males	0			0		
Apr.	0			0		
May	0			0		
Jun.	0			0		
Jul.	0			0		
Aug.	0			0		
Sep.	0			0		
Oct.-Dec.	5	0.791	0.648	5	0.999	0.000
Jan.-Mar. Females	0			0		
Apr.	0			0		
May	0			0		
Jun.	0			0		
Jul.	0			0		
Aug.	0			0		
Sep.	0			0		
Oct.-Dec.	4	1.000	0.022	4	0.999	0.000
Jan.-Dec. M+F	9	1.000	0.039	9	0.999	0.000

Hyp C: Proportion of JW mixing with OW	Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar. Males	0			0		
Apr.	0			0		
May	0			0		
Jun.	0			0		
Jul.	0			0		
Aug.	0			0		
Sep.	0			0		
Oct.-Dec.	5	1.000	0.004	5	0.999	0.000
Jan.-Mar. Females	0			0		
Apr.	0			0		
May	0			0		
Jun.	0			0		
Jul.	0			0		
Aug.	0			0		
Sep.	0			0		
Oct.-Dec.	4	1.000	0.005	4	0.912	0.092
Jan.-Dec. M+F	9	1.000	0.001	9	0.994	0.043

SUB-AREA 2C (bycatch data only, 180 samples)

Pure JE defined in sub-area 2C in Jul.-Dec. for Hypothesis C.

Hyp A and B – mixing between J and O assumed in Oct.-Mar. for adults and year-round for juveniles (bycatch data is primarily from juveniles)

Hyp C – mixing matrices assume mixing between JE and OW-stock from Jan.-Jun.

Hyp A & B: Proportion J mixing with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	22	0.796	0.091	22	0.756	0.043
Apr.		5	0.390	0.224	5	0.279	0.123
May		5	0.447	0.250	5	0.533	0.100
Jun.		1	1.000	0.009	1	0.979	0.174
Jul.		3	1.000	0.005	3	0.999	0.000
Aug.		2	1.000	0.007	2	1.000	0.000
Sep.		0			0		
Oct.-Dec.		27	0.866	0.070	27	0.844	0.037
Jan.-Mar.	Females	46	0.902	0.047	46 with 45 in 1st, 3rd, 4th,7th ,13th,14th	0.917	0.028
Apr.		3	1.000	0.005	3	0.989	0.080
May		10	0.707	0.150	10	0.679	0.077
Jun.		5	0.781	0.249	5	0.763	0.093
Jul.		10	1.000	0.001	10	0.999	0.000
Aug.		3	0.664	0.296	3	0.784	0.126
Sep.		0			0		
Oct.-Dec.		38	0.943	0.039	38	0.949	0.020
Jan.-Dec.	M+F	180	0.863	0.027	180 with 179 in 1st, 3rd, 4th,7th , 13th,14th	0.853	0.014

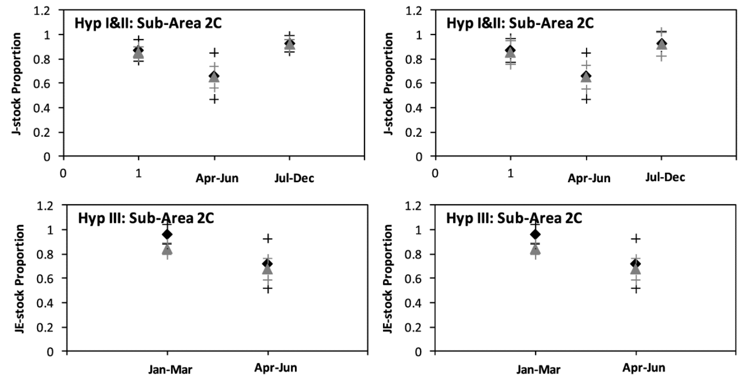
Hyp C: Proportion JE mixing with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.		22	0.897	0.077	22	0.962	0.011
Apr.		5	0.452	0.29	5	0.935	0.029
May		5	0.744	0.236	5	0.912	0.035
Jun.		1	1.000	0.01	1	0.959	0.046
Jul.		3	***1.000***	0.006	3	***1.000***	0.000
Aug.		2	***1.000***	0.008	2	0.999	0.000
Sep.		0					
Oct.-Dec.		27	***1.000***	0.001	27	0.999	0.000
Jan.-Mar.	Males	46	0.932	0.045	46 with 45 in 1st, 3rd, 4th,7th,13th,14th	0.983	0.005
Apr.		3	1.000	0.006	3	0.987	0.019
May		10	0.648	0.174	10	0.979	0.013
Jun.		5	0.766	0.217	5	0.949	0.025
Jul.	Females	10	***1.000***	0.001	10	***1.000***	0.000
Aug.		3	***1.000***	0.006	3	0.999	0.000
Sep.		0			0		
Oct.-Dec.		38	***1.000***	0.001	38	***1.000***	0.000
Jan.-Dec.	M+F	180	0.938	0.025	180 with 179 in 1st, 3rd, 4th,7th,13th,14th	0.887	0.014

Pooling for input to conditioning:

Hyp A & B: Proportion J mixing with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	M F	68	0.868	0.043	67,68,67,67,68,68,67,68, 68,68,68,68,67,67,68,68	0.853	0.023
Apr.-Jun.	M F	29	0.660	0.095	29	0.648	0.043
Jul.-Dec.	M F	83	0.923	0.032	83	0.920	0.017

Hyp C: Proportion JE mixing with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	M F	68	0.960	0.039	67,68,67,67,68,68,67,68, 68,68,68,68,67,67,68,68	0.840	0.023
Apr.-Jun.	M F	29	0.721	0.103	29	0.672	0.044

Plots of pooled mixing proportions for J/JE-stock with O/OW-stock. RH plots are with a minimum 0.05 SE:



SUB-AREA 7CS (bycatch data, 116 samples; scientific permit data, 321 samples; used separately)

Not used for definition of a pure stock.

Mixing matrices assume mixing between J/JE and O/OW year-round for all hypotheses.

Hyp A and B (BYCATCH): Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	7	0.914	0.147	7	0.999	0.000
Apr.		9	0.076	0.110	9	0.245	0.078
May		15	0.192	0.108	15	0.236	0.062
Jun.		5	0.156	0.189	5	0.256	0.105
Jul.		2	0.496	0.357	2	0.527	0.150
Aug.		2	1.000	0.007	2	0.999	0.000
Sep.		1	1.000	0.009	1	1.000	0.000
Oct.-Dec.		14	0.793	0.114	14	0.819	0.053
Jan.-Mar.	Females	10	0.493	0.160	10	0.454	0.079
Apr.		10	0.327	0.161	10	0.202	0.078
May		9	0.112	0.106	9	0.050	0.067
Jun.		13	0.399	0.143	13	0.421	0.069
Jul.		4	0.740	0.225	4	0.658	0.106
Aug.		2	0.501	0.354	2	0.518	0.167
Sep.		1	0.000	0.009	1	0.014	0.238
Oct.-Dec.		12	0.916	0.083	12	0.923	0.047
Jan.-Dec.	M+F	116	0.473	0.048	116	0.494	0.022

Hyp C (BYCATCH): Proportion of JE mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	7	0.953	0.186	7	0.878	0.062
Apr.		9	0.165	0.151	9	0.305	0.084
May		15	0.175	0.158	15	0.252	0.066
Jun.		5	0.000	0.022	5	0.275	0.103
Jul.		2	0.000	0.023	2	0.481	0.154
Aug.		2	1.000	0.008	2	0.999	0.000
Sep.		1	1.000	0.010	1	0.751	0.168
Oct.-Dec.		14	0.905	0.093	14	0.806	0.059
Jan.-Mar.	Females	10	0.597	0.210	10	0.459	0.078
Apr.		10	0.494	0.217	10	0.244	0.080
May		9	0.001	0.074	9	0.069	0.080
Jun.		13	0.358	0.175	13	0.457	0.070
Jul.		4	0.816	0.333	4	0.685	0.111
Aug.		2	1.000	0.020	2	0.494	0.191
Sep.		1	0.000	0.009	1	0.181	0.255
Oct.-Dec.		12	1.000	0.001	12	0.824	0.055
Jan.-Dec.	M+F	116	0.546	0.062	116	0.498	0.023

Hyp A and B (SP): Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		44	0.250	0.072	44	0.289	0.037
May		85	0.184	0.047	85	0.258	0.027
Jun.		40	0.000	0.001	40	0.026	0.034
Jul.		0			0		
Aug.		3	0.297	0.288	3	0.338	0.153
Sep.		1	0.000	0.009	1	0.241	0.268
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		66	0.069	0.035	66	0.098	0.027
May		72	0.205	0.052	72	0.196	0.028
Jun.		9	0.111	0.105	9	0.153	0.064
Jul.		0			0		
Aug.		1	0.000	0.012	1	0.147	0.232
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	321	0.144	0.022	321	0.185	0.013

Hyp C (SP): Proportion of JE mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		44	0.208	0.083	44	0.299	0.036
May		85	0.198	0.057	85	0.270	0.027
Jun.		40	0.000	0.001	40	0.055	0.033
Jul.		0			0		
Aug.		3	1.000	0.02	3	0.348	0.160
Sep.		1	0.998	0.112	1	0.001	0.000
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		66	0.056	0.039	66	0.141	0.029
May		72	0.220	0.063	72	0.188	0.029
Jun.		9	0.200	0.182	9	0.192	0.072
Jul.		0			0		
Aug.		1	0.000	0.011	1	0.093	0.209
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	321	0.149	0.027	321	0.201	0.013

Pooling for input to conditioning:

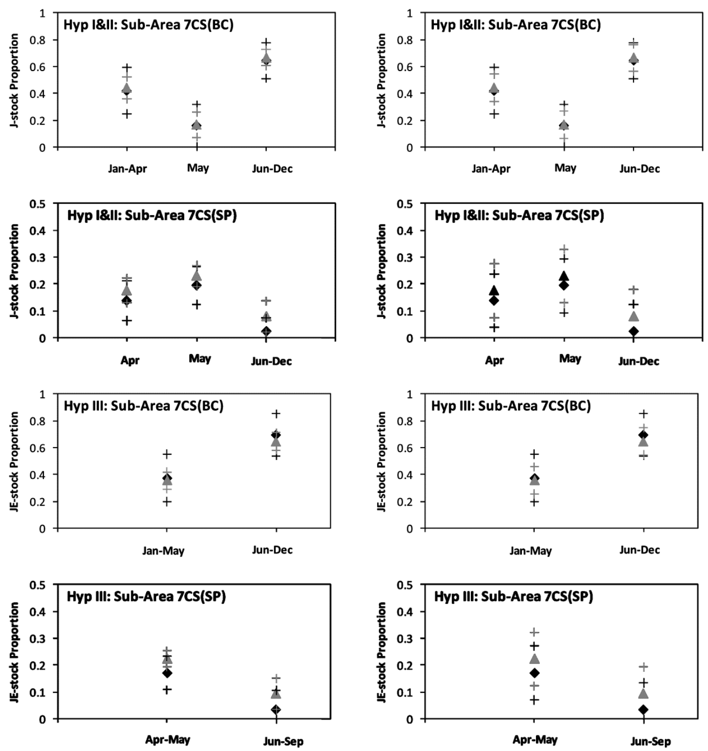
Hyp A and B (BC): Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Apr.	M F	36	0.419	0.086	36	0.441	0.041
May	M F	24	0.160	0.078	24	0.168	0.047
Jun.-Dec.	M F	56	0.645	0.067	56	0.664	0.030

Hyp A and B (SP): Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Apr.	M F	110	0.138	0.037	110	0.176	0.023
May	M F	157	0.194	0.035	157	0.230	0.019
Jun.-Sep.	M F	54	0.025	0.024	54	0.079	0.029

Hyp C (BC): Proportion of JE mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-May	M F	60	0.375	0.088	60	0.356	0.032
Jun.-Dec.	M F	56	0.696	0.078	56	0.646	0.032

Hyp C (SP): Proportion of JE mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Apr.-May	M F	267	0.171	0.031	267	0.223[&]	0.015
Jun.-Sep.	M F	54	0.034	0.036	54	0.093[&]	0.029

Plots of pooled mixing proportions for J/JE-stock mixing with O/OW-stock. RH plots are with a minimum 0.05 SE:



SUB-AREA 7CN (bycatch data, 96 samples; scientific permit data (>2nm), 502 samples; used separately)

Not used for definition of a pure stock

Hyp A and B – mixing between J and O year-round

Hyp C – mixing between JE and OW Apr-Dec.

<u>Comments:</u> Higher proportion of O/OW in SP (offshore) samples compared to BC (coastal) samples. Lower proportion of O/OW in BC&SP (coastal and offshore) during the 2nd half of the year.

Hyp A & B (BYCATCH): Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	3	1.000	0.005	3	0.993	0.122
Apr.		4	0.481	0.259	4	0.333	0.122
May		4	0.754	0.236	4	0.751	0.124
Jun.		7	0.291	0.202	7	0.502	0.095
Jul.		5	0.601	0.232	5	0.555	0.115
Aug.		3	0.301	0.291	3	0.260	0.127
Sep.		2	1.000	0.023	2	0.633	0.164
Oct.-Dec.		9	1.000	0.001	9	0.977	0.027
Jan.-Mar.	Females	3	1.000	0.005	3	1.000	0.000
Apr.		6	0.296	0.205	6	0.450	0.094
May		12	0.153	0.110	12	0.180	0.067
Jun.		15	0.593	0.130	15	0.612	0.060
Jul.		8	0.393	0.201	8	0.286	0.086
Aug.		2	1.000	0.007	2	1.000	0.000
Sep.		2	0.482	0.373	2	0.632	0.212
Oct.-Dec.		11	1.000	0.003	11	0.824	0.060
Jan.-Dec.	M+F	96	0.591	0.054	96	0.582	0.025

Hyp C (BYCATCH): Proportion of JE mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	3	1.000	0.006	3	0.848	0.107
Apr.		4	0.100	0.421	4	0.307	0.129
May		4	0.806	0.363	4	0.734	0.133
Jun.		7	0.165	0.291	7	0.453	0.098
Jul.		5	0.554	0.287	5	0.532	0.112
Aug.		3	0.492	0.550	3	0.242	0.125
Sep.		2	1.000	0.021	2	0.664	0.164
Oct.-Dec.		9	1.000	0.003	9	0.957	0.040
Jan.-Mar.	Females	3	1.000	0.005	3	0.999	0.000
Apr.		6	0.358	0.269	6	0.434	0.107
May		12	0.220	0.139	12	0.138	0.062
Jun.		15	0.778	0.144	15	0.597	0.062
Jul.		8	0.230	0.281	8	0.290	0.089
Aug.		2	1.000	0.008	2	0.867	0.127
Sep.		2	0.330	0.480	2	0.559	0.222
Oct.-Dec.		11	1.000	0.005	11	0.846	0.060
Jan.-Dec.	M+F	96	0.650	0.065	96	0.566	0.026

Hyp A & B (SP): Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		0			0		
Jun.		86	0.060	0.032	86	0.045	0.021
Jul.		23	0.198	0.094	23	0.287	0.051
Aug.		21	0.098	0.087	21	0.190	0.048
Sep.		185	0.114	0.027	185	0.178	0.017
Oct.-Dec.		78	0.168	0.048	78	0.182	0.026
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		0			0		
Jun.		13	0.100	0.109	13	0.101	0.062
Jul.		4	0.000	0.005	4	0.067	0.085
Aug.		1	0.000	0.010	1	0.612	0.222
Sep.		66	0.111	0.044	66	0.128	0.028
Oct.-Dec.		25	0.076	0.061	24	0.126	0.047
Jan.-Dec.	M+F	502	0.112	0.016	501	0.151	0.010

Hyp C (SP): Proportion of JE mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		0			0		
Jun.		86	0.000	0.001	86	0.000	0.000
Jul.		23	0.196	0.113	23	0.268	0.052
Aug.		21	0.075	0.071	21	0.189	0.051
Sep.		185	0.101	0.031	185	0.195	0.018
Oct.-Dec.		78	0.188	0.06	78	0.194	0.027
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		0			0		
Jun.		13	0.000	0.004	13	0.074	0.063
Jul.		4	0.000	0.005	4	0.005	0.125
Aug.		1	0.000	0.009	1	0.473	0.217
Sep.		66	0.096	0.05	66	0.172	0.028
Oct.-Dec.		25	0.104	0.087	24	0.116	0.048
Jan.-Dec.	M+F	502	0.092	0.018	501	0.152	0.010

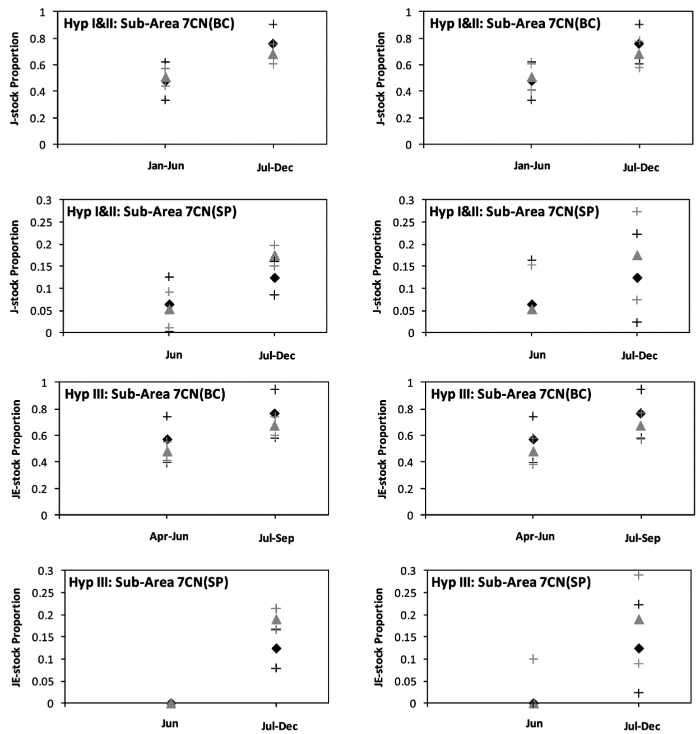
Pooling for input to conditioning:

Hyp A & B (BYCATCH): Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Jun.	M F	54	0.477	0.071	54	0.507	0.033
Jul.-Dec.	M F	42	0.758	0.074	42	0.680	0.036

Hyp C (BYCATCH): Proportion of JE mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.[1]	M F	6	1.000	0.004	6	0.905	0.070
Apr.-Jun.	M F	48	0.486[&]	0.095	48	0.426	0.037
Jan.-Jun.	M F	54	0.569	0.087	54	0.480	0.035
Jul.-Dec.	M F	42	0.764	0.091	42	0.670	0.036

Hyp C (SP): Proportion of JE mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jun.	M F	99	0.000	0.000	99	0.000	0.000
Jul.-Dec.	M F	403	0.119	0.022	403	0.190[&]	0.012

Plots of pooled mixing proportions for J/JE-stock mixing with O/OW-stock. RH plots are with a minimum 0.05 SE:



[1]This proportion corresponded to the original assumption of no OW-stock in 7CN in Jan-Mar. Trial C31 tests sensitivity to alternative mixing proportions corresponding to this assumption.

SUB-AREA 7CN >8.8nm (scientific permit data, 435 samples)
Pure OW defined in sub-area 7CN (>8.8NM) in June for Hypothesis C.
(This 'sub-' sub-area is not used in the trials.)

Hyp C (SP): Proportion of JE mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		0			0		
Jun.		86	***0.000***	0.001	86	***0.000***	0.000
Jul.		20	0.150	0.119	20	0.207	0.055
Aug.		20	0.069	0.067	20	0.109	0.054
Sep.		160	0.056	0.027	159	0.138	0.018
Oct.-Dec.		69	0.102	0.053	69	0.161	0.028
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		0			0		
Jun.		13	***0.000***	0.004	13	***0.074***	0.063
Jul.		2	0.000	0.007	2	0.000	0.000
Aug.		1	0.000	0.009	1	0.473	0.217
Sep.		47	0.091	0.058	47	0.189	0.032
Oct.-Dec.		17	0.030	0.115	16	0.108	0.055
Jan.-Dec.	M+F	435	0.054	0.016	433	0.118	0.011
Jun.	M+F	99	***0.000***	0.000	99	***0.000***	0.000

SUB-AREA 7WR (scientific permit data, 70 samples)
Pure O defined in sub-area 7WR in all months for Hypothesis A and B (for original, but not alternative O definition).
Mixing of OW and OE in sub-area 7WR in Apr.-Sep. for Hypothesis C, otherwise only OW-stock.

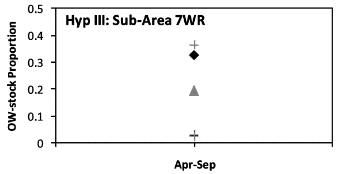
Hyp A & B: Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		39	***0.000***	0.001	39	0.001	0.000
Jun.		20	***0.000***	0.001	20	0.001	0.000
Jul.		2	***0.000***	0.007	2	0.001	0.000
Aug.		1	***0.000***	0.012	1	0.001	0.000
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		7	***0.120***	0.162	7	***0.000***	0.000
Jun.		0			0		
Jul.		1	***0.000***	0.010	1	0.139	0.172
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	70	***0.000***	0.001	70	***0.000***	0.000

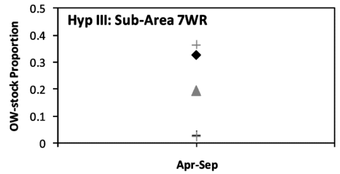
Hyp C: Proportion of OW mixed with OE		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		39	0.166	0.161	39	0.206	0.108
Jun.		20	0.618	0.300	20	0.056	0.166
Jul.		2	1.000	0.010	2	0.000	0.000
Aug.		1	1.000	0.058	1	0.937	1.139
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		7	0.970	0.571	7	0.526	0.300
Jun.		0			0		
Jul.		1	0.000	0.048	1	0.981	0.754
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	70	0.327	0.149	70	0.195	0.085

Pooling for input to conditioning:

Hyp C: Proportion of OW mixed with OE		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
May-Aug.	M F	70	0.327[&]	0.149	70	0.195	0.085

Plots of pooled mixing proportions for OW-stock mixing with OE-stock. RH plots are with a minimum 0.05 SE:





SUB-AREA 7E (scientific permit data, 48 samples)
Pure O defined in sub-area 7E in all months for Hypotheses A and B.
Mixing matrices assume no mixing in this sub-area - only O/OE in sub-area 7E in all months for all Hypotheses.

Hyp A & B: Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0					
Apr.		0					
May		32	***0.081***	0.062	32 with 31 in 5th	0.001	0.000
Jun.		9	***0.000***	0.001	9	***0.000***	0.000
Jul.		2	***0.000***	0.007	2	0.001	0.000
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		4	***0.000***	0.005	4	***0.085***	0.117
Jun.		1	***0.000***	0.009	1	***0.000***	0.000
Jul.		0			0		
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	48	***0.037***	0.042	48 with 47 in 5th	***0.001***	0.000

Hyp C: Proportion of OW mixed with OE		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		32	0.224	0.165	32	0.058	0.114
Jun.		9	0.149	0.293	9	0.300	0.206
Jul.		2	0.000	0.007	2	1.000	0.000
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		4	0.000	0.041	4	0.180	0.280
Jun.		1	0.000	0.013	1	0.001	0.000
Jul.		0			0		
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	48	0.149	0.131	48 with 47 in 5th	0.163	0.087

SUB-AREA 8 (scientific permit data, 48 samples)
Pure O/OE defined in sub-area 8 in all months for Hypotheses I, B and C.

Hyp A & B: Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		30	***0.000***	0.001	31	0.001	0.000
Jun.		88	***0.000***	0.000	88	***0.000***	0.000
Jul.		74	***0.000***	0.001	74	***0.033***	0.023
Aug.		12	***0.000***	0.001	12	***0.008***	0.041
Sep.		1	***0.000***	0.009	1	0.001	0.000
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		7	***0.000***	0.002	7	***0.045***	0.067
Jun.		6	***0.000***	0.004	6	***0.063***	0.106
Jul.		5	***0.000***	0.004	5	0.001	0.000
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	223	***0.000***	0.000	224	***0.010***	0.012

Hyp C: Proportion of OW mixed with OE		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		30	***0.000***	0.004	31	***0.201***	0.142
Jun.		88	***0.000***	0.002	88	***0.000***	0.000
Jul.		74	***0.000***	0.004	74	***0.004***	0.082
Aug.		12	***0.000***	0.017	12	***0.000***	0.000
Sep.		1	0.990	0.713	1	0.284	0.751
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		7	***0.392***	0.858	7	**0.134**	0.312
Jun.		6	***0.282***	0.404	6	**0.008**	0.177
Jul.		5	***0.130***	1.391	5	0.001	0.000
Aug.		0			0		
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	223	***0.000***	0.002	224	**0.001**	0.000

SUB-AREA 9 (scientific permit data, 467 samples)
Pure OE defined in sub-area 9 in all months (Apr-Sep) for Hypothesis C.
Mixing matrices allow for only O/OE in sub-area 9 in Apr-Sep for all Hypotheses.
Mixing matrices allow for mixing with C-stock in sensitivity tests to Hypotheses A and C.

Hyp A & B: Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		28	0.000	0.001	28	0.026	0.031
Jun.		75	0.000	0.000	75	0.034	0.020
Jul.		142	0.000	0.000	142	0.041	0.019
Aug.		168	0.005	0.009	167	0.020	0.015
Sep.		10	0.000	0.003	10 with 9 in 3rd, 5th 9th -16th	0.001	0.000
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		9	0.063	0.112	9	0.018	0.054
Jun.		8	0.000	0.001	8	0.187	0.097
Jul.		12	0.000	0.001	12	0.026	0.047
Aug.		15	0.000	0.001	15	0.103	0.057
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	467	0.000	0.000	466 with 465 in 1st, 3-5th, 9th -14th, 16th and 464 in 14th	0.032	0.009

Hyp C: Proportion of OW mixed with OE		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		28	***0.000***	0.004	28	0.001	0.000
Jun.		75	***0.000***	0.004	75	***0.045***	0.076
Jul.		142	***0.045***	0.076	142	***0.056***	0.060
Aug.		168	***0.065***	0.089	167	***0.046***	0.058
Sep.		10	***0.000***	0.007	10 with 9 in 3rd, 5th 9th -16th	***0.106***	0.220
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		9	***0.078***	0.280	9	***0.000***	0.000
Jun.		8	***0.020***	0.650	8	***0.000***	0.000
Jul.		12	***0.000***	0.028	12	***0.023***	0.158
Aug.		15	***0.000***	0.003	15	***0.282***	0.178
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	467	***0.001***	0.020	466 with 465 in 1st, 3-5th, 9th -14th, 16th and 464 in 14th	***0.035***	0.033

SUB-AREA 11 (bycatch data, 15 samples, Japanese commercial whaling data, 173 samples, scientific permit data, 80 samples)

No pure stocks defined in sub-area 11.
Mixing matrices allow for mixing between J and O stocks from Apr.-Sep. in Hypotheses A and B.
Mixing matrices allow for mixing between JW, OW and OE stocks from Apr.-Sep. in Hypothesis C.

Hyp A & B: Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		2	1.000	0.007	0		
May		14	0.070	0.069	0		
Jun.		9	0.000	0.001	0		
Jul.		30	0.171	0.072	28	0.228	0.045
Aug.		22	0.359	0.111	19	0.461	0.058
Sep.		5	0.168	0.186	1	0.796	0.205
Oct.-Dec.		6	1.000	0.005	6	0.999	0.000
Jan.-Mar.	Females	0			0		
Apr.		55	0.645	0.069	0		
May		51	0.013	0.036	0		
Jun.		25	0.258	0.093	1	0.906	0.240
Jul.		24	0.401	0.105	22	0.458	0.050
Aug.		16	0.010	0.065	11	0.206	0.067
Sep.		2	0.000	0.007	0		
Oct.-Dec.		7	1.000	0.002	7	0.960	0.036
Jan.-Dec.	M+F	268	0.304	0.030	95	0.448	0.025

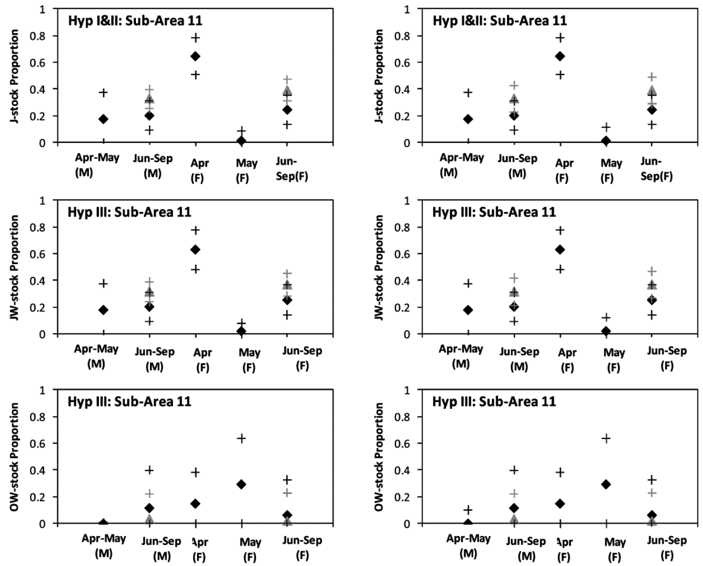
Hyp C: Proportion of JW and OW mixed with OE		Sample size	Prop JW	SE	Prop OW	SE	Sample size	Prop JW	SE	Prop OW	SE
			Haplotypes					Loci			
Jan.-Mar.	Males	0					0				
Apr.		2	1.000	0.005	0.000	0.001	0				
May		14	0.070	0.069	0.000	0.001	0				
Jun.		9	0.000	0.000	0.000	0.013	0				
Jul.		30	0.176	0.073	0.000	0.003	28	0.215	0.045	0.026	0.119
Aug.		22	0.346	0.114	0.186	0.196	19	0.457	0.060	0.049	0.171
Sep.		5	0.195	0.180	0.364	0.778	1	0.801	0.213	0.000	0.002
Oct.-Dec.		6	1.000	0.002	0.000	0.001	6	1.000	0.001	0.000	0.000
Jan.-Mar.	Females	0					0				
Apr.		55	0.628	0.073	0.147	0.117	0				
May		51	0.023	0.028	0.290	0.173	0				
Jun.		25	0.270	0.092	0.062	0.227	1	0.824	0.235	0.000	0.004
Jul.		24	0.409	0.104	0.000	0.002	22	0.444	0.052	0.000	0.002
Aug.		16	0.000	0.006	0.330	0.269	11	0.175	0.065	0.157	0.209
Sep.		2	0.000	0.001	1.000	0.020	0				
Oct.-Dec.		7	1.000	0.001	0.000	0.001	7	0.959	0.037	0.000	0.001
Jan.-Dec.	M+F	268	0.299	0.031	0.145	0.068	95	0.435	0.026	0.000	0.001

Pooling for input to conditioning:

Hyp A & B: Proportion of J mixed with O		Sample size	Proportion Haplotypes	SE	Sample size	Proportion Loci	SE
Apr.-May	M	16	0.175	0.099	0		
Jun.-Sep.	M	66	0.201	0.054	48	0.327	0.036
Apr.	F	55	0.645	0.069	0		
May	F	51	0.013	0.036	0		
Jun.-Sep.	F	67	0.245	0.056	34	0.390	0.041

Hyp C: Proportion of JW and OW mixed with OE		Sample size	Prop JW	SE	Prop OW	SE	Sample size	Prop JW	SE	Prop OW	SE
			Haplotypes					Loci			
Apr.-May	M	16	0.180	0.099	0.000	0.003	0				
Jun.-Sep.	M	66	0.204	0.054	0.114	0.142	48	0.316[&]	0.037	0.032[&]	0.095
Apr.	F	55	0.628	0.073	0.147[&]	0.117	0				
May	F	51	0.023	0.028	0.290[&]	0.173	0				
Jun.-Sep.	F	67	0.254	0.056	0.062[&]	0.132	34	0.367[&]	0.041	0.018[&]	0.106

Plots of pooled mixing proportions for JW-stock (1st) and OW-stock (2nd) mixing with OE-stock.
RH plots are with a minimum 0.05 SE:



ADDITIONAL MIXING PROPORTIONS REQUIRED FOR SENSITIVITY TESTS TO HYPOTHESIS C, ASSUMING EITHER A SINGLE J-STOCK OR A SINGLE O-STOCK

SUB-AREA 2C (bycatch data only, 180 samples)

Pure JE defined in sub-area 2C in Jul.-Dec. for Hypothesis C.
Hyp C – mixing matrices assume mixing between JE and OW-stock from Jan.-Jun.
Hyp C (single J-stock) – mixing matrices assume mixing between J and OW-stock from Jan.-Jun., only J-stock present from Jul.-Dec.
Hyp C (single O-stock) – mixing matrices assume mixing between JE and O-stock from Jan.-Jun., only JE-stock present from Jul.-Dec.

Hyp C (single J-stock): Proportion J mixing with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.		22	0.809	0.097	22	0.768	0.044
Apr.		5	0.432	0.235	5	0.299	0.124
May		5	0.469	0.287	5	0.564	0.100
Jun.		1	1.000	0.009	1	0.999	0.000
Jul.		3	***1.000***	0.005	3	1.000	0.000
Aug.		2	***1.000***	0.007	2	1.000	0.000
Sep.		0			0		
Oct.-Dec.		27	***0.852***	0.074	27	***0.851***	0.038
Jan.-Mar.	Males	46	0.905	0.050	46 with 45 in 1st, 3rd, 4th,7th ,13th,14th	0.929	0.026
Apr.		3	1.000	0.006	3	0.999	0.000
May		10	0.707	0.151	10	0.685	0.078
Jun.		5	0.618	0.281	5	0.756	0.094
Jul.	Females	10	***1.000***	0.001	10	0.999	0.000
Aug.		3	***0.633***	0.313	3	***0.791***	0.124
Sep.		0			0		
Oct.-Dec.		38	***0.939***	0.042	38	***0.949***	0.020
Jan.-Dec.	M+F	180	0.864	0.029	180 with 179 in 1st, 3rd, 4th,7th , 13th,14th	0.865	0.014

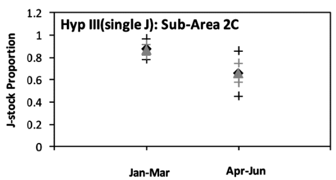
Hyp C (single O-stock): Proportion JE mixing with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.		22	0.824	0.096	22	0.751	0.046
Apr.		5	0.425	0.239	5	0.352	0.125
May		5	0.461	0.258	5	0.510	0.107
Jun.		1	1.000	0.009	1	0.821	0.164
Jul.		3	***1.000***	0.005	3	0.999	0.000
Aug.		2	***1.000***	0.007	2	1.000	0.000
Sep.		0					
Oct.-Dec.		27	***1.000***	0.001	27	***0.997***	0.038
Jan.-Mar.	Males	46	0.966	0.038	46 with 45 in 1st, 3rd, 4th,7th,13th,14th	0.874	0.026
Apr.		3	1.000	0.005	3	0.923	0.076
May		10	0.701	0.15	10	0.732	0.081
Jun.		5	1.000	0.008	5	0.739	0.094
Jul.	Females	10	***1.000***	0.001	10	0.999	0.000
Aug.		3	***0.850***	0.38	3	**0.897**	0.136
Sep.		0			0		
Oct.-Dec.		38	***1.000***	0.001	38	0.999	0.000
Jan.-Dec.	M+F	180	0.922	0.025	180 with 179 in 1st, 3rd, 4th,7th, 13th,14th	0.885	0.014

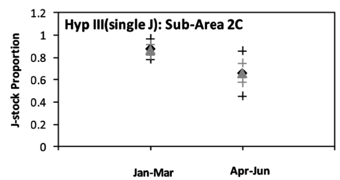
Pooling for input to conditioning:

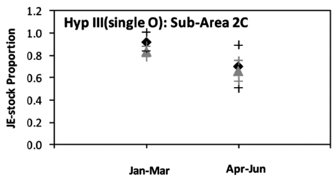
Hyp C (single J-stock): Proportion J mixing with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	M F	68	0.875	0.046	67,68,67,67,68,68,67,68, 68,68,68,68,67,67,68,68	0.868	0.023
Apr.-Jun.	M F	29	0.656	0.102	29	0.661	0.044

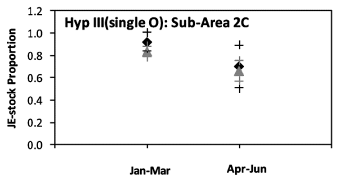
Hyp C (single O-stock): Proportion JE mixing with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	M F	68	0.920	0.042	67,68,67,67,68,68,67,68, 68,68,68,68,67,67,68,68	0.834	0.0 24
Apr.-Jun.	M F	29	0.699	0.097	29	0.662	0.0 45

Plots of pooled mixing proportions for J/JE-stock with O/OW-stock. RH plots are with a minimum 0.05 SE:









SUB-AREA 7CS (bycatch data, 116 samples; scientific permit data, 321 samples; used separately)

Not used for definition of a pure stock.

Mixing matrices assume mixing between J/JE and O/OW year-round for all hypotheses.

Hyp C (single J-stock) (BYCATCH): Proportion of J mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	7	0.863	0.154	7	1.000	0.000
Apr.		9	0.119	0.112	9	0.288	0.080
May		15	0.173	0.113	15	0.248	0.063
Jun.		5	0.065	0.209	5	0.293	0.107
Jul.		2	0.485	0.365	2	0.512	0.155
Aug.		2	1.000	0.074	2	0.999	0.000
Sep.		1	1.000	0.010	1	1.000	0.000
Oct.-Dec.		14	0.914	0.125	14	0.810	0.055
Jan.-Mar.	Females	10	0.466	0.180	10	0.457	0.079
Apr.		10	0.307	0.166	10	0.233	0.078
May		9	0.000	0.008	9	0.058	0.073
Jun.		13	0.379	0.152	13	0.431	0.070
Jul.		4	0.695	0.262	4	0.661	0.106
Aug.		2	0.585	0.535	2	0.483	0.175
Sep.		1	0.000	0.009	1	0.112	0.217
Oct.-Dec.		12	1.000	0.003	12	0.904	0.050
Jan.-Dec.	M+F	116	0.461	0.053	116	0.499	0.023

Hyp C (single O-stock) (BYCATCH): Proportion of JE mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	7	1.000	0.005	7	0.880	0.061
Apr.		9	0.094	0.117	9	0.265	0.081
May		15	0.152	0.113	15	0.227	0.064
Jun.		5	0.128	0.208	5	0.255	0.106
Jul.		2	0.338	0.469	2	0.487	0.152
Aug.		2	1.000	0.007	2	0.999	0.000
Sep.		1	1.000	0.009	1	0.733	0.174
Oct.-Dec.		14	0.777	0.116	14	0.815	0.058
Jan.-Mar.	Females	10	0.553	0.178	10	0.441	0.079
Apr.		10	0.420	0.182	10	0.195	0.081
May		9	0.127	0.120	9	0.050	0.074
Jun.		13	0.403	0.159	13	0.439	0.071
Jul.		4	0.834	0.259	4	0.666	0.111
Aug.		2	0.504	0.356	2	0.536	0.182
Sep.		1	0.000	0.009	1	0.008	0.259
Oct.-Dec.		12	0.923	0.084	12	0.851	0.051
Jan.-Dec.	M+F	116	0.500	0.052	116	0.489	0.023

Hyp C (single J-stock) (SP): Proportion of J mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		44	0.214	0.072	44	0.288	0.037
May		85	0.146	0.044	85	0.284	0.027
Jun.		40	0.000	0.001	40	0.045	0.035
Jul.		0			0		
Aug.		3	0.335	0.411	3	0.348	0.153
Sep.		1	0.000	0.024	1	0.000	0.000
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		66	0.057	0.033	66	0.136	0.028
May		72	0.181	0.053	72	0.185	0.028
Jun.		9	0.121	0.116	9	0.165	0.066
Jul.		0			0		
Aug.		1	0.000	0.013	1	0.229	0.232
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	321	0.120	0.021	321	0.199	0.013

Hyp C (single O-stock) (SP): Proportion of JE mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		44	0.279	0.083	44	0.293	0.037
May		85	0.236	0.056	85	0.247	0.027
Jun.		40	0.000	0.001	40	0.018	0.032
Jul.		0			0		
Aug.		3	0.269	0.305	3	0.332	0.161
Sep.		1	0.000	0.009	1	0.001	0.000
Oct.-Dec.		0			0		
Jan.-Mar.	Females	0			0		
Apr.		66	0.065	0.038	66	0.098	0.028
May		72	0.224	0.056	72	0.189	0.028
Jun.		9	0.117	0.112	9	0.163	0.069
Jul.		0			0		
Aug.		1	0.000	0.011	1	0.066	0.211
Sep.		0			0		
Oct.-Dec.		0			0		
Jan.-Dec.	M+F	321	0.164	0.025	321	0.181	0.013

Pooling for input to conditioning:

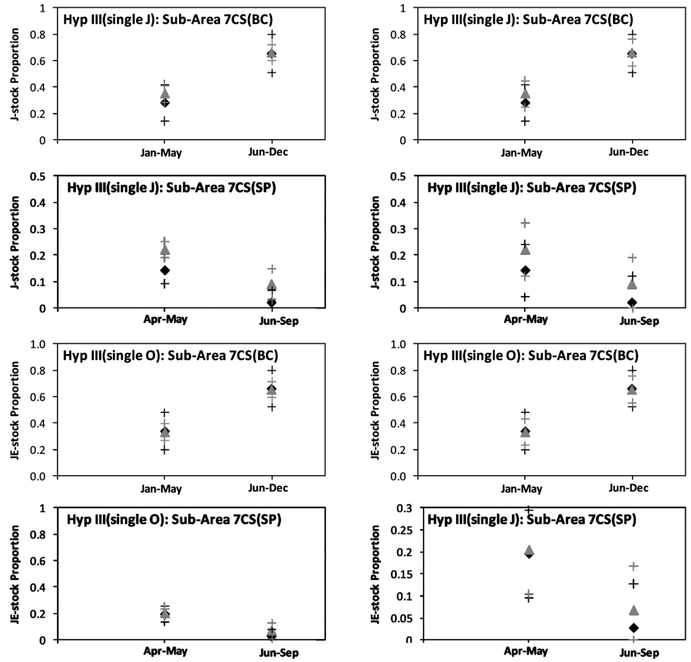
Hyp C (single J-stock) (BC): Proportion of J mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-May	M F	60	0.280	0.069	60	0.348	0.032
Jun.-Dec.	M F	56	0.652	0.073	56	0.661	0.031

Hyp C (single O-stock) (BC): Proportion of JE mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-May	M F	60	0.338	0.070	60	0.331	0.032
Jun.-Dec.	M F	56	0.660	0.070	56	0.654	0.031

Hyp C (single J-stock) (SP): Proportion of J mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Apr.-May	M F	267	0.142	0.025	267	0.221	0.015
Jun.-Sep.	M F	54	0.021	0.023	54	0.090	0.029

Hyp C (single O-stock) (SP): Proportion of JE mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Apr.-May	M F	267	0.195	0.029	267	0.204	0.015
Jun.-Sep.	M F	54	0.027	0.027	54	0.067	0.029

Plots of pooled mixing proportions for J/JE-stock mixing with O/OW-stock. RH plots are with a minimum 0.05 SE:



SUB-AREA 7CN (bycatch data, 96 samples; scientific permit data (>2nm), 502 samples; used separately)
Not used for definition of a pure stock.
Hyp C – mixing between JE and OW Apr.-Dec.
Hyp C (single J-stock) – mixing between J and OW Apr.-Dec
Hyp C (single O-stock) – mixing between JE and O Apr.-Dec.

Hyp C (single J-stock) (BYCATCH): Proportion of J mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	3	1.000	0.005	3	1.000	0.000
Apr.		4	0.439	0.340	4	0.336	0.124
May		4	0.709	0.269	4	0.730	0.134
Jun.		7	0.180	0.208	7	0.488	0.099
Jul.		5	0.551	0.263	5	0.565	0.113
Aug.		3	0.224	0.321	3	0.239	0.121
Sep.		2	0.586	0.534	2	0.637	0.180
Oct.-Dec.		9	1.000	0.001	9	0.978	0.027
Jan.-Mar.	Females	3	1.000	0.005	3	1.000	0.000
Apr.		6	0.283	0.216	6	0.397	0.099
May		12	0.175	0.114	12	0.161	0.064
Jun.		15	0.634	0.136	15	0.627	0.061
Jul.		8	0.260	0.216	8	0.304	0.088
Aug.		2	1.000	0.008	2	0.999	0.000
Sep.		2	0.417	0.414	2	0.681	0.201
Oct.-Dec.		11	1.000	0.004	11	0.849	0.060
Jan.-Dec.	M+F	96	0.570	0.058	96	0.583	0.025

Hyp C (single O-stock) (BYCATCH): Proportion of JE mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	3	1.000	0.005	3	0.841	0.110
Apr.		4	0.499	0.279	4	0.305	0.129
May		4	0.958	0.310	4	0.759	0.126
Jun.		7	0.402	0.243	7	0.481	0.094
Jul.		5	0.608	0.244	5	0.520	0.116
Aug.		3	0.421	0.427	3	0.258	0.135
Sep.		2	1.000	0.007	2	0.633	0.156
Oct.-Dec.		9	1.000	0.001	9	0.956	0.037
Jan.-Mar.	Females	3	1.000	0.005	3	0.999	0.000
Apr.		6	0.315	0.224	6	0.496	0.103
May		12	0.166	0.116	12	0.162	0.067
Jun.		15	0.657	0.141	15	0.593	0.061
Jul.		8	0.475	0.220	8	0.278	0.086
Aug.		2	1.000	0.007	2	0.838	0.129
Sep.		2	0.449	0.391	2	0.458	0.219
Oct.-Dec.		11	1.000	0.004	11	0.821	0.062
Jan.-Dec.	M+F	96	0.646	0.057	96	0.568	0.025

Hyp C (single J-stock) (SP): Proportion of J mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		0			0		
Jun.		86	0.000	0.001	86	0.000	0.000
Jul.		23	0.134	0.085	23	0.295	0.052
Aug.		21	0.072	0.067	21	0.181	0.049
Sep.		185	0.093	0.026	185	0.191	0.017
Oct.-Dec.		78	0.140	0.045	78	0.188	0.027
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		0			0		
Jun.		13	0.000	0.007	13	0.091	0.063
Jul.		4	0.000	0.005	4	0.006	0.110
Aug.		1	0.000	0.01	1	0.649	0.207
Sep.		66	0.075	0.041	66	0.156	0.027
Oct.-Dec.		25	0.059	0.055	24	0.122	0.049
Jan.-Dec.	M+F	502	0.080	0.015	501	0.150	0.010

Hyp C (single O-stock) (SP): Proportion of JE mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		0			0		
May		0			0		
Jun.		86	0.079	0.041	86	0.044	0.022
Jul.		23	0.274	0.113	23	0.258	0.051
Aug.		21	0.127	0.106	21	0.195	0.050
Sep.		185	0.109	0.029	185	0.177	0.018
Oct.-Dec.		78	0.232	0.059	78	0.180	0.027
Jan.-Mar.	Females	0			0		
Apr.		0			0		
May		0			0		
Jun.		13	0.095	0.14	13	0.082	0.062
Jul.		4	0.000	0.005	4	0.066	0.093
Aug.		1	0.000	0.009	1	0.448	0.228
Sep.		66	0.122	0.049	66	0.134	0.029
Oct.-Dec.		25	0.108	0.076	24	0.113	0.044
Jan.-Dec.	M+F	502	0.131	0.019	501	0.148	0.010

Pooling for input to conditioning:

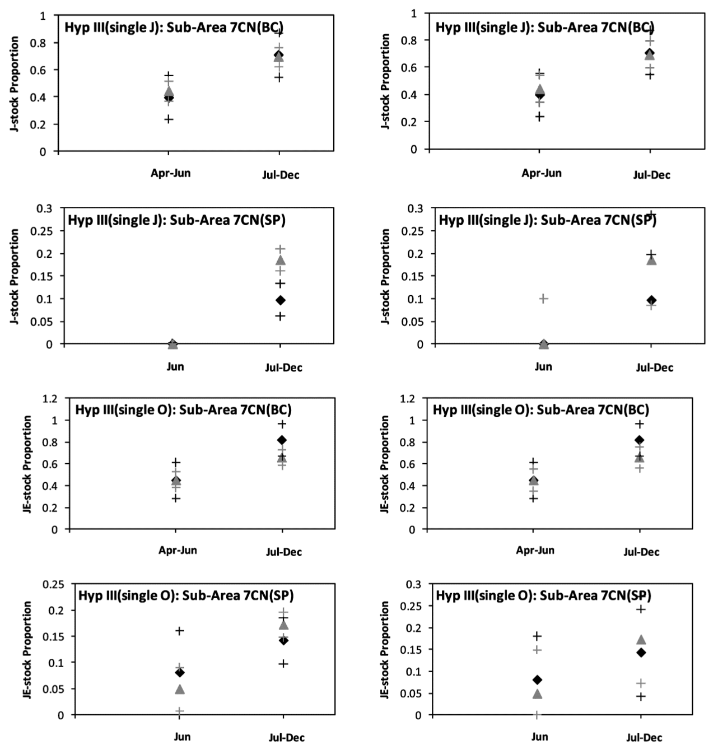
Hyp C (single J-stock) (BYCATCH): Proportion of J mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Apr.-Jun.	M F	48	0.396	0.080	48	0.441	0.037
Jul.-Dec.	M F	42	0.707	0.082	42	0.693	0.036

Hyp C (single O-stock) (BYCATCH): Proportion of JE mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Apr.-Jun.	M F	48	0.447	0.082	48	0.450	0.036
Jul.-Dec.	M F	42	0.817	0.073	42	0.658	0.037

Hyp C (single J-stock) (SP): Proportion of J mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jun.	M F	99	0.000	0.001	99	0.000	0.000
Jul.-Dec.	M F	403	0.097	0.018	402	0.185	0.012

Hyp C (single O-stock) (SP): Proportion of JE mixed with O		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jun.	M F	99	0.080	0.040	99	0.049	0.021
Jul.-Dec.	M F	403	0.142	0.022	402	0.172	0.012

Plots of pooled mixing proportions for J/JE-stock mixing with O/OW-stock. RH plots are with a minimum 0.05 SE:



SUB-AREA 11 (bycatch data, 15 samples, Japanese commercial whaling data, 173 samples, scientific permit data, 80 samples)
No pure stocks defined in sub-area 11.
Mixing matrices allow for mixing between J and O stocks from Apr.-Sep. in Hypotheses A and B.
Hyp C: Mixing matrices allow for mixing between JW, OW and OE stocks from Apr.-Sep.
Hyp C (single J-stock): Mixing matrices allow for mixing between J, OW and OE stocks from Apr.-Sep.
Hyp C (single O-stock): Mixing matrices allow for mixing between JW and O-stocks from Apr.-Sep.

Hyp C (single J-stock): Proportion of J and OW mixed with OE		Sample size	Prop JW	SE	Prop OW	SE	Sample size	Prop JW	SE	Prop OW	SE
				Haplotypes					Loci		
Jan.-Mar.	Males	0					0				
Apr.		2	1.000	0.005	0.000	0.001	0				
May		14	0.070	0.069	0.000	0.001	0				
Jun.		9	0.000	0.000	0.000	0.013	0				
Jul.		30	0.176	0.073	0.000	0.003	28	0.215	0.045	0.026	0.119
Aug.		22	0.346	0.114	0.186	0.196	19	0.457	0.060	0.049	0.171
Sep.		5	0.195	0.180	0.364	0.778	1	0.801	0.213	0.000	0.002
Oct.-Dec.		6	1.000	0.002	0.000	0.001	6	1.000	0.001	0.000	0.000
Jan.-Mar.	Females	0					0				
Apr.		55	0.628	0.073	0.147	0.117	0				
May		51	0.023	0.028	0.290	0.173	0				
Jun.		25	0.270	0.092	0.062	0.227	1	0.824	0.235	0.000	0.004
Jul.		24	0.409	0.104	0.000	0.002	22	0.444	0.052	0.000	0.002
Aug.		16	0.000	0.006	0.330	0.269	11	0.175	0.065	0.157	0.209
Sep.		2	0.000	0.001	1.000	0.020	0				
Oct.-Dec.		7	1.000	0.001	0.000	0.001	7	0.959	0.037	0.000	0.001
Jan.-Dec.	M+F	268	0.299	0.031	0.145	0.068	95	0.435	0.026	0.000	0.001

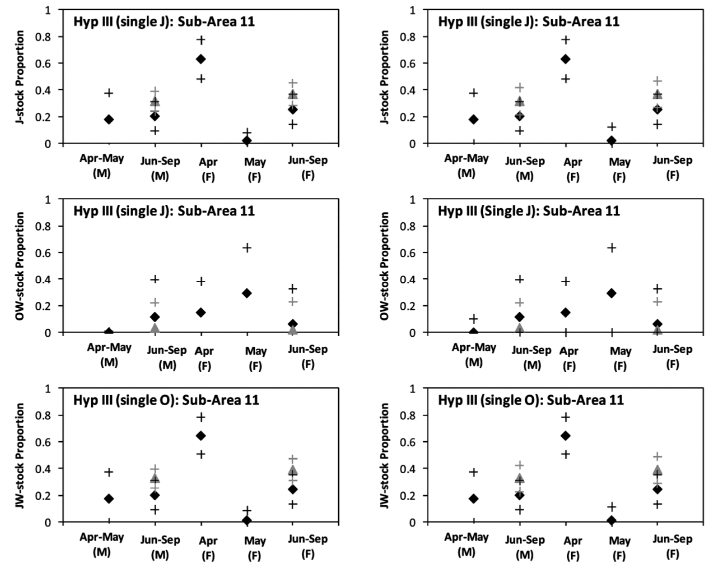
Hyp C (single O-stock): Proportion of JW mixed with O		Sample size	Proportion	SE	Sample size (x16)	Proportion	SE
			Haplotypes			Loci	
Jan.-Mar.	Males	0			0		
Apr.		2	1.000	0.007	0		
May		14	0.070	0.069	0		
Jun.		9	0.000	0.001	0		
Jul.		30	0.171	0.072	28	0.228	0.045
Aug.		22	0.359	0.111	19	0.461	0.058
Sep.		5	0.168	0.186	1	0.796	0.205
Oct.-Dec.		6	1.000	0.005	6	0.999	0.000
Jan.-Mar.	Females	0			0		
Apr.		55	0.645	0.069	0		
May		51	0.013	0.036	0		
Jun.		25	0.258	0.093	1	0.906	0.240
Jul.		24	0.401	0.105	22	0.458	0.050
Aug.		16	0.010	0.065	11	0.206	0.067
Sep.		2	0.000	0.007	0		
Oct.-Dec.		7	1.000	0.002	7	0.960	0.036
Jan.-Dec.	M+F	268	0.304	0.030	95	0.448	0.025

Pooling for input to conditioning:

Hyp C (single J-stock): Proportion of J and OW mixed with OE		Sample size	Prop J	SE	Prop OW	SE	Sample size	Prop J	SE	Prop OW	SE
				Haplotypes					Loci		
Apr.-May	M	16	0.180	0.099	0.000	0.003	0				
Jun.-Sep.	M	66	0.204	0.054	0.114	0.142	48	0.316	0.037	0.032	0.095
Apr.	F	55	0.628	0.073	0.147	0.117	0				
May	F	51	0.023	0.028	0.290	0.173	0				
Jun.-Sep.	F	67	0.254	0.056	0.062	0.132	34	0.367	0.041	0.018	0.106

Hyp C (single O-stock): Proportion of JW mixed with O		Sample size	Proportion	SE	Sample size (x16)	Proportion	SE
			Haplotypes			Loci	
Apr.-May	M	16	0.175	0.099	0		
Jun.-Sep.	M	66	0.201	0.054	48	0.327	0.036
Apr.	F	55	0.645	0.069	0		
May	F	51	0.013	0.036	0		
Jun.-Sep.	F	67	0.245	0.056	34	0.39	0.041

Plots of pooled mixing proportions for JW-stock (1st) and OW-stock (2nd) mixing with OE-stock.
RH plots are with a minimum 0.05 SE:



ADDITIONAL MIXING PROPORTIONS REQUIRED FOR SENSITIVITY TESTS TO HYPOTHESIS C, ASSUMING EITHER NO OW-STOCK OR NO OE-STOCK IN SUB-AREA 11

SUB-AREA 11 (bycatch data, 15 samples, Japanese commercial whaling data, 173 samples, scientific permit data, 80 samples)
No pure stocks defined in sub-area 11.
Mixing matrices allow for mixing between J and O stocks from Apr.-Sep. in Hypotheses A and B.
Hyp C: Mixing matrices allow for mixing between JW, OW and OE stocks from Apr.-Sep.
Hyp C (No 'OW' in 11 or 12SW): Mixing matrices allow for mixing between JW and OE stocks from Apr.-Sep.
Hyp C (No 'OE' in 11 or 12SW): Mixing matrices allow for mixing between JW and OW stocks from Apr.-Sep.

Hyp C (no OW-stock): Proportion of JW mixed with OE		Sample size	Proportion	SE	Sample size (x16)	Proportion	SE
			Haplotypes			Loci	
Jan.-Mar.	Males	0			0		
Apr.		2	1.000	0.007	0		
May		14	0.070	0.069	0		
Jun.		9	0.000	0.001	0		
Jul.		30	0.176	0.073	28	0.216	0.045
Aug.		22	0.374	0.110	19	0.459	0.059
Sep.		5	0.191	0.181	1	0.801	0.213
Oct.-Dec.		6	1.000	0.005	6	0.999	0.000
Jan.-Mar.	Females	0			0		
Apr.		55	0.654	0.068	0		
May		51	0.032	0.033	0		
Jun.		25	0.271	0.091	1	0.824	0.235
Jul.		24	0.409	0.104	22	0.444	0.052
Aug.		16	0.033	0.062	11	0.179	0.065
Sep.		2	0.000	0.007	0		
Oct.-Dec.		7	1.000	0.002	7	0.959	0.037
Jan.-Dec.	M+F	268	0.312	0.030	95	0.435	0.026

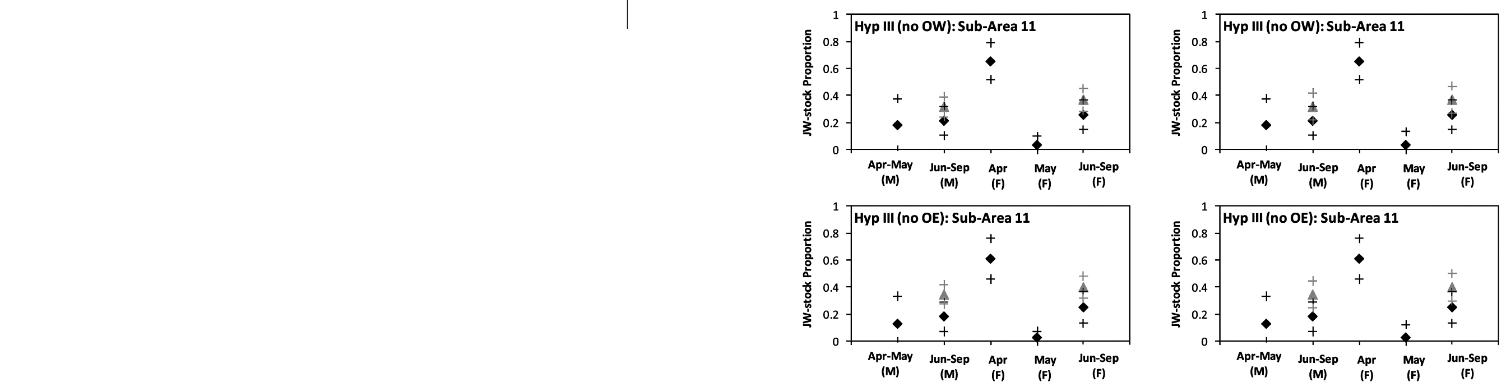
Hyp C (no OE-stock): Proportion of JW mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Jan.-Mar.	Males	0			0		
Apr.		2	1.000	0.007	0		
May		14	0.067	0.072	0		
Jun.		9	0.000	0.001	0		
Jul.		30	0.167	0.075	28	0.251	0.045
Aug.		22	0.307	0.115	19	0.474	0.058
Sep.		5	0.200	0.179	1	0.824	0.220
Oct.-Dec.		6	1.000	0.005	6	0.999	0.000
Jan.-Mar.	Females	0			0		
Apr.		55	0.610	0.075	0		
May		51	0.024	0.024	0		
Jun.		25	0.268	0.095	1	0.839	0.257
Jul.		24	0.419	0.115	22	0.480	0.051
Aug.		16	0.000	0.003	11	0.203	0.067
Sep.		2	0.000	0.007	0		
Oct.-Dec.		7	1.000	0.002	7	0.965	0.033
Jan.-Dec.	M+F	268	0.272	0.031	95	0.464	0.025

Pooling for input to conditioning:

Hyp C (no OW-stock): Proportion of JW mixed with OE		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Apr.-May	M	16	0.126	0.103	0		
Jun.-Sep.	M	66	0.181	0.054	48	0.346	0.036
Apr.	F	55	0.610	0.075	0		
May	F	51	0.024	0.024	0		
Jun.-Sep.	F	67	0.249	0.058	34	0.399	0.041

Hyp C (no OE-stock): Proportion of JW mixed with OW		Sample size	Proportion Haplotypes	SE	Sample size (x16)	Proportion Loci	SE
Apr.-May	M	16	0.180	0.099	0		
Jun.-Sep.	M	66	0.212	0.054	48	0.317	0.037
Apr.	F	55	0.654	0.068	0		
May	F	51	0.032	0.033	0		
Jun.-Sep.	F	67	0.256	0.055	34	0.368	0.041

Plots of pooled mixing proportions for JW-stock (1st) mixing with OW/OE-stock. RH plots are with a minimum 0.05 SE:



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De Moor, C.L. 2011. Calculation of stock mixing proportions, including correction for 'missing alleles': unpooled results. Paper SC/D11/NPM4 presented to the First Intersessional Workshop for the *Implementation Review* of western North Pacific common minke whales, 12-16 December 2011, Tokyo, Japan (unpublished). [Paper available from the Office of this Journal].

International Whaling Commission. 2013. Report of the Second 'First Intersessional Workshop' for the *Implementation Review* of Western North Pacific Common Minke Whales. *J. Cetacean Res. Manage. (Suppl.)* 14:357-70.

Appendix 3

SUMMARY OF ABUNDANCE ESTIMATES OF THE NORTH PACIFIC COMMON MINKE WHALES IN RMP/*IST*

Tomio Miyashita and Takahashi Hakamada

To correspond to the request from the Second Intersessional Workshop for the North Pacific common minke whale RMP/*IST* review in March 2013, we presented the figures showing primary effort, primary position, survey block, sub-area and area definition for abundance estimation. We also present the table including area size, research distance and number of primary sightings, effective search and references.

Table 1

Summary of abundance estimates of the western North Pacific common minke whales in RMP/*IST*s.

Sub-area	Year	Aerial coverage (%)	Timing	Area size (n.miles^2)	effort (n.mile)	*n*	Encounter rate (/100 n.miles)	ESW (n.miles)	Mean school size	*P*	CV(P)	Fig.	Reference
6E	2002	79.1	May-Jun.	71,914	2,605	21	0.806	0.361	1.11	891	0.608	10	Miyashita *et al.* (2009)
	2003	79.1	May-Jun.	71,914	2,483	19	0.846	0.361	1.11	935	0.357	11	Miyashita *et al.* (2009)
	2004	79.1	May-Jun.	71,914	1,064	7	0.658	0.361	1.11	727	0.372	12	Miyashita *et al.* (2009)
7CS	2004	36.7	May	9,853	129	7	5.435	0.606	1.14	504	0.291	3	Agreed at 2013 Workshop, IWC (2014)
	2006	100.0	Jun.- Jul.	26,826	264	23	8.718	0.431	1.36	3,690	1.199	5	Hakamada and Kitakado (2010rev)
	2012	100.0	May-Jun.	26,826	851	16	1.880	0.349	1.23	890	0.393	7	Hakamada *et al.* (2013rev)
7CN	2003	75.4	May	18,281	247	3	1.214	0.604	1.00	184	0.805	2	Hakamada and Kitakado (2010rev)
	2012	66.7	May-Jun.	16,171	649	17	2.619	0.863	1.23	302	0.454	7	Hakamada *et al.* (2013rev)
	2012	66.7	Sep.	16,171	550	19	3.453	0.863	1.23	398	0.507	7	Hakamada *et al.* (2013rev)
7WR	2003	26.7	May-Jun.	21,939	668	7	1.048	0.431	1.00	267	0.700	2	Agreed at 2013 Workshop, IWC (2014)
	2004	88.8	May-Jun.	72,991	789	7	0.887	0.484	1.29	863	0.648	3	Hakamada and Kitakado (2010rev)
	2007	88.8	Jun.-Jul.	72,991	465	3	0.645	0.431	1.00	546	0.953	6	Hakamada and Kitakado (2010rev)
7E	2004	57.1	May-Jun.	48,208	390	3	0.770	0.422	1.00	440	0.779	3	Hakamada and Kitakado (2010rev)
	2006	57.1	May-Jun.	48,208	461	2	0.433	0.422	1.00	247	0.892	5	Hakamada and Kitakado (2010rev)
	2007	57.1	Jun.-Jul.	48,208	-	0	0.000	-	-	0	-	6	Hakamada and Kitakado (2010rev)
8	1990	62.2	Aug.-Sep.	-	-	-	-	-	-	1,057	0.706	8,9	IWC (1997, p.203; p.211)
	2002	65.0	Jun.-Jul.	162,689	1,184	0	0.000	-	-	0	-	1	Hakamada and Kitakado (2010rev)
	2004	40.5	Jun.	101,373	917	8	0.872	0.461	1.14	1,093	0.576	3	Hakamada and Kitakado (2010rev)
	2005	65.0	May-Jul.	162,789	1,434	1	0.070	0.431	1.00	132	1.047	4	Hakamada and Kitakado (2010rev)
	2006	65.0	May-Jul.	162,789	1,039	3	0.289	0.761	1.00	309	0.677	5	Hakamada and Kitakado (2010rev)
	2007	65.0	Jun.-Jul.	162,789	914	2	0.219	0.456	1.00	391	1.013	6	Hakamada and Kitakado (2010rev)
9	1990	35.1	Aug.-Sep.	-	-	-	-	-	-	8,264	0.396	8,9	IWC (2004)
	2003	33.2	Jul.-Sep.	190,676	2,533	40	1.579	0.609	1.03	2,546	0.276	2	Hakamada and Kitakado (2010rev)
9N	2005	67.8	Aug.-Sep.	188,452	605	1	0.165	0.371	1.00	420	0.969	15	Miyashita and Okamura (2011)
10W	2006	59.9	May-Jun.	69,009	1,542	36	2.335	0.361	1.11	2,476	0.312	16	Miyashita and Okamura (2011)
10E	2002	100.0	May-Jun.	27,823	629	12	1.908	0.361	1.11	816	0.658	10	Miyashita *et al.* (2009)
	2003	100.0	May-Jun.	27,823	422	4	0.948	0.361	1.11	405	0.566	11	Miyashita *et al.* (2009)
	2004	100.0	May-Jun.	27,823	631	7	1.109	0.361	1.11	474	0.537	12	Miyashita *et al.* (2009)
	2005	64.6	May-Jun.	27,823	513	8	1.559	0.361	1.11	599	0.441	13	Agreed at 2013 Workshop, IWC (2014)
11	1990	100.0	Aug.-Sep.	-	-	-	-	-	-	2,120	0.449	8,9	Agreed in 2003, extract from Buckland *et al.* (1992)
	1999	100.0	Aug.-Sep.	-	-	-	-	-	-	1,456	0.565	20	IWC (2004)
	2003	33.9	Aug.-Sep.	15,243	265	10	3.774	0.361	1.11	882	0.820	14	Miyashita and Okamura (2011)
	2007	20.2	Aug.-Sep.	9,064	535	19	3.551	0.473	1.11	377	0.389	17	Miyashita and Okamura (2011)
12SW	1990	100.0	Aug.-Sep.	-	-	-	-	-	-	5,244	0.806	8,9	Agreed in 2003, extract from Buckland *et al.* (1992)
	2003	100.0	Aug.-Sep.	84,015	493	13	2.637	0.361	1.11	3,401	0.409	14	Miyashita and Okamura (2011)
12NE	1990	100.0	Aug.-Sep.	-	-	-	-	-	-	10,397	0.364	8,9	Agreed in 2003, extract from Buckland *et al.* (1992)
	1992	89.4	Aug.-Sep.	-	-	-	-	-	-	11,544	0.380	21	IWC (2004); Miyashita and Shimada (1994)
	1999	63.8	Aug.-Sep.	-	-	-	-	-	-	5,088	0.377		Agreed at 2013 Workshop, IWC (2014)
	2003	46.0	Aug.-Sep.	151,111	694	39	5.620	0.361	1.11	13,067	0.287	14	Miyashita and Okamura (2011)

Key for Figs 1-21
Trackline on effort=thick black line.
Primary sightings=solid circles.
Secondary sightings=open circles.
Sub-area definition=thick grey line.
Area definition for estimate=dashed line.

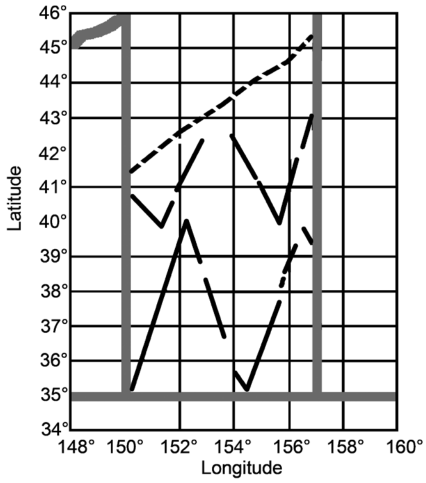

Fig. 1. Sub-area 8: JARPN II 2002 survey.

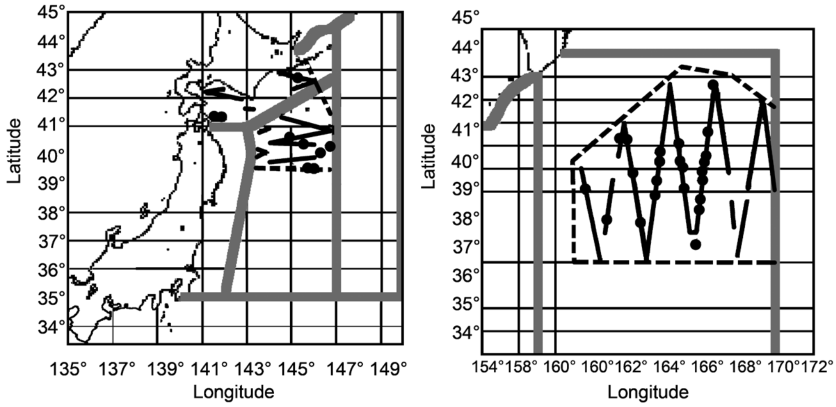

Fig. 2. Sub-areas 7CN and 7WR (left panel) and 9 (right panel): JARPN II 2003 survey.

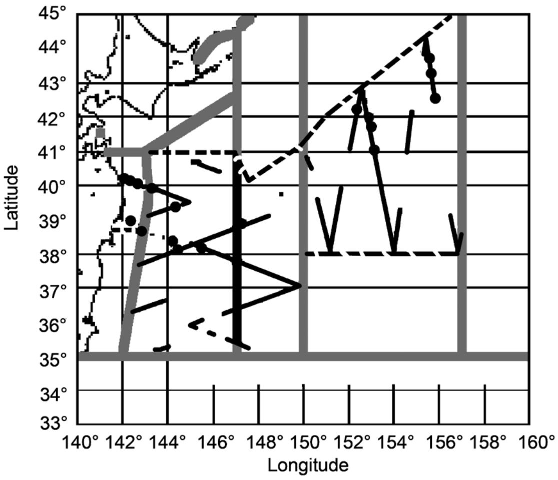

Fig. 3. Sub-areas 7CS, 7WR, 7E and 8: JARPN II 2004 survey.

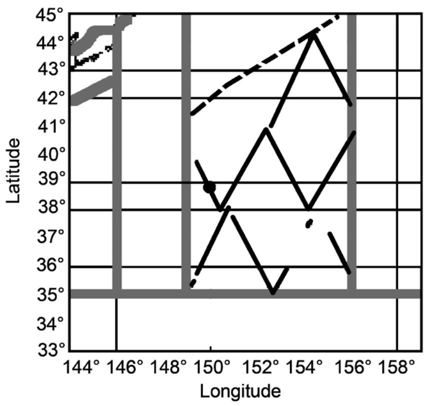

Fig. 4. Sub-area 8: JARPN II 2005 survey.

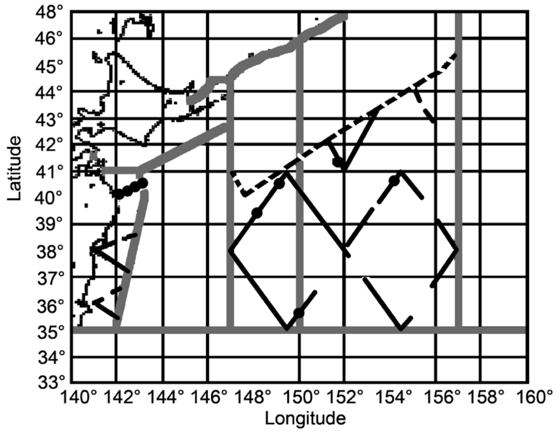

Fig. 5. Sub-areas 7CS, 7E and 8: JARPN II 2006 survey.

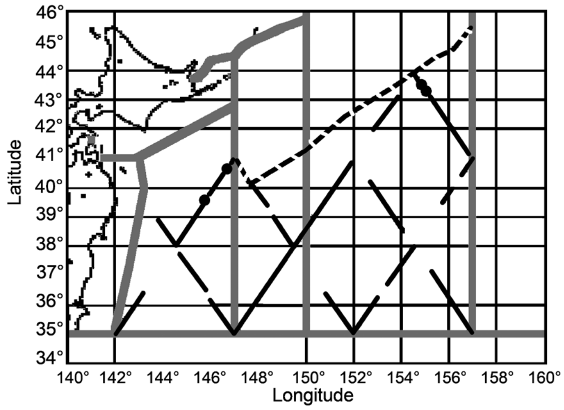

Fig. 6. Sub-areas 7WR, 7E and 8: JARPN II 2007 survey.

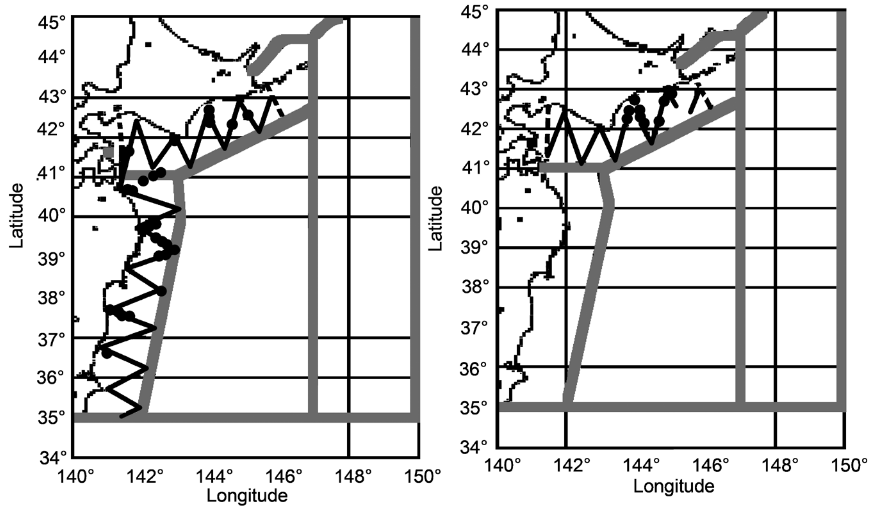

Fig. 7. Sub-area 7CS and 7CN in the first survey (left panel) and the second survey (right panel): JARPN II 2012 survey.

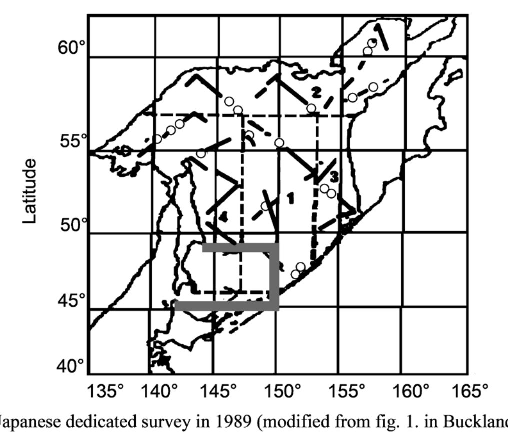

Fig. 8. Japanese dedicated survey in 1989 (modified from fig. 1. in Buckland *et al.*, 1992).

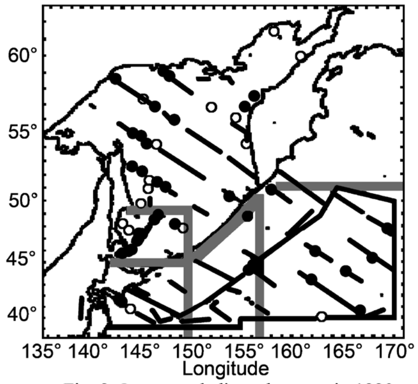

Fig. 9. Japanese dedicated survey in 1990 (modified from fig. 1. in Buckland *et al*., 1992).

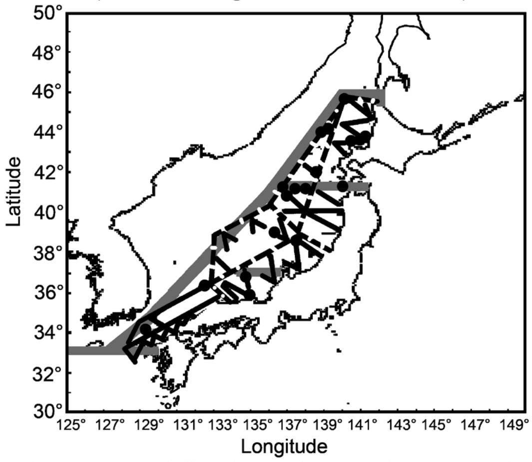

Fig. 10. Japanese dedicated survey in 2002: sub-area 6EN and 10E.

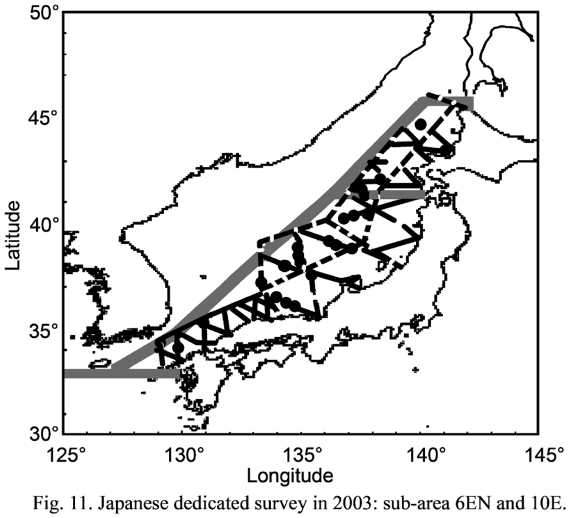

Fig. 11. Japanese dedicated survey in 2003: sub-area 6EN and 10E.

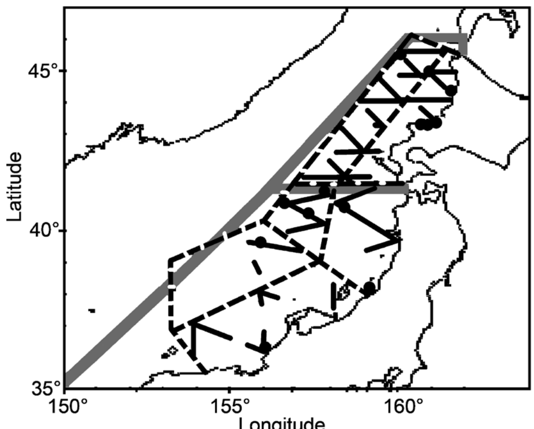

Fig. 12. Japanese dedicated survey in 2004: sub-area 6EN and 10E.

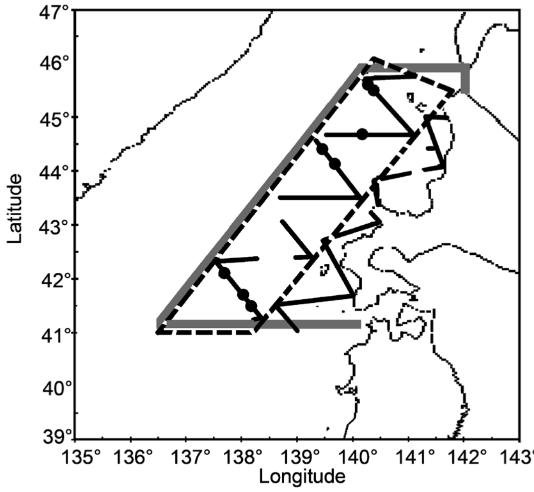

Fig. 13. Japanese dedicated survey in 2003: sub-area 10E.

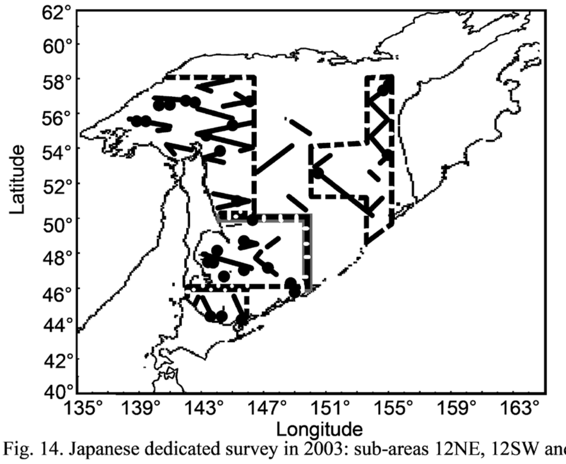

Fig. 14. Japanese dedicated survey in 2003: sub-areas 12NE, 12SW and 11.

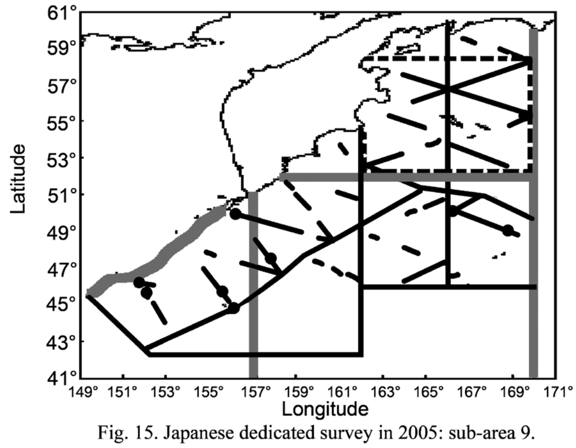

Fig. 15. Japanese dedicated survey in 2005: sub-area 9.

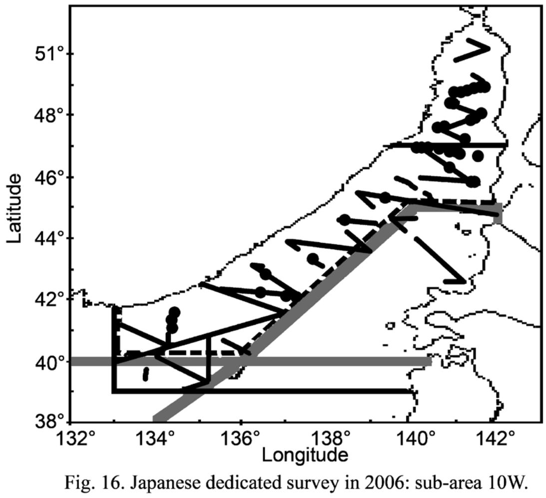

Fig. 16. Japanese dedicated survey in 2006: sub-area 10W.

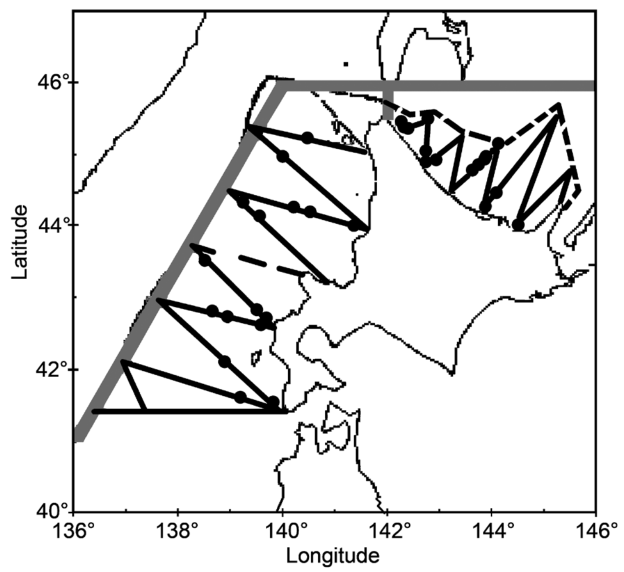

Fig. 17. Japanese dedicated survey in 2007: sub-area 11.

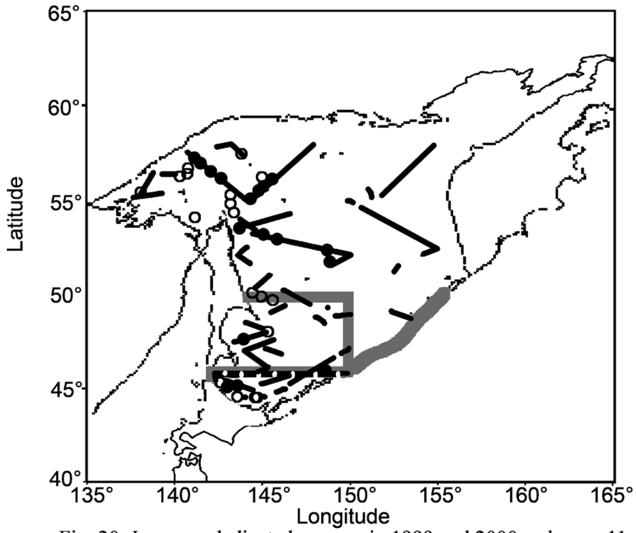

Fig. 20. Japanese dedicated surveys in 1999 and 2000: sub-area 11. Primary sightings in 1999 (solid circle) and in 2000 (open circle).

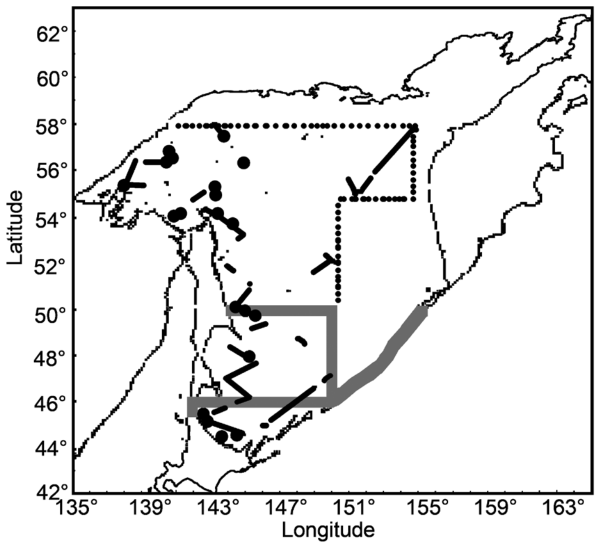

Fig. 18. Japanese dedicated survey in 1999: sub-areas 10NE, 10SW and 11. The dotted line shows the restriction from the Russian Government and observers onboard the vessel.

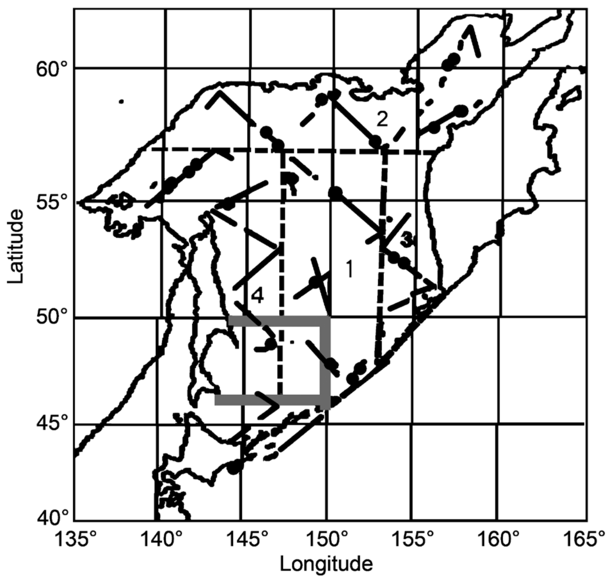

Fig. 21. Japanese dedicated survey in 1992: sub-area 10NE.

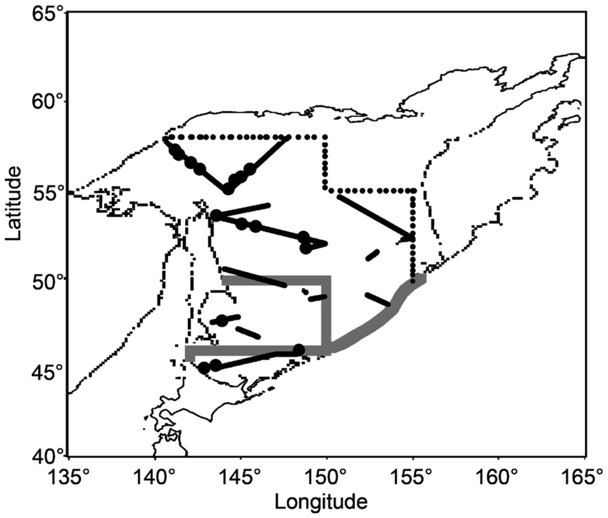

Fig. 19. Japanese dedicated survey in 1999: sub-areas 10NE, 10SW and 11. The dotted line shows the restriction from the Russian Government and observers onboard the vessel.

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Appendix 4

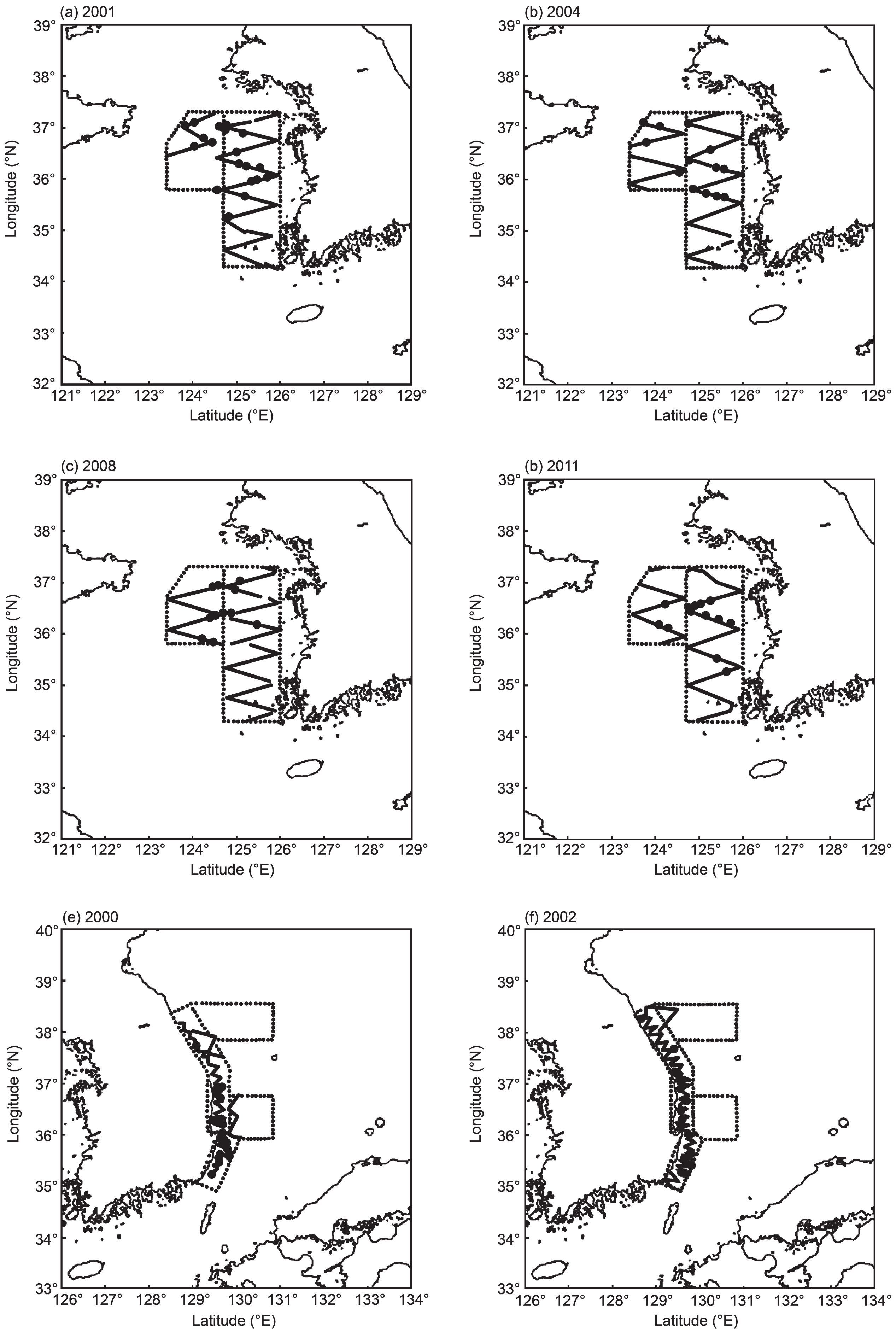
SUMMARY OF ABUNDANCE ESTIMATES OF THE WESTERN NORTH PACIFIC COMMON MINKE WHALES USING KOREAN SIGHTING SURVEYS IN SUB-AREAS 5 AND 6W

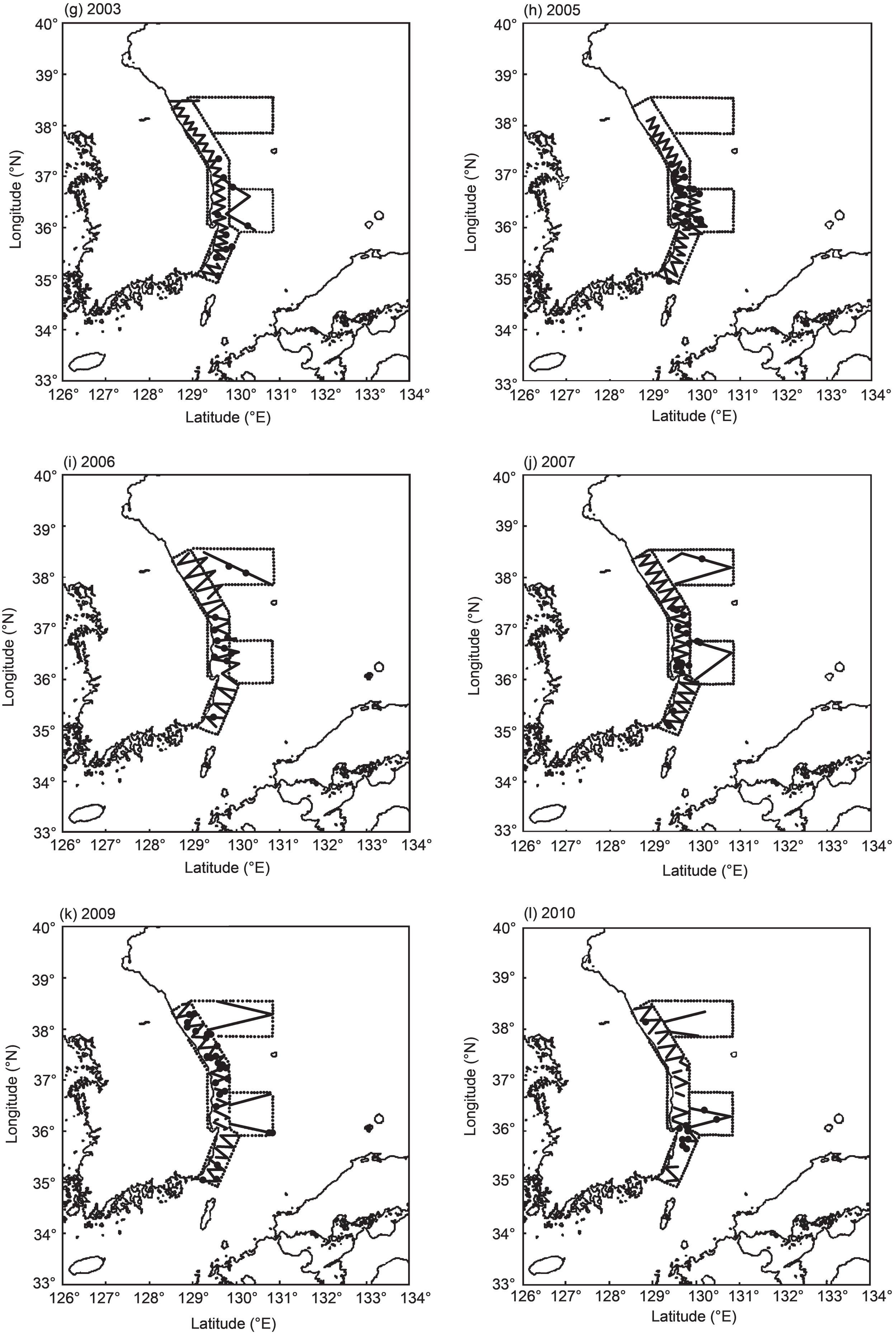
Yong-Rock An

Table 1

Summary of abundance estimate of the western North Pacific common minke whales using Korean sighting surveys (see Figs a-l).

Year	Sub-area	Survey period	Area size (n.mile^2)	Area coverage (%)	Survey effort (n.mile)	No. sightings	Encounter rate (N/n.mile)	ESW (n.mile)	Mean school size	P	CV(P)	Fig.
2001	5	Apr.-May	15,678	13.0	751	27	0.036	0.243	1.07	1,534	0.523	(a)
2004	5	Apr.-Jun.	15,678	13.0	807	18	0.022	0.257	1.06	799	0.321	(b)
2008	5	Apr.-May	15,678	13.0	841	17	0.020	0.244	1.18	680	0.372	(c)
2011	5	Apr.-May	15,678	13.0	1,228	14	0.011	0.302	1.07	587	0.405	(d)
2000	6W	May-Jun.	10,046	14.3	709	25	0.035	0.408	1.08	549	0.419	(e)
2002	6W	May-Jun.	10,046	14.3	590	16	0.027	0.276	1.06	391	0.614	(f)
2003	6W	Apr.-May	10,046	14.3	1,064	14	0.013	0.318	1.14	485	0.343	(g)
2005	6W	Apr.-May	10,046	14.3	846	19	0.022	0.291	1.16	336	0.317	(h)
2006	6W	Apr.-May	10,046	14.3	833	13	0.016	0.132	1.08	459	0.516	(i)
2007	6W	Apr.-May	10,046	14.3	941	20	0.021	0.244	1.15	574	0.437	(j)
2009	6W	Apr.-May	10,046	14.3	1,133	35	0.031	0.226	1.09	884	0.286	(k)
2010	6W	Apr.-May	10,046	14.3	2,310	21	0.009	0.180	1.10	1,014	0.387	(l)


(a) 2001
(b) 2004
(c) 2008
(b) 2011
(e) 2000
(f) 2002
Longitude (°N)
Latitude (°E)
32°
33°
34°
35°
36°
37°
38°
39°
40°
121°
122°
123°
124°
125°
126°
127°
128°
129°
130°
131°
132°
133°
134°



(g) 2003
(h) 2005
(i) 2006
(j) 2007
(k) 2009
(l) 2010
Longitude (°N)
Latitude (°E)
33°
34°
35°
36°
37°
38°
39°
40°
126°
127°
128°
129°
130°
131°
132°
133°
134°

Annex E

Report of the Standing Working Group on Aboriginal Subsistence Whaling Management Procedures

Members: Donovan (Convenor), Allison, Baba, Baulch, Bickham, Brandão, Broker, Brownell, Butterworth, Childerhouse, Chilvers, Cipriano, Collins, Cooke, De Moor, Double, Dupont, Efirmchuk, Elvarsson, Fortuna, Givens, Holloway, Holm, Iñíguez, Kelly, Kim, H., Kitakado, Kock, Lang, Legorreta-Jaramillo, Litovka, Marzari, Nelson, Palsbøll, Perkins, Punt, Reeves, Ritter, Robbins, Roel, Rose, Sakamoto, Scheidat, Scordino, Simmonds, Skaug, Stachowitsch, Suydam, Tajima, Tiedemann, Víkingsson, Vinnikov, Walløe, Waples, Wilson, Witting, Yasokawa, Yoshida.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks

Donovan welcomed the participants to the meeting. He noted that the major part of the work of the SWG this year is to build upon the progress made at the intersessional workshop (SC/65a/Rep02) held in Copenhagen in December 2012 on developing *SLA*s for the Greenlandic hunts, with an initial emphasis on humpback whales and bowhead whales. That Workshop dealt with a number of topics and they are dealt with where appropriate on the SWG's agenda. The SWG will also consider management advice for the hunts of Greenland and St Vincent and The Grenadines.

1.2 Election of Chair

Donovan was elected Chair.

1.4 Appointment of rapporteurs

Givens, Scordino, Butterworth and Punt acted as rapporteurs with assistance from the Chair.

1.5 Adoption of Agenda

The adopted agenda is given as Appendix 1.

1.6 Documents available

The new primary documents available to the SWG were SC/65a/AWMP01-07.

2. GRAY WHALES WITH EMPHASIS ON THE PCFG (PACIFIC COAST FEEDING GROUP)

2.1 Report of intersessional Workshop (SC/65a/Rep02)

In 2010, the Committee agreed that PCFG (Pacific Coast Feeding Group) whales should be treated as a separate management unit. PCFG whales are defined as gray whales observed (i.e. photographed) in multiple years between 1 June and 30 November in the PCFG area (IWC, 2011a, p.22). Not all whales seen within the PCFG area at this time will be PCFG whales and some PCFG whales will be found outside the PCFG area at various times during the year. The Makah tribe would like to take gray whales in the Makah usual and accustomed fishing grounds (U&A) in the future and the objective of the *SLA*s they proposed is to minimise the risk to the PCFG whales and meet the Commission's conservation objectives. An important component of this is to restrict hunting to the migratory season, i.e. prior to 1 June. The Committee began the evaluation process in 2011.

Last year, the Committee had agreed that two *SLA* variants (one with research provisions) met the conservation objectives of the Commission (IWC, 2013b, p.19). *SLA* variant 1 proposed that struck-and-lost whales did not count towards the APL (the 'allowable PCFG limit' – a protection level) i.e. there is no management response to PCFG whales struck but not landed. *SLA* variant 2 proposed that all struck-and-lost whales counted to the APL irrespective of hunting month, i.e. the number of whales counted towards the APL may exceed the actual number of PCFG whales struck. However, the Committee also noted that the two variants did not exactly mimic the proposed hunt and expressed concern that the actual conservation outcome of the proposed hunt had not been fully tested. The reason for this relates to how strikes in May are treated in *SLA* calculations. In the variants, the APL is adjusted to account for how many whales the Makah hunting plan would permit in May.

The two tested *SLA* variants bracketed the possible Makah hunting plans, assuming either 7 or 0 strikes in May for Variants 1 and 2, respectively. The Committee had approved Variant 2 but had stated that Variant 1 only met the Commission's conservation objectives if it was accompanied by a specific annual research programme (i.e. a photo-identification programme to monitor the relative probability of harvesting PCFG whales, the results of which are presented to the Scientific Committee for evaluation each year).

Donovan summarised progress made during the intersessional Workshop (SC/65a/Rep02). There are insufficient data to determine the proportion of strikes that would occur in May or prior to May, and the Workshop agreed to test six new variants to cover the full range of possible strikes occurring in May or prior to May, i.e. variants allowing x strikes prior to May where $x = 1,…,6$. In particular, it had recommended that the full set of trials be repeated for these six variants (in addition to the two *SLA*s agreed by the Committee last year).

The Workshop also recommended that the photo-id catalogue for the eastern North Pacific gray whales (that will be used to assess whether landed whales are from the PCFG) be made publicly available as it is a key component of the management approach. It was pleased to be informed that funding is available to digitise the catalogue. Weller informed the SWG that NOAA still has funds available to digitise the catalogue of PCFG whales. Scordino noted that work is underway to compile photographs from a few key contributors for a photo catalogue of PCFG whales to be held at NOAA's National Marine Mammal Laboratory; this catalogue, at least initially, will not be publicly available.

2.2 New information and results

2.2.1 Further evaluation of proposed Makah Hunt

SC/65a/AWMP06 presented trial results for the six *SLA* variants discussed above. By examining the final depletion statistic for all evaluation and robustness trials for the six new *SLA* variants and Variants 1 and 2 used in the 2012 *Implementation Review*, the authors concluded that:

(1) the conservation performance of the new variants was intermediate between Variant 1 and Variant 2;
(2) there is not a uniform, linear increase in conservation performance caused by reducing the maximum number of strikes that occur prior to May;
(3) there is a point of saturation at which increasing the number of strikes prior to May does not lead to a decrease in conservation performance; and
(4) the results show that conservation performance changes as would be expected.

In summary, the performance of all the new variants was no worse than for Variant 1 and no better than for Variant 2. These conclusions also hold true for other conservation performance statistics examined.

The SWG thanked the authors for their work. The SWG recalled that the research requirement for Variant 1 had been imposed because its conservation performance was inferior to that of Variant 2 on a small number of trials. The SWG **agreed** that the newly tested *SLA*s performed acceptably and met the Commission's conservation objectives provided that they, like Variant 1, are accompanied by a photo-identification programme to monitor the relative probability of harvesting PCFG whales which is undertaken each year and the results presented to the Scientific Committee for evaluation.

SC/65a/AWMP03 presented an update on the availability of PCFG whales in the Makah U&A based on photo-identification surveys. With data collected from 1984 to 2011, strong evidence was found for PCFG whales being more available in the Strait of Juan de Fuca (56% of whales observed being PCFG whales) as compared to the Pacific Ocean (31%). This difference is statistically significant (Fisher's exact test, $p<0.01$). This finding supports the Makah Tribe's proposed prohibition of hunting in the Strait of Juan de Fuca. No significant differences were found for comparisons of the availability of PCFG whales by month in the Pacific Ocean. The updated availability of PCFG gray whales in Pacific Ocean waters of the Makah U&A presented in this paper was not appreciably different to the 30% availability used in the 2012 *Implementation Review*.

The SWG **welcomed** this update. It noted that the research program to monitor the availability of PCFG whales has the added benefit of collecting data that aids the assessment of risk that the Makah hunt would strike a whale identified in the western North Pacific (WNP) that has migrated to the US west coast discussed below. In response to the discussion, Scordino **agreed** to examine the possibility of trends in the data and include it in an updated paper for next year's meeting.

As noted last year (IWC, 2013b, p.20), observations of gray whales identified in the WNP migrating to areas off the coast of North America (Alaska to Mexico) raise concern about placing the WNP population at potential risk of being harmed or killed accidentally in the proposed Makah hunt. It was noted that the research programme to monitor the availability of PCFG whales has the added benefit of collecting data that aids the assessment of risk that the Makah hunt would strike a whale identified in the WNP that has migrated to the US west coast.

Given the ongoing concern about status of the gray whales in the WNP, in 2011 the Scientific Committee emphasised the need to estimate the probability of a western gray whale being killed during aboriginal gray whale hunts (IWC, 2012). Additionally, in the USA it is required that NOAA prepare an Environmental Impact Statement (EIS) pertaining to the Makah's request for a waiver under the US Marine Mammal Protection Act (MMPA) in order to hunt gray whales. The EIS will include an estimate of the likelihood of Makah hunters approaching, pursuing, and attempting to strike a WNP gray whale in addition to the likelihood of actual strikes (assumed to result in death or serious injury).

Moore and Weller (2013) estimated the probability that one or more whales identified in the WNP might be killed during the hunt proposed by the Makah Indian Tribe. This analysis updated the analysis of mortality risk provided to last year in Moore and Weller (2012) by incorporating Committee from feedback last year's meeting (IWC, 2013b, p.20). The probability of striking or taking a WNP gray whale during the proposed Makah hunt was estimated using four different sets of models (six models in total). The author's 'most plausible' model uses all available information and includes the least number of assumptions. Based on this model, the probability of striking at least one WNP gray whale in a single season ranged from 0.007 to 0.036, depending on whether the median or upper 95th percentile estimate is used and on which maximum is used for the total number of whales struck. The probability of striking at least one WNP gray whale during a five-year period ranges from 0.036 to 0.170 across the same scenarios. The expected number to be struck ranges from 0.01 to 0.04 for a single year and from 0.04 to 0.19 across 5 years.

Estimates from this analysis are considered by the authors to be precautionary since they assume that the Makah will achieve their proposed maximum strike limits. The results offer a conservative initial step in assessing the potential risk of WNP gray whales incurring mortality incidental to the proposed hunt on the ENP population by the Makah Indian Tribe.

The SWG **welcomed** this paper, recognising that it represents initial work. It notes that it will provide a contribution to the recommended workshop examining gray whales throughout the North Pacific (Annex F).

2.2.2 Other information

Mate summarised his recent satellite tagging work on PCFG gray whales. In 2012, Mate and his colleagues tagged nine additional gray whales off Oregon and northern California to those previously reported. Six of those continued transmitting until the whales visited the breeding grounds and returned to the Pacific Northwest; many are still providing data. In 2009, all of the satellite tagged whales visited the same lagoon, Ojo de Liebre, but in 2012 several whales travelled farther south to water offshore of San Ignacio Lagoon and Magdalena Bay. In 2009 and 2012 a tagged PCFG gray whale migrated as far north as Icy Bay, Alaska, beyond the management-defined range of the PCFG whales. Many of the tagged whales migrated further north initially in the spring than where they spent most of their PCFG feeding season. Considering the number of tags deployed and the success of their deployment, Mate noted that it will be possible to define home ranges and core areas for individuals. Mate also mentioned that ongoing research assessing the wound healing in tagged whales may be ready for presentation to the Scientific Committee next year. Finally, Mate reported on plans to deploy as many as 12 more tags in 2013. To the extent possible, attempts will be made to tag the same whales that were tagged in 2009 to see if those whales utilise the same home range, migration timing and routes, and breeding areas each year.

Weller briefly reported on a scientific task force (comprising eight NMFS scientists with expertise in fields relevant to stock structure assessment) workshop held by the US National Marine Fisheries Service (NMFS) to assess gray whale stock structure (Weller *et al.*, 2013). While the primary focus was to provide advice in terms of US domestic legislation, much of the work was also of scientific relevance to the IWC Scientific Committee. New information has suggested the possibility of recognising two additional stocks in US waters to the eastern North Pacific stock currently recognised: (1) the Pacific Coast Feeding Group (PCFG); and (2) the western North Pacific (WNP) stock. The task force reviewed new information relevant to gray whale stock structure, including the results of genetic, photo-identification, tagging and other studies. It agreed on a series of questions relevant to evaluating whether the PCFG and/or the WNP gray whales qualify as stocks under US guidelines and followed a structured decision-making process. The task force concluded that there was substantial uncertainty regarding whether the PCFG qualified as a separate stock and was unable to provide definitive advice. It did, however, advise that the WNP stock should be recognised as a stock. The task force provided recommendations for future work, including the continuation of field studies as well as additional analysis of the existing photo-identification and genetic data.

The SWG thanked Weller and noted that the report represented a thorough review of the current knowledge of PCFG and WNP gray whales. In response to a question on how the US defines a stock, Weller responded that the primary criterion is demographic independence. The SWG noted that the Scientific Committee continues to work on definitions relating to 'stock' and related terms and that this report will be of value to the working group on stock definition. It also **agreed** that it will provide valuable input to the recommended workshop examining gray whales throughout the North Pacific (see Annex F).

2.3 Summary and recommendations

The SWG **concluded** that the conservation performance of the proposed Makah whaling management plan has now been fully analysed within the *SLA* evaluation framework. It **agreed** that the proposed management plan meets the conservation objectives of the Commission provided that if struck and lost animals are not proposed to be counted toward the APL then a photo-identification research programme to monitor the relative probability of harvesting PCFG whales in the Makah usual and accustomed fishing grounds (U&A) is undertaken each year and the results presented to the Scientific Committee for evaluation. In other words, only Variant 2 was judged to meet the Commission's conservation objectives without the research requirement.

In regards to questions on whether the SWG should consider conducting an *Implementation Review* to evaluate the potential impacts of the Makah hunt on whales identified in the WNP, it was **agreed** that before an *Implementation Review* is conducted that the recommended workshop be held to review the range-wide population structure and status of North Pacific gray whales (see Annex F).

3. CONSIDERATION OF WORK REQUIRED TO DEVELOP *SLA*S FOR ALL GREENLAND HUNTS BEFORE THE END OF THE INTERIM PERIOD

3.1 Common minke whales and fin whales

3.1.1 Report from the intersessional Workshop (SC/65a/Rep02)

The Workshop noted the potential overlap between RMP and AWMP management with respect to common minke whales and fin whales in the North Atlantic. It agreed that the process of developing *SLA*s and RMP *Implementations* for stocks in regions where both commercial and aboriginal catches occur should include the following steps: (a) development of a common trials structure which adequately captures uncertainties regarding stock structure, mixing, MSYR, etc.; (b) identification of an *SLA* which performs as adequately as possible if there are no commercial catches; and (c) evaluation of the performance of RMP variants given the *SLA* selected at step (b). The work on RMP/AWMP-lite in this regard (see Item 3.1.3) was welcomed.

3.1.1.1 STOCK STRUCTURE

The Workshop recognised the need for consistency in stock structure hypotheses with RMP *Implementations.*

With respect to fin whales it had noted that the present hypotheses will be reviewed during the RMP *Implementation Review* scheduled for the 2013 meeting of the Scientific Committee. It also noted that it may be possible to base the *SLA* for fin whales off West Greenland on operating models which considered West Greenland only, i.e. in effect assuming that the animals found off West Greenland comprise a single stock that is adequately represented by the abundance estimates obtained off West Greenland. The rationale for this is that even if there are multiple stocks off West Greenland (as was suggested in some hypotheses considered during the RMP *Implementation*), it may be reasonable to assume that they are susceptible to capture in the aboriginal hunt proportionally to their abundance when the survey is conducted. In contrast, varying proportions of the multiple stocks over time would violate this assumption. The RMP *Implementation Review* should be asked to consider carefully any evidence that there may be more than one stock mixing off West Greenland.

With respect to common minke whales, the Workshop noted that it has been agreed that a joint AWMP/RMP stock structure workshop will be held in the intersessional period between the 2013 and 2014 annual meetings of the Scientific Committee (see Item 3.1.3 below). The results of this workshop will be essential to the *SLA* development process.

The SWG **endorsed** the conclusions and recommendations of the Workshop in this regard.

3.1.2 Joint RMP/AWMP Workshop(s) on stock structure

The SWG noted that the Steering Group for this meeting (which included SWG members including the Chair) had met to develop a work plan and that this had been reported to the sub-committee on the RMP (Annex D, Appendix 2). The SWG reiterated its support for this Workshop, first agreed last year (Donovan *et al.*, 2013), and the work plan developed.

3.1.3 AWMP/RMP-lite

SC/65a/Rep02 had introduced the idea of a new computer program called RMP/AWMP-lite, which is a platform written in R which implements a management strategy evaluation framework for evaluating the performance of catch and strike limit algorithms. The essence of RMP/AWMP-lite is the use of an age-aggregated model rather than an age-structured model to considerably speed up calculations; this will allow developers more easily to explore the properties of candidate *SLA*s before they are submitted to rigorous full testing. This framework can be used to evaluate management schemes where multiple stocks of whales are exploited by a combination of commercial and aboriginal whaling operations. The operating models can be conditioned to the actual data to allow an evaluation of whether stock structure assumptions and other hypotheses are comparable with the available data. The Workshop had suggested several improvements and extensions to the program. The SWG **endorsed** the conclusions and recommend-ations of the Workshop in this regard.

In discussion, Punt noted that all but one of the tasks had been completed (see SC/65a/RMP05). The ability to apply an *SLA* based on an independently-written routine has been implemented for the bowhead and humpback trials, but not in AWMP/RMP-lite. He noted that AWMP/RMP-lite had become complicated owing to the recent developments, which may warrant changing the way the code is implemented.

The Workshop recalled that the current approach to evaluating *SLA*s for the Greenlandic hunts treats each species independently even though need is expressed as a total amount of meat over multiple species. It was noted that once single-species *SLA*s are developed, a multispecies 'need surface' which expresses the trade-offs among need for several species in terms of a multi-dimensional inequality constraint could be considered because it should be easier to satisfy total need rather than satisfying maximum needs separately for several species.

The SWG **endorsed** the conclusions and recommend-ations of the Workshop in this regard, **reiterating** that work on single-species *SLA*s should be completed before multi-species considerations are examined.

The Workshop had also noted that the RMP and AWMP dealt with ship strikes and by-catch differently. The RMP catch limit is for all human-induced removals so that the commercial catch is the difference between the RMP catch limit and the expected removals due to, for example, ships strikes and bycatch. In contrast, the aim of the AWMP is not to maximize catch, but rather to satisfy need. Consequently, the strike limit is not reduced by ship strikes and by-catch. Rather, the trials used to select *SLA*s account for future levels of other human-caused removals, but the strike limit is still related only to need. Thus, the removals from the population in the case of aboriginal hunts would be the strike limit plus other human-caused removals.

The SWG **endorsed** the conclusions and recommend-ations of the Workshop in this regard, noting that this approach is used for other human-induced removals under Items 3.2 and 3.3 below.

3.1.4 Discussion and work plan

The work plan for SWG in relation to the development of *SLA*s for the hunts for fin and minke whales off West Greenland is partially dependent upon the associated work on RMP *Implementation Reviews* for fin and common minke whales. In terms of activity over the coming year the SWG will:

(1) examine the final modelling framework and trial specifications for North Atlantic fin whales being developed intersessionally including at an RMP intersessional workshop by a steering group (which includes AWMP members) and examine how this can be incorporated into *SLA* development;
(2) participate in the joint AWMP/RMP workshop on stock structure of common North Atlantic minke whales agreed last year to review stock structure hypotheses and review the results from the AWMP perspective an emphasis on Greenland;
(3) examine the discussions and results of the RMP *Implementation Review* for common North Atlantic minke whales that will start with a pre-meeting before SC/65b from an AWMP perspective; and
(4) receive need envelopes from Greenland for North Atlantic fin and common minke whale hunts off Greenland.

3.2 Humpback whales

3.2.1 Report from intersessional Workshop (SC/65a/Rep02)

Donovan briefly summarised the new information available for humpback whales off West Greenland from the Workshop (SC/65a/Rep02).

3.2.1.1 STOCK STRUCTURE

With respect to stock structure, the Committee agreed in 2007 that the West Greenland feeding aggregation was the appropriate management unit to consider when formulating management advice. Whales from this aggregation mix with individuals from other similar feeding aggregations on the breeding grounds in the West Indies (IWC, 2008, p.21).

The Committee also received valuable information from 30 satellite-tagged whales (Heide-Jørgensen, 2012). This found that few excursions were made outside the areas covered by the 2005 and 2007 aerial surveys which took place during August-September, although one animal left West Greenland in June and reached Newfoundland in July (i.e. would not have been available for counting). Two whales departed from West Greenland and took a route south along Labrador and Newfoundland. The Workshop recognised the value of such work to both stock structure and abundance and encouraged its continuation.

Photo-identification data are also valuable for stock structure and movement studies. Subsequent to the Workshop Witting confirmed that all photographs from West Greenland had been submitted to the North Atlantic humpback Catalogue who also informed the Chair that one match had been made with the Gulf of Maine in addition to matches from eastern Canada that confirmed the results from the telemetry studies.

The Workshop endorsed the previous Scientific Committee recommendation that the West Greenland feeding aggregation was the appropriate management unit and that it should be treated as a single stock in the trials.

3.2.1.2 ABUNDANCE

The Workshop reviewed the abundance estimates that had been received and adopted by the Scientific Committee. These are discussed further under Item 3.2.2.1 below.

The Workshop had agreed to use the estimates of relative abundance from aerial surveys to condition the trials. Since available abundance estimates from the mark-recapture studies covered a shorter period and were heavily correlated it was agreed that they would only be used in a *Robustness Trial*. However, the Workshop had also agreed that given that mark-recapture abundance estimates may become common in the future for both humpback and bowhead whales, efforts should be made to develop ways to better integrate them into the operating models for the *SLA* trials. It had also agreed that for future surveys, only absolute estimates of abundance would be generated.

3.2.1.3 REMOVALS

3.2.1.3.1 DIRECT CATCHES

Noting past difficulties in modelling the full western North Atlantic (including allocation of past catches) and the decision to treat the feeding aggregation as the appropriate management unit, it was agreed that trials would begin in 1960 under an assumption that the age-structure in that year is steady. The catch series for this period is known and this is treated as the best catch series and no alternatives are required. It can be found in the revised trial specifications to the present report (see Appendix 2).

None of the photographic recaptures of humpback whales from St. Vincent and the Grenadines have been made with animals from the West Greenland feeding aggregation, so these catches are not included in the catch series. However, given possible migration routes (e.g. from telemetry data), it was noted that known direct catches occurred from whaling stations off the east coast of Canada after 1960 that may have included some 'West Greenland' animals.

Making simple assumptions (Greenland whales are estimated to be off Newfoundland for ~1 month in comparison to Canadian whales which are there for ~ 6 months and taking the relative abundances of the two populations into account) leads to an estimated potential direct catch of Greenland humpbacks off Canada of up to 5% of the total direct catch. The Workshop agreed that this will be incorporated into the catch series in the revised trial specifications, but that no future direct catches off Canada will be simulated.

3.2.1.3.2 BYCATCHES AND SHIP STRIKES

The Workshop addressed the question of bycatches in both West Greenland and elsewhere. For West Greenland, noting that the crab fishery which was primarily responsible for bycatches has now peaked, it was agreed that future bycatches for Greenland will be generated assuming that the exploitation rate due to bycatch in the future equals that estimated for the trial in question over the most recent five-years. As no bycatches were reported for the 1960-2000 period for West Greenland, it was noted that this assumption is conservative in that bycatches will be assumed for the future.

With respect to bycatches of 'West Greenland' animals outside West Greenland, the Workshop agreed to an approach similar to that for direct catches, i.e. the estimated potential direct catch of Greenland humpbacks off Canada could be up to 5% of the total Canadian bycatch. Should ship strikes occur, the same approach would be used. The Secretariat agreed to investigate the available information on bycatch and ship strikes.

3.2.1.4 BIOLOGICAL PARAMETERS

The Workshop noted that prior distributions need to be specified for three biological parameters: (a) the non-calf survival rate; (b) the age-at-maturity; and (c) the maximum pregnancy rate. The objective is to develop priors (taken to be uniform for all three parameters) which are plausible based on the range of estimates in the literature. The values for these parameters used in the actual trials will encompass a narrower range than these priors because the priors will be updated by the data on abundance and trends in abundance during the conditioning process.

The Workshop agreed that the prior for non-calf survival, S_{1+}, will be U[0.9, 0.995]. The lower bound for this prior is the lower 95% confidence interval for the estimate of non-calf survival obtained by Larsen and Hammond (2004) while the upper bound is the upper 95% confidence interval for the estimate of non-calf survival rate for humpback whales in Prince William Sound, Alaska reported by Zerbini *et al.* (2010). Zerbini *et al*. (2010) based their estimates of maximum rates of increase on the non-calf survival rate estimate for this population.

The maximum pregnancy rate, f_{max}, is the pregnancy rate in the limit of zero population and thus is not measureable but is expected to be higher than observed pregnancy rates. Based on its review of the available information, the Workshop agreed that the prior will be U[0.4, 0.8]. The lower bound for this prior is close to the average of the estimates of pregnancy rate for humpback whale stocks reported by Zerbini *et al.* (2010). The upper bound was based on the view that the theoretical maximum (i.e. all mature females giving birth every year) is infeasible but that an estimate that involved a high proportion of animals on a one-year cycle (individuals have been observed to do this) should be considered.

The Workshop agreed that the prior for the age-at-maturity should be U[4, 12]. This is based on data from individually identified whales and incorporated the lower ages-at-first-parturition reported by Clapham (1992) and Gabriele *et al.* (2007) and the high value reported by Robbins (2007).

Recognising the great uncertainty in these priors given the paucity of data, the Workshop agreed that it was important to develop a *Robustness Trial* in which the priors for the biological parameters are modified by lowering the upper bounds for the priors for S_{1+} and f_{max} and increasing the lower bound for a_m.

The abundance data are not informative about carrying capacity and the Workshop agreed that trials should be based on the prior for carrying capacity, *K*, proposed in Punt (2012), U[0, 30,000], noting that the estimated total catch of North Atlantic humpback whales is approximately 30,000 (Reeves and Smith, 2002).

3.2.1.5 NEED

Need envelopes are an important component of developing a trial structure and are the responsibility of the relevant Governments. Need envelopes for humpback whales were submitted to the Workshop in Witting (2012) and these reflected the Greenlandic preference for humpback whales over fin whales and Greenland's desire for flexibility. The need envelope is summarised in Fig. 2. Reiterating that the determination of catch limits is a matter for the Commission but recognising that the Committee needs to be in a position to provide scientific advice on any need requests, the Workshop had agreed that need envelopes that increased over the initial three quota blocks from ten to twenty whales should capture this issue. Hence, the following three need envelopes were agreed [10, 15, 20-20], [10, 15, 20-40] and [10, 15, 20-60], with the middle envelope being considered the base case. Witting had also suggested consideration of an additional 'backup' scenario of initially adding ten humpback whales to the base case envelope (this was intended to compensate for any unforeseen decline in the common minke whale strike limits of up to approximately 60 minke whales).

3.2.1.6 *SLA*S TO BE CONSIDERED

The Workshop had agreed that all of the trials would be conducted for a bounding case and for two 'reference *SLA*s', in addition to any other *SLA*s which might be proposed by developers:

(1) the *Strike Limit* is set to the need;
(2) the *Strike Limit* is based on the interim *SLA* (IWC, 2009); and
(3) the *Strike Limit* is based on a variant of the interim *SLA* which makes use of all of the estimates of abundance, but downweights them based on how recent they are.

The Workshop had also agreed that the developers would be provided with:

(1) total need for the next block;
(2) catches by sex;
(3) mortalities due to bycatch in fisheries and ship strikes; and
(4) estimates of absolute abundance and their associated CVs.

3.2.1.7 TRIAL STRUCTURE

The Workshop developed proposed *Evaluation* and *Robustness* trials. These formed the basis for discussions under Item 3.2.3.

3.2.2 Discussion of the Workshop report and the results of intersessional work

The SWG **thanked** the Workshop for it comprehensive work and **broadly endorsed** its conclusions and recommendations; where appropriate they are either incorporated in the trial specifications (see Appendix 2) or provided the basis for further discussions under Item 3.2.3 below.

3.2.2.1 ABUNDANCE ESTIMATES

SC/65a/AWMP01 analysed surfacing time and availability bias for humpback whales in West Greenland, providing updated estimates of abundance. A total of 31 satellite-linked time-depth-recorders of three different types were deployed on humpback whales in West Greenland in May and July 2009-10. Over the period whales were tracked, the SLTDRs recorded the fraction of a 6-hour period that the whales spent at or above 2m depth. This depth is considered to be the maximum depth humpback whales are reliably detected on visual aerial surveys in West Greenland. Eighteen transmitters provided both data on the surface time and the drift of pressure transducer. The average surface time for these whales over the entire tracking period and during the two 6-hr periods with daylight was 28.3% (CV=0.06). Six whales that met data filtering criteria had reduced drift of the depth transmitter and their average surface time was 33.5% (CV=0.10). Previous analyses of visual aerial survey data have shown that the amount of time whales are available to be seen by observers is not an instantaneous process. Therefore the surface time needs to be corrected for a positive bias of about 10% when developing a correction factor for availability bias which increases the availability to 36.8% (CV=0.10). The most recent survey of humpback whales in West Greenland was conducted in 2007 and corrections with this availability factor provides fully corrected abundance estimates of 4,090 (CV=0.50) for mark-recapture distance sampling analysis and 2,704 (CV=0.34) for a strip census abundance estimate. These estimates are about 25% larger than previous estimates from the same survey. The annual rate of increase was 9.4% per year (SE 0.01) which was unchanged from the published paper.

The SWG noted that the methods behind the new estimates had been discussed fully at previous meetings when considering the 2007 survey. The revised estimate here was based on updated and improved information on the diving behaviour of whales from additional satellite tag data. It therefore **accepted** the new strip census abundance estimate as the best estimate. The full list of estimates accepted by the SWG is provided in Table 1. This information is also included in the trial specifications (see Appendix 2).

3.2.2.2 STOCK STRUCTURE

Noting the importance of information of photo-identification studies both to stock structure and the possibility of human-induced mortality outside the West Greenland area, the SWG **recommended** that Greenlandic scientists to work with the College of the Atlantic to develop a full overview of the available data and present this to the proposed intersessional Workshop.

3.2.2.3 REMOVALS

In the light of discussions at the workshop and at the present meeting, the SWG **agreed** that the Secretariat should continue to work with Canadian scientists and others to finalise the catch series (direct and indirect) following the guidelines agreed at the Workshop and present a final series to the proposed intersessional Workshop.

3.2.2.4 INITIAL INVESTIGATIONS OF *SLA*S

The SWG proceeded to discuss the results provided by the two sets of developers of candidate *SLA*s, which were based on trials as developed at the Intersessional Workshop. As the SWG discussed the results of this work for humpback and bowhead whales together, these are considered further under Item 3.4.

3.2.3 Trial structure

Based on the Workshop report and discussions above, the SWG revised the final trial structure for evaluation of *SLA*s for the West Greenland humpback whale hunt (also see Appendix 2).

During review of the trial specifications, it was noted that the prior distribution for f_{max} had been defined to be Unif[0.4,0.8], whereas data from Zerbini *et al.* (2010) included some lower estimates. In response to a question as to whether the lower end of the f_{max} prior should be adjusted downward accordingly, it was noted, however that the Zerbini *et al.* (2010) data referred to *observed* increase rates, whereas f_{max} referred to *theoretical maximum* rates. Values of f_{max} below 0.4 were regarded as very unlikely, and no change to the specifications was made.

The SWG **agreed** to replace need envelope D with C for trials 3A and 3B. The justification was that envelope D (involving pre-emptively higher initial need) would be very unlikely to be sought if the first survey was delayed until year 15. The SWG also agreed to add trials using need envelope C for all evaluation trials numbered 2A, 2B, and 4 or higher since it was important to consider the case when no initial jump in need was requested.

The SWG **agreed** that it was appropriate to include trials based on the environmental variability model for population dynamics developed by Cooke (2007) be included. This model reflects the impact of this variability on the population growth rate. The effect is not symmetrical because this growth rate is bounded for demographic reasons. This results in a qualitative difference being predicted in the behaviour of recovering populations. These first follow a steady exponential trend, but once somewhat higher abundance is reached much more variable behaviour can ensue (as indeed appears evident, for example, for the South West Atlantic right whale and Eastern North Pacific gray whale population). The SWG **agreed** that these environmental variability trials were plausible and thus should be considered *Evaluation Trials*. Since conditioning using this approach may prove problematic, it was also **agreed** that this model would be used only for future projections. These new trials are referred to as 'asymmetric environmental stochasticity'. Trial 8 will be parameterised intersessionally (Witting).

The factors considered in the trials are summarised in Table 1.

In preparation for evaluating *SLA*s for subsistence hunting of bowheads and humpback whales off West Greenland, the SWG reviewed the performance statistics, tables, and graphs used for past *SLA* evaluation and *Implementation Reviews*, to identify what methods were found most effective and informative.

Statistic D8 ('rescaled final population') was clarified in light of the fact that known or projected incidental removals will occur for some stocks hunted in West Greenland (e.g. Canadian hunting of bowhead whales). D8 has previously

Table 1

Factors tested in the trials.

Factors	Levels (reference levels shown bold and underlined)	
	Humpback whales	Bowhead whales
$MSYR_{1+}$	1%, 3%, **5%**, 7%	1%, **2.5%**, 4%
$MSYL_{1+}$	0.6	**0.6**, **0.8**
Time dependence in K*	**Constant**, halve linearly over 100 years	
Time dependence in natural mortality, M*	**Constant**, double linearly over 100 years	
Episodic events*	**None**, 3 events occur between years 1-75 (with at least two in years 1-50) in which 20% of the animals die. Events occur every five years in which 5% of the animals die.	
Need envelope	A: 10, 15, 20; 20 thereafter	**A: 2, 3, 5; 5 thereafter**
	B: 10, 15, 20; 20->40 over years 18-100	B: 2, 3, 5; 5 -> 10 over years 18-100
	C: 10, 15, 20; 20->60 over years 18-100	**C: 2, 3, 5; 5 -> 15 over years 18-100**
	D: 20, 25, 30; 30->50 over years 18-100	
Future Canadian catches	N/A	**A: 5 constant over 100 years**
		B: 5-> 10 over 100 years
		C: 5-> 15 over 100 years
		D: 2.5 constant over 100 years?
Survey frequency	5 year, **10 year**, 15 year	
Historic survey bias	0.8, **1.0**, 1.2	0.5, **1.0**
First year of projection, τ	**1960**	**1940**
Alternative priors	$S_{1+} \sim U[0.9, 0.99]$; $f_{max} \sim U[0.4, 0.6]$; $a_m \sim U[5, 12]$	N/A
Strategic surveys	Extra survey if a survey estimate is half of the previous survey estimate	
Asymmetric environmental stochasticity parameters	To be finalised by an intersessional group	

*Effects of these factors begin in year 2013 (i.e. at start of management). The adult survival rate is adjusted so that if catches were zero, then average population sizes in 250-500 years equals the carrying capacity. Note: for some biological parameters and levels of episodic events, it may not be possible to find an adult survival rate which satisfies this requirement.

been defined as the ratio of the final abundance (either 1+ or mature females) after 100 years with removals given by the *SLA* to the final abundance 'under a scenario of zero strikes'. For over a decade of AWMP *SLA* development for several fisheries no incidental take has been considered, so the condition of 'zero strikes' has been equivalent to 'zero removals'. Indeed, some SWG members had believed incorrectly that D8 was calculated relative to zero removals. The possibility of non-zero incidental removals now highlighted this point of confusion.

Therefore, the SWG defined statistic D8(0) to represent rescaled final population relative to a scenario with zero removals *of any kind*, and D8=D8(inc) to refer to the existing statistic which is relative to a scenario with zero strikes but possibly non-zero incidental removals. Statistic D8(0) is boldfaced to indicate that it is 'considered …more important'.

The same confusion about incidental removals applies to the abundance in year t under a scenario of zero strikes, denoted P_t^*. The SWG defined $P_t^*(0)$ and $P_t^*(\text{inc})$ analogously to D8(0) and D8(inc).

The SWG promoted statistic N12 ('mean downstep') to the boldfaced 'more important' category, and demoted R1 ('relative recovery') to non-boldfaced.

Consistent with past efforts, the SWG **agreed** to produce two sets of output when evaluating candidate *SLA*s. The first is a comprehensive library of all output, including the 5%tile and median values of all statistics (boldfaced 'more important' or otherwise), and all graphs and other output listed in the trial specifications. The library will be available for inspection but not used as the primary basis for SWG discussion. The second output set is a subset of the comprehensive library. It contains only the tables and graphs anticipated to be the most useful for SWG evaluation of candidate *SLA*s. The elements of this review set are discussed below.

A table of 5%tile and median values of certain statistics will be included in the review set. The most important aspect of this table is that the same quantities for different *SLA*s should be arranged in a column with aligned decimal points, so that like numbers can be compared vertically. The next paragraph summarises the contents of the table and a possible format. Apart from the columnwise comparison requirement, the format may be adjusted to partition the contents and fit on the page(s) sensibly.

Columns of the table are 5%tile and median values for D1(1+), D1(mature females), D8(0), D8(inc), D9(1+), D10(1+), N9(20) and N9(100). Row blocks of the table correspond to trial scenarios. Rows within a block correspond to different strike limit rules. Within a block, there would be one row for each candidate SLA. Also included in the block would be rows for removals=0 (i.e. no strikes or incidental removals), strikes=0 (but incidental removals do occur), and strikes=need.

In addition to this table, the following plots will be included in the review set.

(1) The 'Zeh plots' (IWC, 2013c). The statistics to be displayed in the Zeh plots will be all those described for the table above, and N12 ('mean downstep'). Note that the Zeh plots rely on more quantiles of the statistics than just the 5th and 50th ones shown in the table.

(2) The plots defined as D6, i.e. abundance trajectory plots of P_t versus t ($t = 0,\ldots,100$). All 100 simulated abundance trajectories for one algorithm are superimposed on this plot. Each plot pertains to a single *SLA* and a single trial scenario. Plots for 1+ abundance will be included in the review set, and analogous plots for the mature female component will be included in the comprehensive library.

(3) Plots of C_t versus t, as a step-function over 5-year blocks ($t = 0,\ldots,100$). All 100 simulated quota trajectories for one algorithm are superimposed on this plot. Each plot pertains to a single *SLA* and a single trial scenario. Superimposed in this plot (in a different color and heavier line type) will be the pointwise 5%tile trajectory of C_t.

(4) The plots defined as D7 (pointwise quantile abundance trajectories). In these plots, the three pairs of trajectory

lines (i.e. 5%tiles and medians for P_t, $P_t^*(0)$ and $P_t^*(\text{inc})$ will be superimposed on the same plot. Colour and line type will distinguish these.

(5) A new type of plot to compare depletion performance of several *SLA*s on a single graph. In this plot (one per trial scenario), the pointwise α^{th} percentile time trajectory of 1+ abundance is plotted, as in D7. However, the trajectories for all candidate *SLA*s are superimposed on the same plot. These are distinguished by color and line type. The three reference trajectories determined by assuming 0 strikes, 0 removals, and catch=need are *not* included in these plots. Two sets of such plots will be made, corresponding to α=5 and α=50.

3.3 Bowhead whales

3.3.1 Report from the intersessional Workshop (SC/65a/Rep02)

3.3.1.2 STOCK STRUCTURE

The current working hypothesis in the Scientific Committee is a single Baffin Bay-Davis Strait stock of bowhead whales (see Fig. 1). However, pending the availability of some genetic analyses, the Scientific Committee had agreed that the possibility that there are in fact two different stocks present in the overall area, with the second located in the Foxe Basin-Hudson Strait region, cannot be ruled out (e.g. see IWC, 2009, p.23).

No new information was available to the Workshop. Given that the objective was to develop an *SLA* for the Greenland hunt of bowhead whales, the Workshop had agreed to proceed first on a conservative basis that assumed that the absolute abundance of bowhead whales on the West Greenland wintering area would be informed by abundance estimates from data for that region only (see below). Only if such an *SLA* proved unable to meet need would abundance estimate information and stock structure considerations from the wider area shown in Fig. 1 be taken into account.

3.3.1.2 ABUNDANCE

The Workshop reviewed the available abundance estimates (SC/65a/Rep02, table 8). It is not possible to combine the Foxe Basin-Hudson Bay 2003 survey with the 2002 Prince Regent Inlet survey to obtain an estimate for the entire Davis Strait-Baffin Bay-Foxe Basin area. The Workshop therefore agreed to condition the operating model using data for Davis Strait-Baffin Bay stock only.

The 2002 survey in Prince Regent Inlet might not be conducted again whereas regular surveys will be conducted off West Greenland. The Workshop therefore agreed to conduct trials: (a) in which the estimate for Prince Regent Inlet is treated as an estimate of absolute abundance; and (b) in which the estimates from West Greenland are treated as estimates of absolute abundance.

While the sex ratio of animals in West Greenland is ~80:20 in favour of females (Heide-Jørgensen *et al.*, 2010b), it is expected that the sex ratio for the current whole population is 50:50 (based on historic catches over the whole region and present Canadian catches). The Workshop agreed that the trials will assume that the proportion of males available to the surveys will be the observed average male/female ratio in the biopsy samples.

Estimates of relative abundance from aerial surveys were also considered by the Workshop which agreed that an overdispersion parameter should be estimated for these sightings data under the assumption that the data are negative binomially distributed. Estimates of relative abundance are also available from genetic mark recapture studies. For similar reasons to those given for humpback whales above,

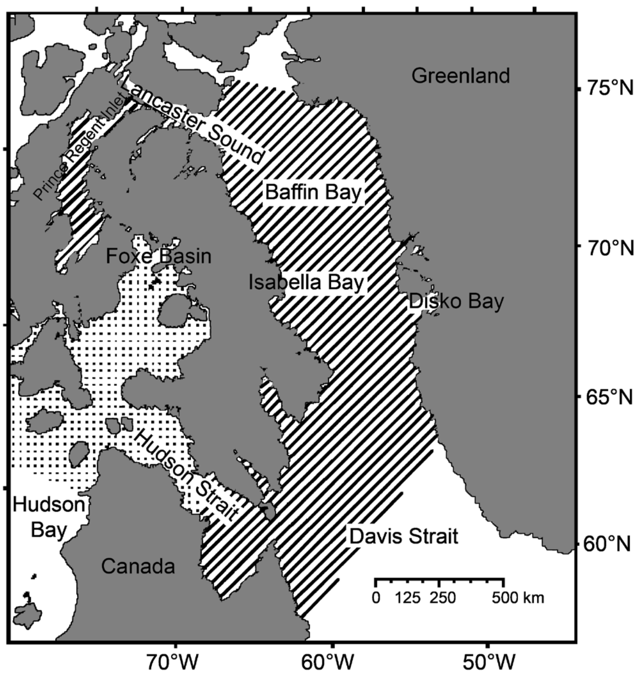


Fig. 1. Stock structure hypotheses for bowhead whales and place names referred to in the text. Hashed lines are for a Davis Strait-Baffin Bay stock while the dotted area refers to a Foxe Basin – Hudson Bay stock.

the Workshop agreed that these are not suitable for use now but that work should continue to enable these data to be used in the future; however, it accorded the work low priority at this time.

The Workshop agreed that the information provided to the *SLA* will be the results of surveys off West Greenland (relative indices if the operating model is conditioned to the estimate of abundance for Prince Regent Inlet and absolute if the operating model is conditioned to the estimate of abundance for West Greenland).

3.3.1.3 REMOVALS

For reasons similar to those agreed for humpback whales given above, the Workshop agreed that population projections should begin from a recent year (1940). This is earlier than for humpback whales because of the extended age-structure of the population.

The Workshop agreed that all the recent (post-1940) direct catches of bowhead whales by Canada and Denmark (Greenland) are known and thus that there was no need to consider an alternative catch series.

For 2011, Canada set an allowance of a maximum of four bowhead whales to be hunted in the Eastern Canadian Arctic. It is not known whether this allowance is for landed whales alone or whether it includes struck and lost whales; this is being investigated by the Secretariat.

The Workshop agreed that four scenarios regarding future Canadian catches should be considered (constant 5, 5 increasing to 10 over 100 years, 5 increasing to 15 over 100 years, constant 2.5; the last case reflects a situation in which half of the Canadian catches are taken from a different stock than the West Greenland catches). The sex-ratio for the West Greenland catches will be set to the sex ratio observed in the biopsy samples taken off West Greenland over the 2002-11 period while that for the Canadian catches should be set to the observed sex-ratio (the observed ratio for the Baffin Bay/Davis Strait whales taken by Canada is 4 male, 1 female, 4 unknown – this is being confirmed by the Secretariat).

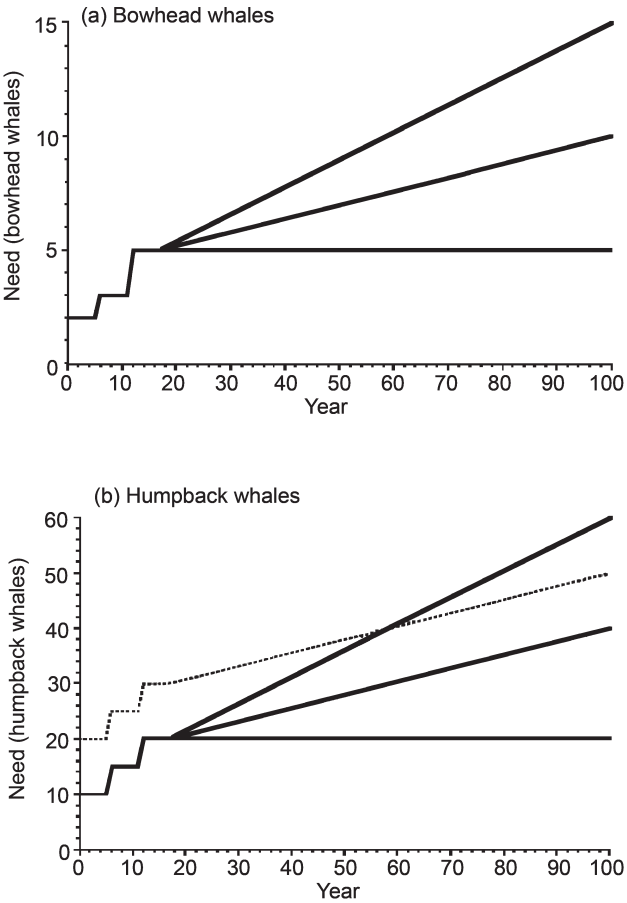


Fig. 2. Need envelopes A-D established for West Greenland bowhead and humpback whale trials.

Recent bycatches of bowhead whales by Denmark (Greenland) and any information for Canada that can be found by the Secretariat will be will be included in the revised trials specification. The Workshop noted that if the number of ship strikes increases as the Northwest Passage opens up, this could trigger an *Implementation Review*.

3.3.1.4 BIOLOGICAL PARAMETERS

In the absence of information for this region, the Workshop agreed to use the priors for f_{max}, S_{1+} and a_m used for the *Implementation* for the Bering-Chucki-Beaufort Seas bowhead whales, noting that these incorporate considerable uncertainty for all three parameters.

3.3.1.5 NEED

Brandon and Scordino (2012), presented to the Workshop, had suggested three scenarios, each of which involves an increase to the need from 2 to 5 at the start of the projection period followed by either: (1) no increase of need; (2) a doubling; and (3) a tripling of need in a linear fashion over the total time period. This is shown in Fig. 2.

3.3.1.6 TRIALS

The Workshop developed proposed *Evaluation* and *Robustness* trials. These formed the basis for discussions under Item 3.3.3.

3.2.2 Discussion of the Workshop report and the results of intersessional work

The SWG thanked the Workshop for it comprehensive work and **broadly endorsed** its conclusions and recommendations; where appropriate they are incorporated in the trial specifications (Appendix 2) or provided the basis for further discussion under Item 3.3.3 below.

3.3.2 RESULTS OF INITIAL WORK ON *SLA*S

The SWG received initial results provided by the two sets of developers of candidate *SLA*s, which were based on trials as developed at the Intersessional Workshop. As the SWG discussed the results of this work for humpback and bowhead whales together, these are considered further under Item 3.4.

3.3.3 Trial structure

The SWG finalised the trial structure (see Appendix 2) for evaluation of *SLA*s for the West Greenland bowhead whale hunt.

The SWG adopted the same planned evaluation strategies (statistics, tables, graphs) as described in Item 3.2.3 for the humpback case. This includes clarification of the abundance and depletion statistics in the situation of zero strikes and/or incidental removals.

SC/65a/Rep02 described *Evaluation Trials* 8A and 8B in which Canadian bowhead strikes tripled over 100 years. The SWG **agreed** to change these from *Evaluation Trials* to *Robustness Trials* (now 4A and 4B). It noted that a situation where Canadian bowhead strikes increased so much would trigger an *Implementation Review*, and therefore it was not necessary to incorporate such a scenario in the tested parameter space.

For the same reasons documented for humpback whales (see Item 3.2.3), the SWG **agreed** to add *Evaluation Trials* involving 'asymmetric environmental stochasticity'. It also **agreed** to include need scenario B in all *Evaluation Trials.*

A number of the preliminary results considered under Item 3.4 illustrated that it would be difficult to meet conservation objectives satisfactorily when the need level was high, especially if Canadian catches (which are taken by a non-IWC member country) increase. The SWG discussed whether it would be advisable to reconsider how strike quotas and incidental removals (i.e. by Canadian hunters) are accounted for in the *SLA* computations. However, it **agreed** to continue with the current framework but also **agreed** that this topic should be further considered at the next intersessional workshop.

3.4 Results from initial work on *SLA*s for humpback and bowhead whales

The SWG discussed the results provided by the two sets of developers of candidate *SLAs*, which were based on trials as developed at the intersessional Workshop.

Witting introduced SC/65a/AWMP04 which describes candidates *SLA*s for the West Greenland hunt on humpback whales. Two candidates based on the current interim *SLA* are proposed. They are both simple data based procedures with no internal population model, and they were selected from a total set of 48 examined procedures. All procedures were tested on a selected set of evaluation trials that included nearly all low production trials, and here they were set to pass a test of acceptable conservation performance (5th percentile of D10 larger than one) before they could be chosen as an acceptable procedure dependent upon their need satisfaction performance and other features. Both procedures estimate the strike limit as a function of 3% of the 2.5th percentile of an estimate of abundance. They put additional limits on the strike limit if the point-estimate of abundance is below 1,200, and one of the two procedures sets the strike limit to need if it exceeds 80% of need.

Witting then presented SC/65a/AWMP05 which describes candidates *SLA*s for the West Greenland hunt on bowhead whales. A similar approach to that taken in SC/65a/AWMP04 was followed. However, none of the 29

*SLA*s initially considered were able to pass the conservation criterion for the low production trials of the two alternative B and C scenarios for future Canadian catches, where annual Canadian catches are assumed to increase from 5 to 10, and from 5 to 15 over the simulation period. Not even a zero-*SLA*, which assumed zero Greenlandic catches for the whole period, was able to pass the conservation criterion when the Canadian catches increased from 5 to 15. Hence, the *SLA* development was restricted to trials where the annual Canadian catches were assumed to be no higher than five. The procedure with highest need satisfaction and acceptable conservation performance on these trials was then selected as a candidate *SLA*. This ($r_5N_{2.5}$PS) procedure sets the strike limit as a function of 0.5% of the 2.5th percentile of an estimate of abundance, it puts additional limits on the strike limit if the point-estimate of abundance is below 1,200, and it sets the strike limit to need if it exceeds 80% of need. Another candidate ($r_1N_{2.5}$Pa) was selected to optimise need satisfaction should annual need not exceed 5 in the future. This procedure provides higher need satisfaction than $r_5N_{2.5}$PS, and it sets the strike limit as a function of 1% of the 2.5th percentile putting additional limits on the strike limit if the point-estimate of abundance is below 800. While selected to have acceptable D10 conservation performance only on the low need trials, conservation performance for $r_1N_{2.5}$Pa on the high need trials failed only marginally on trial B03BC.

Brandão presented results for four possible *SLA*s from SC/65a/AWMP02. One of the *SLA*s considered is the Interim *SLA* which is based on the most recent estimate of abundance, while the other three *SLA*s are variants of a weighted-average interim *SLA* which uses all abundance estimates, but earlier abundance estimates are downweighted compared to more recent ones. A simple integrative approach to provide a ready coarse comparison of the performance of each *SLA* across all the evaluation and robustness trials was put forward, based on the lower 5%-iles of the N9 (need satisfaction) and D1 (depletion) performance statistics. An index of depletion (D_{imp}) is first computed that measures the extent by which the *SLA* under consideration improves depletion compared to the *Strike Limit = Need SLA*. A statistic is put forward that gives a measure (Q) of the deviation from the ideal scenario of obtaining a result given values of the lower 5%-ile need satisfaction (N9) and of the index of depletion from a trial of both to be (close to) 1. There are two simple approaches to comparing the performance of *SLA*s under trials using this statistic, where averages are readily taken over all trials. These averages could apply either to the *Q* statistic itself or to a ranking for each trial based on the value of *Q* across the *SLA*s considered. There was generally little to choose between the four *SLA*s considered in terms of performance measured by these statistics. There was a qualitative difference between the two species: for humpback whales the *SLA* using the most recent abundance estimate only was preferred, whereas for bowheads the preference was to use all estimates with little downweighting for time since the survey. However, none of the *SLA*s considered performed adequately in terms of resource depletion for the lowest $MSYR_{1+}$ values considered.

In discussion both sets of developers responded to questions of clarification. The protection level concept introduced in the Witting *SLA*s was noted with interest, and it was suggested that this concept might be introduced to the Brandão *SLA*s to attempt to arrest the poor conservation performance on some trials. It was noted that at this stage, each set of developers had developed their own approaches to choose amongst the *SLA* candidates which they had tested. The SWG noted that this was an acceptable approach for developer to take when investigating the performance of their initial *SLA*s before deciding to put 'official' candidates forward but **re-iterated** that final choices would need to be based on the full set of performance statistics agreed for the trials.

3.5 Future consideration of multispecies advice

3.5.1 Report of intersessional Workshop (SC/65a/Rep02)

The Workshop referred to earlier discussions (IWC, 2011b; Witting, 2008) on this matter which have noted that Greenland's need is expressed in terms of tonnes of edible products, and for operational reasons some flexibility (to allow for temporal variability in the species composition of this tonnage) is important and would be preferred. The inclusion of such flexibility within a set of *SLA*s for a number of species, where these *SLA*s would need to be inter-linked, is a challenging scientific task in terms of designing the necessary simulation tests. The Workshop had re-iterated previous advice that this aspect is best pursued only after separate *SLA*s, which operate independently for each species, have been developed and accepted.

3.5.2 Conclusions and recommendations

The SWG endorsed the Workshop's conclusion and **re-iterated** previous advice (IWC, 2012) that this issue is best pursued only after separate *SLA*s, which operate independently for each species, have been developed and accepted.

4. ANNUAL REVIEW OF MANAGEMENT ADVICE

The SWG noted that the Commission had not reached agreement on strike limits for Greenland at the 2012 Annual Meeting (IWC, 2013a). It based its management advice on the same limits considered last year. In providing this advice it noted that the Commission has endorsed the interim safe approach (based on the lower 5th percentile for the most recent estimate of abundance) for providing advice for the Greenland hunts developed by the Committee in 2008 (IWC, 2009, p.16); it was agreed that that this should be considered valid for two blocks, i.e. up to the 2018 Annual Meeting.

4.1 Common minke whales off West Greenland

4.1.1 New information (incl. catch data and agreed abundance estimates)

In the 2012 season, 144 minke whales were landed in West Greenland and 4 were struck and lost. Of the landed whales, there were 109 females, 33 males and two of unknown sex. Genetic samples were obtained from 112 of these whales. Last year, the Committee has re-emphasised the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP workshop (see Annex D). The SWG **welcomed** the fact that nearly 80% of the catch had been sampled in 2012 and encouraged continued sample collection.

This year, the SWG adopted a revised estimate of abundance for the 2007 survey. The revised published estimate (16,100 CV=0.43) was slightly lower than that first agreed in 2009. The SWG noted that this estimate is an underestimate of the total population by an unknown amount.

4.1.2 Management advice

In 2009, the Committee was for the first time able to provide management advice for this stock. This year, using the agreed

Table 2
Most recent estimates of abundance for the Central stock of common minke whales.

Small Area(s)	Year(s)	Abundance and CV
CM	2005	26,739 (CV=0.39)
CIC	2007	10,680 (CV=0.29)
CG	2007	1,048 (CV=0.60)
CIP	2007	1,350 (CV=0.38)

interim approach and the revised estimate of abundance given under Item 4.1.1, the SWG **advised** that an annual strike limit of 164 will not harm the stock. It **drew attention** to the fact that this is 14 whales lower than its advice of last year due to the revised 2007 abundance estimate.

4.2 Common minke whales off East Greenland

4.2.1 New information (incl. catch data and agreed abundance estimates)

Four female common minke whales were struck (and landed) off East Greenland in 2012. Two were females and the sex of the other two was unknown. The SWG was **pleased** to note that genetic samples were obtained from all minke whales caught in East Greenland (these could be used *inter alia* to determine the sex of the unknown animals). The Committee **again emphasised** the importance of collecting genetic samples from these whales, particularly in the light of the proposed joint AWMP/RMP workshop (see Annex D).

4.2.2 Management advice

Catches of minke whales off East Greenland are believed to come from the large Central stock of minke whales. The most recent strike limit of 12 represents a very small proportion of the Central Stock – see Table 2. The SWG **repeats** its advice of last year that the strike limit of 12 will not harm the stock.

4.3 Fin whales off West Greenland

4.3.1 New information (incl. catch data and agreed abundance estimates)

A total of four fin whales (all females) were landed, and one was struck and lost, off West Greenland during 2012. The SWG was **pleased** to note that genetic samples were obtained from three whales. The SWG **re-emphasised** the importance of collecting genetic samples from these whales, particularly in the light of the proposed work to develop a long-term *SLA* for this stock.

4.3.2 Management advice

Based on the agreed 2007 estimate of abundance for fin whales (4,500 95%CI 1,900-10,100), and using the agreed interim approach, the SWG **repeated** its advice that an annual strike limit of 19 whales will not harm the stock.

4.4 Humpback whales off West Greenland

4.4.1 New information (incl. catch data and agreed abundance estimates)

A total of seven (two males; four females; one unknown sex) humpback whales were landed (three more were struck and lost) in West Greenland during 2012. The SWG was **pleased** to learn that genetic samples were obtained from all of these whales and that Greenland was contributing fluke photographs to the North Atlantic catalogue – four have been submitted from whales taken since 2010. The SWG again **emphasised** the importance of collecting genetic samples and photographs of the flukes from these whales, particularly with respect to the MoNAH and YoNAH initiatives (Clapham, 2003; YoNAH, 2001).

This year, the SWG **endorsed** the revised fully corrected abundance estimate for West Greenland from the 2007 survey of 2,704 (CV=0.34) for the strip census abundance estimate (see Item 3 above). The agreed annual rate of increase of 0.0917 (SE 0.0124) remains unchanged.

4.4.2 Management advice

Based on the revised agreed estimate of abundance for humpback whales given above and using the agreed interim approach, the SWG **agreed** that an annual strike limit of 10 whales will not harm the stock.

4.5 Humpback whales off St Vincent and The Grenadines

4.5.1 New information (incl. catch data and agreed abundance estimates)

No new information or catch data were provided in time for consideration by the SWG although information has been requested by the Secretariat. Lang reported that there is one sample collected from a humpback whale taken on 11 April 2012 in the SWFSC tissue archive. The SWG **welcomed** this information.

Iñíguez reported information obtained from local newspapers on hunts on St Vincent and the Grenadines: a 35ft male (8 March 2013); a 41ft female and a 35ft male (both 18 March 2013); and another whale with no length or sex information (12 April 2013).

Regarding the same stock, he referred to reports that residents of Petite Martinique, Grenada, spent hours attempting to drive a mature whale onto a beach using five inflatable boatss, two large trader boats and a speedboat on 22 November 2012. The whale finally escaped but was harpooned four times. He has no further information on what happened with this whale.

4.5.2 Management advice

The SWG repeated its previous strong recommendations that St. Vincent and The Grenadines:

(1) provide catch data, including the length of harvested animals, to the Scientific Committee; and
(2) that genetic samples be obtained for any harvested animals as well as fluke photographs, and that this information be submitted to appropriate catalogues and collections.

The SWG has agreed that the animals found off St. Vincent and the Grenadines are part of the large West Indies breeding population (abundance estimate 11,570 95%CI 10,290-13,390). The Commission adopted a total block catch limit of 24 for the period 2013-18 for Bequians of St. Vincent and The Grenadines. The SWG **repeated** its advice that this block catch limit will not harm the stock.

The SWG draws the Commission's attention to the unofficial reports of attempts to land a humpback whale in Grenada; the Schedule specifies that the quota applies only to Bequians of St. Vincent and The Grenadines. The SWG requests that the Secretariat contact the Government of Grenada to obtain official information on this incident.

5. ABORIGINAL WHALING MANAGEMENT SCHEME

5.1 Guiding principles for *SLA* development and evaluation

The SWG noted that considerable effort had been put into general consideration of the development of *SLA*s at the beginning of the AWMP process (IWC, 2000; 2001; 2002).

It **agreed** that it would be useful to briefly outline some guiding principles for *SLA*s to assist developers of candidate *SLA*s for the Greenland hunts. These are summarised below.

(a) The primary objective of any *SLA* is to meet the objectives set by the Commission with respect to need satisfaction and conservation performance, with priority given to the latter.
(b) *SLA*s must incorporate a feedback mechanism.
(c) Once need has been met for the 'high' need envelope while giving acceptable conservation performance, then there is no need to try to improve the performance of an *SLA* further.
(d) Simple *SLA*s are to be preferred, providing this simplicity does not compromise achieving the Commission's objectives.
(e) With respect to (d), empirical procedures may prove preferable to population model based procedures because (1) they are more easily understood by stakeholders and (2) there is little chance for significant updating of population model parameters (e.g. MSYR) over time as the extent of additional data will probably be limited for populations subject to aboriginal whaling only. Nevertheless, the choice of the form for any candidate *SLA* lies entirely in the hands of its developer, with selection amongst candidates to be based only on performance in trials.
(f) If in developing *SLA*s, a situation arises where relatively simple *SLA*s fail on one or a few trials where the circumstances which might lead to the failure occur only many years in the future, rather than attempt to develop more complex *SLA*s to overcome this problem, a simpler *SLA* could be proposed despite this failure, and the difficulties dealt with by means of an *Implementation Review* should there be indications in the future that the circumstances concerned are arising. This principle applies only to: (1) circumstances in a scenario that are external and independent of the hunting/quota feedback loop, such as very high values of the future need envelope; and (2) are judged to be very unlikely to occur in the next few decades. Failure of an *SLA* to perform acceptably in some circumstance is not in itself a reason to apply this principle.

5.2 Scientific aspects of an aboriginal whaling scheme

In 2002, the Committee **strongly recommended** that the Commission adopt the Aboriginal Subsistence Whaling Scheme (IWC, 2003). This covers a number of practical issues such as survey intervals, carryover, and guidelines for surveys. The Committee has stated in the past that the AWS provisions constitute an important and necessary component of safe management under AWMP *SLA*s and it **reaffirms** this view as it has for the previous 11 years.

6. PROGRESS ON FOLLOW-UP WORK ON CONVERSION FACTORS FOR THE GREENLANDIC HUNT

6.1 New information

In 2009, the Commission appointed a small working group (comprising several Committee members) to visit Greenland and compile a report on the conversion factors used by species to translate the Greenlandic need request which is provided in tonnes of edible products to numbers of animals (Donovan *et al.*, 2010). At that time the group provided conversion factors based upon the best available data, noting that given the low sample sizes, the values for species other than common minke whales should be considered provisional. The group also recommended that a focused attempt to collect new data on edible products taken from species other than common minke whales be undertaken, to allow a review of the interim factors; and that data on both 'curved' and 'standard' measurements are obtained during the coming season for all species taken. The report was endorsed by the Scientific Committee (IWC, 2011a, p.21).

Since then the Committee has received progress reports but has commented that more detail and information is required. Last year the Committee recommended:

(1) the provision of a full scientific paper to the next annual meeting that details *inter alia* at least: a full description of the field protocols and sampling strategy (taking into account previous suggestions by the Committee); analytical methods; and a presentation of the results thus far, including information on the sex and length of each of the animals for which weight data are available; and
(2) the collection and provision of data on Recommendation No. 2 of Donovan *et al.* (2010) comparing standard versus curvilinear whale lengths. This should be done for all three species on as many whales as possible.

SC/65a/AWMP07 reports on the collection of weights and length measures from fin, humpback and bowhead whales caught in West Greenland. To improve the data collection process, information meetings involving biologists, hunters, wildlife officers and hunting license coordinators were held in the larger towns in 2012, and an information folder was produced and distributed to the hunters. The data collection process was also combined with an existing research project on hunting samples in order to get a stronger involvement of biologists. When researchers participate in hunts they train the hunters in measuring the lengths (curved and standard) and they make sure that the meat is weighed.

Until now the reporting rate has been lower than expected, with the data obtained in 2012 being from only one fin whale and one humpback whale, and the total number of reports since 2009 being from six bowhead whales, six humpback whales and three fin whales. These data provide preliminary yield estimates for all edible products of 9,014kg (SE:846) per humpback whale, of 6,967kg (SE:2,468) per fin whale, and of 8,443kg (SE:406) per bowhead whale. These numbers are all somewhat lower than the suggested yield in Donovan *et al.* (2010), and this is especially pronounced for fin whales. Nevertheless, the obtained estimates for fin whales fall within the range of previous yield weight estimates for fin whales in West Greenland.

A major reason for the low reporting rate has been the almost complete absence of weighing equipment where the whalers could weigh the different products. To increase the reporting rate, the Greenland Institute of Natural Resources has now purchased and distributed cranes to major towns for the hunters to use for weighing when landing a catch. It was also realised that the 'bin system' described in previous reports is more complicated than first anticipated because there is a large variation in the size of the bins used within the same hunt and between hunters. It is therefore now recommended that hunters weigh all edible products with the crane weight when they land the meat with the crane in the harbor. This approach will be investigated further in 2013 and discussed with the hunters. Owing to the logistical difficulties involved with whale hunts in Greenland (which

Table 3

Summary of absolute abundance estimates. Relative abundance estimates for use in the trials are given in Appendix 2 (Table 3).

Area	Year	Corr*	Estimate and approx. 95% CI and CV	IWC reference	Original reference
Common minke whale					
West Greenland	2007	A+P	16,100 (6,930-37,400) (CV:0.43)	IWC (2010); SC/65a	Heide-Jørgensen *et al.* (2010c)
West Greenland	2005	A+P	10,790 (3,400-34,300) (CV:0.59)	IWC (2008)	Heide-Jørgensen *et al.* (2008)
West Greenland	1993	A	8,370 (3,600-19,440) (CV:0.43)	IWC (1995)	Larsen (1995)
Fin whale					
West Greenland	2007		4,360 (1,810-10,530) (CV:0.45)	IWC (2009)	Heide-Jørgensen *et al.* (2010a)
West Greenland	2005	P	3,230 (1,360-7,650) (CV:0.44)	IWC (2008)	Heide-Jørgensen *et al.* (2008)
West Greenland	1988	A	1,100 (554-2,180) (CV:0.35)	IWC (1993)	IWC (1993)
Humpback whale					
West Greenland	2007	A+P	4,090 (1,690-9,880); (CV:0.45) MRDS	IWC (2009); SC/65a	Heide-Jørgensen *et al.* (2012); SC/65a/AWMP01
West Greenland	2007*	A+P	2,700 (1,390-5,270) (CV:0.34) strip census	IWC (2009); SC/65a	Heide-Jørgensen *et al.* (2012); SC/65a/AWMP01
Bowhead whale					
Prince Regent Inlet	2002	A+P	6,340 (3,119-12,906) (CV:0.36)	IWC (2009)	IWC (2009)
Foxe Basin – Hudson Bay	2003	A+P	1,525 (333-6,990) (CV:0.78)	IWC (2009)	IWC (2009)
West Greenland	2007	A+P	1,229 (489-3,090) (CV: 0.47)	IWC (2008)	Heide-Jørgensen *et al.* (2007);
Isabella Bay	2009	A+P?	1,105 (515-2,370) (CV: 0.39)	SC/65a/Rep02	Hansen *et al*. (2012)

*Indicates whether the estimate has been corrected for availability bias and/or perception bias.

are widespread along the coast and occur at unpredictable times during a long season) and the required change in the reporting system and subsequent need for training, it is likely that it will take several years to collect sufficient data on edible products.

6.2 Discussion

In response to questions, a number of clarifications were made. The original intention of weighing ten boxes had been so that an average weight per box could be developed to be multiplied by the total number of boxes to obtain an estimated total weight. However, with the efficient crane weights that are now in place in three cities, and with the finding that hunters may use different sized boxes even for the same whale, it has now been decided to weigh all boxes.

There were only five cases when scientists were able to be present at a humpback catch, and the low number illustrates the logistical difficulties in having scientists present at hunts. Witting did not have the precise details of this work or of the number of wildlife officers who may be able to assist in the work but will consult in Greenland. Efficient reporting requires not only training of hunters, but also the distribution of weighing equipment, so that hunters can report on their own.

In conclusion, the SWG **agreed** that the report was an advance on those previously received (and provided the first information on curvilinear lengths). However, it also **agreed** that it still did not provide sufficient information to fulfil the recommendations of last year. While aware of the logistical difficulties involved in obtaining these data, it **repeated its recommendations** of last year given in the second paragraph of this section. It **encouraged** Witting to assist in the writing of such a report to ensure that it better meets the request of the SWG next year.

7. CONSERVATION MANAGEMENT PLANS (CMPS)

The SWG noted the request for sub-groups to consider potential priority candidates for CMPs (SC/65a/SCP01). After considering the criteria given in that document the SWG **agreed** that it had no candidates for CMPs.

8. UPDATED LIST OF ACCEPTED ABUNDANCE ESTIMATES

The SWG noted the request to develop a list of accepted abundance estimates for consideration as part of an overall summary for all species to be developed by the Plenary. This was developed and has been forwarded for Plenary compilation. The abundance estimates agreed by this SWG are summarised above in Table 3.

9. WORK PLAN AND BUDGET REQUESTS

9.1 Work plan

The SWG **agreed** that the Chair should develop the work plan based upon the substantive items in the report. This is give in Table 4.

9.2 Budget requests

Intersessional Workshop on Developing SLA*s for the Greenlandic hunts*

The existing interim safe procedure for the Greenlandic hunts agreed in 2008 (IWC, 2009, p.16) was agreed to be valid for up to quota blocks so up to 2018. The Committee has identified completion of the development of long-term *SLA*s for these hunts as high priority work. In order to meet the proposed timeframe, an intersessional Workshop is required. The focus of the proposed Workshop is to: (1) to review the results of the developers of *SLA*s for humpback whales and bowhead whales; (2) finalise the modelling framework/trial structure for these hunts; (3) develop a work plan to try to enable completion of work on *SLA*s for these two hunts at the 2014 Annual Meeting; and (4) consider possible input (e.g. using AWMP/RMP-lite) for the joint AWMP/RMP workshop on North Atlantic common minke whale stock structure. The Workshop will be held in early 2014 in Copenhagen, Denmark, hosted by the Greenland representation; the costs are for IPs travel. It is intended to hold this back-to-back with and RMP Workshop on fin whales to save travel costs given some common membership.

AWMP Developers' fund

The developers fund has been invaluable in the work of *SLA* development and related essential tasks of the SWG.

Table 4
Work plan.

Item	Topic	Responsible persons	Deadline/target
3.1	Participate in the RMP North Atlantic fin whale RMP *Implementation* process and report back on the implications of this for *SLA* development for the Greenland hunt.	Donovan, Punt, Witting, Butterworth.	2014 Annual Meeting
3.1	Hold joint AWMP/RMP workshop on the stock structure of common minke whales in the North Atlantic (also see Annex D).	Joint Steering Group under Palsbøll.	Expected spring 2014
3.1	Submit need envelopes for West Greenland fin and common minke whales.	Witting.	Early Jan. 2014
3.2 and 3.3	Finalise the trials for the West Greenland humpback and bowhead whales (including coding) to allow developers to work intersessionally. Ensure that standard software is available to produce agreed performance statistics, as well as tabular and graphical output.	Steering Group convened by Donovan (Punt, Givens, Butterworth, Witting). Coding to be undertaken by Punt and Allison and developers.	(1) Agree specification and parameterisation by email and Skype: end Jul. 2013. (2) Complete coding and supply to developers: end Aug. 2013
3.2	Present overview of photo-identification work with respect to movements to inform stock structure and human induced mortality outside West Greenland.	Greenlandic scientists and College of the Atlantic (to be co-ordinated by Witting).	As soon as possible – ideally end of Aug. to assist Allison (see below), at latest in time for intersessional Workshop in early Jan. 2014
3.2 and 3.3	Finalise removals series including consideration of human-induced mortality outside the West Greenland area.	Allison.	End Aug. 2013
3.2 and 3.3	Continue initial exploration of potential *SLA*s for the Greenland humpback and bowhead whale hunts.	Developers.	For presentation at intersessional Workshop in early Jan. 2014
6.2	Produce full report on Greenlandic conversion factor programme.	Greenlandic authorities (assisted by Witting).	2014 Annual Meeting

It has been agreed as a standing fund by the Commission. The primary development tasks facing the SWG are for the Greenlandic fisheries. These tasks are of high priority to the Committee and the Commission. The fund is essential to allow progress to be made. It now stands at £8,000 and a request of £7,000 is made to restore it to the initial target level of £15,000.

10. ADOPTION OF REPORT

The report was adopted at 1900hrs on 11 June 2103. The SWG authorised the Chair to make editorial changes to the report as necessary to improve clarity. It also agreed that he should develop the work plan based upon the substantive items. The Chair thanked the participants for the constructive and co-operative attitude throughout these important discussions, some of which are highly technical. In particular, he thanked the developers for their work during the intersessional period that had greatly facilitated progress and the rapporteurs for their dedicated work. The SWG thanked the Chair for his efficient and good-humoured guidance.

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Appendix 1

AGENDA

1. Introductory items
    - 1.1 Convenor's opening remarks
    - 1.2 Election of Chair
    - 1.4 Appointment of rapporteurs
    - 1.5 Adoption of Agenda
    - 1.6 Documents available
2. Gray whales with emphasis on the PCFG (Pacific Coast Feeding Group)
    - 2.1 Report of intersessional Workshop (SC/65a/Rep02)
    - 2.2 New information and results
        - 2.2.1 Further evaluation of proposed Makah Hunt
        - 2.2.2 Other information
    - 2.3 Summary and recommendations
3. Consideration of work required to develop *SLAs* for all Greenland hunts before the end of the interim period
    - 3.1 Common minke whales and fin whales
        - 3.1.1 Report from the intersessional Workshop (SC/65a/Rep02)
        - 3.1.2 Joint RMP/AWMP Workshop(s) on stock structure
        - 3.1.4 Discussion and work plan
    - 3.2 Humpback whales
        - 3.2.1 Report from the intersessional workshop (SC/65a/Rep02)
        - 3.2.2 Discussion of the Workshop report and the results of intersessional work
        - 3.2.3 Trial structure
    - 3.3 Bowhead whales
        - 3.3.1 Report from the intersessional Workshop (SC/65a/Rep02)
        - 3.2.2 Discussion of the Workshop report and the results of intersessional work
        - 3.3.3 Trial structure
    - 3.4 Results from initial work on *SLA*s for humpback and bowhead whales
        - 3.5.2 Conclusions and recommendations
4. Annual review of management advice
    - 4.1 Common minke whales off West Greenland
        - 4.1.1 New information (incl. catch data and agreed abundance estimates)
    - 4.2 Common minke whales off East Greenland
        - 4.2.1 New information (incl. catch data and agreed abundance estimates)
        - 4.2.2 Management advice
    - 4.3 Fin whales off West Greenland
        - 4.3.1 New information (incl. catch data and agreed abundance estimates)
        - 4.3.2 Management advice
    - 4.4 Humpback whales off West Greenland
        - 4.4.1 New information (incl. catch data and agreed abundance estimates)
        - 4.4.2 Management advice
    - 4.5 Humpback whales off St Vincent and The Grenadines
        - 4.5.1 New information (incl. catch data and agreed abundance estimates)
        - 4.5.2 Management advice
5. Aboriginal Whaling Management Scheme
    - 5.1 Guiding principles for *SLA* development and evaluation
    - 5.2 Scientific aspects of an aboriginal whaling scheme
6. Progress on follow-up work on conversion factors for the Greenlandic hunt
    - 6.1 New information
    - 6.2 Discussion
7. Conservation Management Plans (CMPs)
8. Updated list of abundance estimates
9. Work plan and budget requests
    - 9.1 Work plan
    - 9.2 Budget requests
10. Adoption of report

Appendix 2

TRIAL SPECIFICATIONS FOR HUMPBACK AND BOWHEAD WHALES OFF WEST GREENLAND

[NB: Aspects of these specifications, including those highlighted, will be finalised prior to the 2014 Annual Meeting by an Intersessional Steering Group and Workshop]

A. The population dynamics model

The underlying dynamics model is deterministic, age- and sex-structured, and based on the Baleen II model (Punt, 1999).

A.1 Basic dynamics

Equations A1.1 provide the underlying 1+ dynamics.

$$\begin{aligned} R^{m/f}_{t+1,a+1} &= (R^{m/f}_{t,a} - C^{m/f}_{t,a}) S_a + U^{m/f}_{t,a} S_a \delta_{a+1} && 0 \le a \le x-2 \\ R^{m/f}_{t+1,x} &= (R^{m/f}_{t,x} - C^{m/f}_{t,x}) S_x + (R^{m/f}_{t,x-1} - C^{m/f}_{t,x-1}) S_{x-1} && \\ U^{m/f}_{t+1,a+1} &= U^{m/f}_{t,a} S_a (1-\delta_{a+1}) && 0 \le a \le x-2 \end{aligned} \quad \text{(A1.1)}$$

$R^{m/f}_{t,a}$ is the number of recruited males/females of age a at the start of year t;

$U^{m/f}_{t,a}$ is the number of unrecruited males/females of age a at the start of year t;

$C^{m/f}_{t,a}$ is the catch of males/females of age a during year t (whaling is assumed to take place in a pulse at the start of each year);

δ_a is the fraction of unrecruited animals of age a-1 which recruit at age a (assumed to be independent of sex and time);

S_a is the annual survival rate of animals of age a:

$$S_a = \begin{cases} S_0 & \text{if } a = 0 \\ S_{1+} & \text{if } 1 < a \le a_a \\ & \text{if } a > a_a \end{cases} \quad \text{(A1.2)}$$

S_0 is the calf survival rate;

S_{1+} is the survival rate for animals aged 1 and older; and

x is the maximum (lumped) age-class (all animals in this and the x-1 class are assumed to be recruited and to have reached the age of first parturition). x is taken to be 15 for humpback whales and 35 for bowhead whales for these trials.

A.2 Births

The number of births at the start of year t+1, B_{t+1}, is given by Equation A2.1:

$$B_{t+1} = b_{t+1} N^f_{t+1} \quad \text{(A2.1)}$$

N^f_t is the number of mature females at the start of year t:

$$N^f_t = \sum_{a=a_m}^{x} (R^f_{t,a} + U^f_{t,a}) \quad \text{(A2.2)}$$

a_m is the age-at-maturity (the convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition);

b_{t+1} is the probability of birth/calf survival for mature females:

$$b_{t+1} = \max(0, b_K \{1 + A(1 - [N^{1+}_{t+1} / K^{1+}]^z)\}) \quad \text{(A2.3)}$$

$$N^{1+}_t = \sum_{a=1}^{x} (R^f_{t,a} + U^f_{t,a} + R^m_{t,a} + U^m_{t,a})$$

$$K^{1+} = \sum_{a=1}^{x} (R^f_{-\infty,a} + U^f_{-\infty,a} + R^m_{-\infty,a} + U^m_{-\infty,a}) \quad \text{(A2.4)}$$

b_K is the average number of live births per year per mature female at carrying capacity;
A is the resilience parameter; and
z is the degree of compensation.

The number of female births, B_t^f, is computed from the total number of the births during year *t* using Equation A2.5:

$$B_t^f = 0.5 \ \ B_t \tag{A2.5}$$

The numbers of recruited/unrecruited calves is given by:

$$\begin{array}{ll} R_t^f = \alpha_0 \, B_t^f & R_t^m = \alpha_0 \, (B_t - B_t^f) \\ U_t^f = (1-\alpha_0) B_t^f & U_t^m = (1-\alpha_0)(B_t - B_t^f) \end{array} \tag{A2.6}$$

α_0 is the proportion of animals of age 0 which are recruited (0 for these trials).

A.3 Catches

The historical (t<2013) removals are taken to be equal to the total reported removals (including struck and lost, by-catch, ship strikes, etc.) catches (Table 1). The sex-ratio of future aboriginal catches is assumed to be 50:50 F:M (bowheads) and 20:80 F:M (humpbacks) while the sex ratio of by catches, ship strikes and Canadian catches is assumed to be 50:50 F:M. Catches are taken uniformly from the recruited component of the population:

$$C_{t,a}^m = C_t^m \, R_{t,a}^m / \sum_{a'} R_{t,a'}^m \, ; \qquad C_{t,a}^{m/f} = C_t^f \, R_{t,a}^f / \sum_{a'} R_{t,a'}^f \tag{A3.1}$$

$C_t^{m/f}$ is the catch of males/females during year *t*.

The total catch in a given future year is the sum of: (a) the minimum of the need for that year, Q_t, and the corresponding strike limit; (b) bycatches in fisheries; (c) ship strikes; and (d) aboriginal catches in Canada (only bowheads).

The total bycatch during future year y is computed by applying the average exploitation rate during 2007-11 to the number of 1+ animals in year y, i.e.:

$$\tilde{C}_t = \tilde{F} \, N_t^{1+} \tag{A3.2}$$

$\tilde{F}$ is the average exploitation rate due to by-catch during 2007-11:

$$\tilde{F} = \sum_{t=2007}^{2011} (\tilde{C}_t^f + \tilde{C}_t^m) / \sum_{t=2007}^{2011} N_t^{1+} \tag{A3.3}$$

A.4 Recruitment

The proportion of animals of age a that would be recruited if the population was pristine is a knife-edged function of age at age a_r, i.e.:

$$\alpha_a = \begin{cases} 0 & \text{if} \ \ 0 \le a < a_r \\ 1 & \text{otherwise} \end{cases} \tag{A4.1}$$

a_r is the age-at-recruitment (assumed to be 5 for humpbacks and 1 for bowhead whales).

The (expected) number of unrecruited animals of age a that survive to age a+1 is $U_{t,a}^{m/f} \, S_a$. The fraction of these that then recruit is:

$$\delta_{a+1} = \begin{cases} [\alpha_{a+1} - \alpha_a] / [1-\alpha_a] & \text{if} \ 0 \le \alpha_a < 1 \\ 1 & \text{otherwise} \end{cases} \tag{A4.2}$$

A.5 Maturity

Maturity is assumed to be a knife-edged function of age at age a_m.

A.6 Initialising the population vector

The numbers at age in the pristine population are given by:

$$\begin{array}{ll} R_{-\infty,a}^{m/f} = 0.5 \ \ N_{-\infty,0} \ \ \alpha_a \prod_{a'=0}^{a-1} S_{a'} & \text{if} \ \ 0 \le a < x \\ U_{-\infty,a}^{m/f} = 0.5 \ \ N_{-\infty,0} \ \ (1-\alpha_a) \prod_{a'=0}^{a-1} S_{a'} & \text{if} \ \ 0 \le a < x \\ R_{-\infty,x}^{m/f} = 0.5 \ \ N_{-\infty,0} \prod_{a'=0}^{x-1} \dfrac{S_{a'}}{(1-S_x)} & \text{if} \ \ a = x \end{array} \tag{A6.1}$$

Table 1

Total removals? of bowhead and humpback whales.

Year	M	F	Year	M	F	Year	M	F
(a) Bowhead whales								
1940	1	1	1970	0	0	2000	0.5	0.5
1941	0.5	0.5	1971	1	1	2001	0	0
1942	0	0	1972	0	0	2002	0	0
1943	0	0	1973	0.5	0.5	2003	0.5	0.5
1944	0	0	1974	0	0	2004	0.5	0.5
1945	1.5	1.5	1975	1.5	1.5	2005	0.5	0.5
1946	0.5	0.5	1976	0	0	2006	0	0
1947	0.5	0.5	1977	0	0	2007	0	0
1948	0	0	1978	0	0	2008	1.5	1.5
1949	0	0	1979	0.5	0.5	2009	3	3
1950	0	0	1980	0.5	0.5	2010	2.5	2.5
1951	0	0	1981	0	0	2011	0	1
1952	0	0	1982	0	0	2012	0	0
1953	0	0	1983	0	0			
1954	0	0	1984	0	0			
1955	0.5	0.5	1985	0.5	0.5			
1956	0.5	0.5	1986	0	0			
1957	0	0	1987	0	0			
1958	0	0	1988	0	0			
1959	0.5	0.5	1989	0	0			
1960	0	0	1990	0	0			
1961	0.5	0.5	1991	0	0			
1962	0	0	1992	0	0			
1963	0	0	1993	0	0			
1964	0.5	0.5	1994	0.5	0.5			
1965	0.5	0.5	1995	0	0			
1966	0	0	1996	0.5	0.5			
1967	0.5	0.5	1997	0	0			
1968	0	0	1998	0.5	0.5			
1969	0	0	1999	0	0			
1935	0	0						
1936	0	0						
1937	0	0						
1938	0	0						
1939	0.5	0.5						
(b) Humpbacks								
1960	0	1	1980	8	8	2000	0	2
1961	0	1	1981	6	6	2001	1	1
1962	1	1	1982	6	6	2002	2	1
1963	0	0	1983	7	9	2003	0	1
1964	0	0	1984	8	8	2004	2	1
1965	0	1	1985	4	4	2005	2	3
1966	2	2	1986	0	0	2006	0	0
1967	2	2	1987	0	0	2007	1	1
1968	2	3	1988	0	1	2008	1	2
1969	1	2	1989	1	1	2009	0	0
1970	0	0	1990	0	1	2010	4	6
1971	2	2	1991	0	1	2011	3	5
1972	1	2	1992	0	1	2012	4	9
1973	5	6	1993	0	0			
1974	4	5	1994	0	1			
1975	4	5	1995	0	0			
1976	4	5	1996	0	0			
1977	8	9	1997	0	0			
1978	12	12	1998	0	1			
1979	7	8	1999	0	1			

$R^{m/f}_{-\infty,a}$ is the number of animals of age a that would be recruited in the pristine population;

$U^{m/f}_{-\infty,a}$ is the number of animals of age a that would be unrecruited in the pristine population; and

$N_{-\infty,0}$ is the total number of animals of age 0 in the pristine population.

The value for $N_{-\infty,0}$ is determined from the value for the pre-exploitation size of the 1+ component of the population using the equation:

$$N_{-\infty,0} = K^{1+} / \left(\sum_{a=1}^{x-1} \left(\prod_{a'=0}^{a-1} S_{a'} \right) + \frac{1}{1-S_x} \prod_{a'=0}^{x-1} S_{a'} \right) \quad \text{(A6.2)}$$

In common with the trials for the Eastern North Pacific gray whales (IWC, 2013), the trials are based on the assumption that the age-structure at the start of year τ is stable rather than that the population was at its pre-exploitation equilibrium size at the start of (say) 1600, the first year for which catch estimates are available. The determination of the age-structure at the start of year τ involves specifying the effective 'rate of increase', γ, that applies to each age-class. There are two components contributing to γ, one relating to the overall population rate of increase (γ^+) and the other to the exploitation rate. Under the assumption of knife-edge recruitment to the fishery at age a_r, only the γ^+ component (assumed to be zero following Punt and Butterworth [2002] applies to ages a of a_r or less. The number of animals of age a at the start of year τ relative to the number of calves at that time, $N^*_{\tau,a}$, is therefore given by the equation:

$$N^*_{\tau,a} = \begin{cases} 1 & \text{if } a = 0 \\ N^*_{\tau,a-1} S_{a-1} & \text{if } a \le a_r \\ N^*_{\tau,a-1} S_{a-1}(1-\gamma^+) & \text{if } a_r < a < x \\ N^*_{\tau,x-1} S_{x-1}(1-\gamma^+)/(1-S_x(1-\gamma^+)) & \text{if } a = x \end{cases} \quad \text{(A6.3)}$$

B_τ is the number of calves in year τ and is derived directly from equations A2.1 and A2.3 (for further details see Punt, 1999).

$$B_\tau = \left(1 - \left[1/(N^f_\tau b_K) - 1\right]/A\right)^{1/z} \frac{K^{1+}}{N^{1+,*}_\tau} \quad \text{(A6.4)}$$

The effective rate of increase, γ, is selected so that if the population dynamics model is projected from year τ to a year Ψ, the size of the 1+ component of the population in a reference year Ψ equals a value, P_Ψ which is drawn from a prior.

A.7 z and A

A, z and S_0, are obtained by solving the system of equations that relate *MSYL*, *MSYR*, S_0, S_{1+}, $f_{\max}$ a_m, A and z, where $f_{\max}$ is the maximum theoretical pregnancy rate (Punt, 1999).

A.8 Conditioning

The method for conditioning the trials (i.e. selecting the 100 sets of values for the parameters a_m, S_0, S_{1+}, K^{1+}, A and z) is based on a Bayesian assessment. The algorithm for conducting the Bayesian assessment is as follows:

(a) Draw values for the parameters S_{1+}, $f_{\max}$, a_m, $MSYR_{1+}$, $MSYL_{1+}$, K^{1+}, P_Ψ, CV_{add} (the additional variance for the estimates of 1+ abundance in Ψ) from the priors in Table 2. The additional variance for the estimates of absolute abundance and indices of relative abundance are assumed to be the same. It is not necessary to draw values for $MSYR_{1+}$ and $MSYL_{1+}$ because the values for these quantities are pre-specified rather than being determined during the conditioning process.
(b) Solve the system of equations that relate *MSYL*, *MSYR*, S_0, S_{1+}, $f_{\max}$, a_m, A and z to find values for S_0, A and z.
(c) Calculate the likelihood of the projection which is given by[1]:

$L=L_1L_2$ (L_2 applies only to the sighting rates for bowheads) where:

$$L_1 = \prod_t \frac{1}{\sqrt{\Omega_t^2 + CV^2_{add2}}} \exp\left(-\frac{(\ell n P_t^{obs} - \ell n\left(B_c \hat{P}_t\right))^2}{2(\Omega_t^2 + CV^2_{add2,t})}\right) \quad \text{(A8.1a)}$$

$$L_2 = \prod_t (\rho \hat{P}_t)^{N_t^{obs}} e^{-\rho \hat{P}_t} \quad \text{(A8.1a)}$$

P_t^{obs} is the estimate of the (1+) abundance at the start of year t (Table 3);

$\hat{P}_t$ is the model-estimate of the (1+) abundance which pertain to the survey estimates of abundance at the start of year t;:

$$\hat{P}_t = \tilde{S}^f \sum_{a=1}^{x} (R^f_{t,a} + U^f_{t,a}) + \tilde{S}^m \sum_{a=1}^{x} (R^m_{t,a} + U^m_{t,a}) \quad \text{(A.8.2)}$$

Ω_t is the (sampling) standard deviation of the logarithm of P_t^{obs} (approximated by its coefficient of variation, $CV^{obs}_{est,t}$ - see Table 3);

$\tilde{S}^f, \tilde{S}^m$ is the relative selectivity for females and males (1:1 for humpbacks and 1:0.25 for bowheads);

$E(CV^2_{add2,t})$ is the square of the actual CV of the additional variation for year t:

[1]The priors for the survey bias and additional variation are integrated out as these are nuisance parameters.

$$E(CV_{add2,t}^2) = \eta(0.1 + 0.013P^* / \hat{P}_t) = CV_{add2}^2 \frac{0.1 + 0.013P^* / \hat{P}_t}{0.1 + 0.013P^* / \hat{P}_\Psi} \quad \text{(A8.3)}$$

N_t^{obs} is the number of animals counted during year t (a relative index of abundance; Table 3b),

ρ is the constant of proportionality between the number of 1+ animals and the population counts, and

B_c is the bias associated with a relative index of abundance (different for each relative index).

Steps (a)-(c) are repeated a large number (typically 1,000,000) of times.

100 sets of parameters vectors are selected randomly from those generated using steps (a)-(c), assigning a probability of selecting a particular vector proportional to its likelihood. The number of times steps (a)-(c) are repeated is chosen to ensure that each of the 100 parameter vectors are unique.

The bulk of the trials for humpbacks are conditioned on the estimate of absolute abundance (Table 3a) and the time series of relative abundance based on aerial surveys (Table 3b). The relative indices of abundance based on mark-recapture are used when conditioning one of the *Robustness Trials*.

Table 2

The prior distributions.

Parameter	Prior distribution (humpbacks)	Prior distribution (bowheads)
Non-calf survival rate, S_{1+}	U[0.90, 0.995]	N(1.059, 0.0378[2]), truncated at 0.995
Age-at-maturity, a_m	U[4, 12]	N(20,32) truncated at 13.5 and 26.5
Transition age	0	U[1,9]
K^{1+}	U[0, 30,000]	U[0, 40,000]
$MSYL_{1+}$	Pre-specified	Pre-specified
$MSYR_{1+}$	Pre-specified	Pre-specified
Maximum pregnancy rate, $1/f_{max}$	U[1.25, 2.5]	U[2.5, 4]
Additional variation (population estimates), CV_{add}, in year Ψ	U[0, 0.35]	U[0, 0.35]
Abundance in year Ψ, P_Ψ	$\ell nP_{2007} = N(\ell n2{,}154, (0.36^2 + CV_{add}^2))$	A: $\ell nP_{2002} = N(\ell n6{,}340; (0.38^2 + CV_{add}^2))$ B: $\ell nP_{2007} = N(\ell n1{,}229, (0.47^2 + CV_{add}^2))$
Additional variation (relative indices), CV_{add2}	U[0.2, 0.6]	U[0.2, 0.6]
Bias of relative abundance indices, B_c	$\ell nB_c \sim U[-\infty, \infty]$ (see[1])	$\ell nB_c \sim U[-\infty, \infty]$ (see[1])

[1]This is the non-informative prior for a scale parameter.

Table 3

Estimates of absolute abundance (a) and estimates of relative abundance (b).

Year	Estimate	CV
(a) Estimate of absolute abundance		
Bowhead whales		
2002	6,340	0.38
2007	1,229	0.47
Humpback whales		
2007	2,700	0.34

(b) Estimates of relative abundance

Bowhead whales

Year	Estimate	CV	Year	Effort L, (km)	Count
2006	1229	0.47	1981	951	1
2012	829	0.35	1982	2,273	1
			1990	591	1
			1991	1,088	3
			1993	577	0
			1994	1,092	0
			1998	1,184	5
			1999	1,104	0
			2006	791	9
			2012	1,574	25

Humpback whales

Year	Estimate	CV	Year[1]	Estimate[1]	CV[1]
1984	99	0.40	1982	271	0.13
1985	177	0.44	1989	357	0.16
1987	220	0.62	1990	355	0.12
1988	200	0.74	1991	566	0.42
1989	272	0.75	1992	376	0.19
1993	873	0.53	1993	348	0.12
2005	1,158	0.35			
2007	1,020	0.35			

[1]Not used in the *Evaluation Trials.*

B. Data generation

B.1 Absolute abundance estimates

The historic (t<2013) abundance estimates (and their CVs) are provided to the *SLA* and are taken to be those in Table 3a for humpback whales and the relative indices of abundance for bowhead whales in Table 3b. An estimate of abundance together with an estimate of its CV is generated, and is provided to the *SLA,* once every F years during the management period (starting in year 2017 for humpbacks and 2022 for bowheads; F=10 years beyond the year with the last estimate of abundance). The CV of the abundance estimate (CV_{true}) is different from the CV provided to the *SLA*.

The survey estimate, $\hat{S}$, may be written as:

$$\hat{S} = B_A \;\; P \;\; Y \;\; w / \mu = B_A \;\; P^* \;\; \beta^2 \;\; Y \;\; w \tag{B1.1}$$

B_A is the bias;

P is the current 1+ population size ($= \hat{P}_t$); (B1.2)

Y is a lognormal random variable: $Y=e^{\phi}$ where: $\phi \sim N[0;\sigma_\phi^2]$ and $\sigma_\phi^2 = \ell n(1+\alpha^2)$ (B1.3)

w is a Poisson random variable, independent of Y, with $E(w) = \text{var}(w) = \mu = (P/P^*)/\beta^2$; and (B1.4)

P^* is the reference population level (the pristine size of $\hat{P}_t$).

The steps used in the program to generate the abundance estimates and their CVs are given below[2].

The *SLA* is provided with estimates of CV_{est} for each future sightings estimate. The estimate of $CV_{est,t}$ is given by:

$$\hat{C}V_{est,t} = \sqrt{\sigma_t^2 (\chi_n^2 / n)} \qquad\qquad \sigma_t^2 = \ell n(1 + E(CV_{est,t}^2)) \tag{B1.5}$$

$E(CV_{est,t}^2)$ is the sum of the squares of the actual CVs due to estimation error:

$$E(CV_{est,t}^2) = \theta^2 (a^2 + b^2 / w\beta^2) \tag{B1.6}$$

χ_n^2 is a random number from a χ^2 distribution with n (=19; the value assumed for the single stock trials for the RMP) degrees of freedom; and

a^2, b^2 are constants and equal to 0.02 and 0.012 respectively.

The relationship between CV_{est} and CV_{true} is given by:

$$\eta = [E(CV_{true}^2) - E(CV_{est}^2)] / (0.1 + 0.013 P^* / P) \tag{B1.7}$$

where η is a constant known as the additional variance factor. The value of η is based on the population size and CVs for year Ψ:

$$\eta = CV_{add}^2 / (0.1 + 0.013 P^* / P_\Psi) \tag{B1.8}$$

The values of α and β are then computed as:

$$\alpha^2 = \theta^2 a^2 + \eta \;\; 0.1, \qquad\qquad \beta^2 = \theta^2 b^2 + \eta \;\; 0.013 \tag{B1.9}$$

C. Need

The level of need supplied to the *SLA* is the total need for the 6-year period for which strike limits are to be set. The scenarios regarding need are listed in Table 4.

D. Trials

Table 4 lists all of the factors considered in the trials. The set of *Evaluation Trials* is given in Table 5 and the *Robustness Trials* in Table 6.

[2]The steps used to generate estimates of abundance and their CVs are as follows (steps (i)-(iii) are part of the conditioning process).

(i) Read in CV_{est} (Table 3). Generate values of CV_{add}^2 for year Ψ.

(ii) Set η using equation B1.8 and the value of CV_{add} from step (i).

(iii) Set θ^2 using equation B1.6 and the values for CV_{est} from step (i) and $w\beta^2=P/P^*=P_{1968}/P^*$. Set α^2 and β^2 using equation B1.9.

(iv) Generate w (Poisson random variable – equation B1.4) and ϕ (lognormal random variable –equation B1.3).

(v) Set abundance estimate $\hat{S}$ using equation B1.1.

(vi) Generate $\hat{C}V_{est,t}$ from a χ_n^2 distribution using equation B1.5.

Table 4

Factors tested in the trials.

Factors	Levels (reference levels shown bold and underlined)	
	Humpback whales	Bowhead whales
MSYR$_{1+}$	1%, 3%, **5%**, 7%	1%, **2.5%**, 4%
MSYL$_{1+}$	0.6	**0.6**, 0.8
Time dependence in *K**	**Constant**, Halve linearly over 100yr	
Time dependence in natural mortality, *M**	**Constant,** Double linearly over 100yr	
Episodic events*	**None**, 3 events occur between years 1-75 (with at least 2 in years 1-50) in which 20% of the animals die, Events occur every 5 years in which 5% of the animals die	
Need envelope	A: 10, 15, 20; 20 thereafter B: 10, 15, 20; 20->40 over years 18-100 C: 10, 15, 20; 20->60 over years 18-100 D: 20, 25, 30; 30->50 over years 18-100	**A: 2, 3, 5; 5 thereafter** B: 2, 3, 5; 5 -> 10 over years 18-100 C: 2, 3, 5; 5 -> 15 over years 18-100
Future Canadian catches	N/A	**A: 5 constant over 100 years** B: 5-> 10 over 100 years C: 5-> 15 over 100 years D: 2.5 constant over 100 years?
Survey frequency	5 yr, **10 yr**, 15 yr	
Historic survey bias	0.8, **1.0**, 1.2	0.5, **1.0**
First year of projection, τ	1960	1940
Alternative priors	$S_{1+} \sim U[0.9, 0.99]$; $f_{max} \sim U[0.4, 0.6]$; $a_m \sim U[5, 12]$	N/A
Strategic surveys	Extra survey if a survey estimate is half of the previous survey estimate	
Asymmetric environmental stochasticity parameters	To be finalised by an intersessional group	

*Effects of these factors begin in year 2013 (i.e. at start of management). The adult survival rate is adjusted so that in catches were zero, then average population sizes in 250-500 years equals the carrying capacity. *Note*: for some biological parameters and levels of episodic events, it may not be possible to find an adult survival rate which satisfies this requirement.

Table 5

The *Evaluation Trials*. Values given in bold type show differences from the base trial.

Trial	Description	*MSYR*$_{1+}$	Need scenarios	Survey freq.	Historic survey bias	Conditioning option
(a) Humpback whales						
1A	MSYR$_{1+}$=5%	5%	A, B, C, D	10	1	Y
1B	MSYR$_{1+}$=3%	**3%**	A, B, C, D	10	1	Y
1C	MSYR$_{1+}$=7%	**7%**	A, B, C, D	10	1	Y
2A	5 year surveys	5%	B, C, D	**5**	1	1A
2B	5 year surveys; MSYR$_{1+}$=3%	3%	B, C, D	**5**	1	1B
3A	15 year surveys	5%	B, C	**15**	1	1A
3B	15 year surveys; MSYR$_{1+}$=3%	3%	B, C	**15**	1	1B
4A	Survey bias = 0.8	5%	B, C, D	10	**0.8**	Y
4B	Survey bias = 0.8; MSYR$_{1+}$=3%	**3%**	B, C, D	10	**0.8**	Y
5A	Survey bias = 1.2	5%	B, C, D	10	**1.2**	Y
5B	Survey bias = 1.2; MSYR$_{1+}$=3%	**3%**	B, C, D	10	**1.2**	Y
6A	3 episodic events	5%	B, C, D	10	1	1A
6B	3 episodic events; MSYR$_{1+}$=3%	**3%**	B, C, D	10	1	1B
7A	Stochastic events every 5 years	5%	B, C, D	10	1	1A
7B	Stochastic events every 5 years; MSYR$_{1+}$= 3%	**3%**	B, C, D	10	1	1B
8A	Asymmetric environmental stochasticity	5%	B, C, D	10	1	??
8B	Asymmetric environ. stochasticity; MSYR$_{1+}$=3%	**3%**	B, C, D	10	1	??

Trial	Description	*MSYR*$_{1+}$	Need scenario	Survey freq.	Canadian catches	Historic survey bias	Conditioning option
(b) Bowhead whales (each conducted conditioning to the estimate of abundance for West Greenland, treating it as absolute abundance)							
1A	MSYR$_{1+}$=2.5%	2.5%	A, B, C	10	A	1	Y
1B	MSYR$_{1+}$=1%	**1%**	A, B, C	10	A	1	Y
1C	MSYR$_{1+}$=4% (and MSYL$_{1+}$=0.8)	**4%**	A, B, C	10	A	1	Y
2A	5 year surveys	2.5%	A, B, C	**5**	A	1	1A
2B	5 year surveys; MSYR$_{1+}$=1%	**1%**	A, B, C	**5**	A	1	1B
3A	15 year surveys	2.5%	A, B, C	**15**	A	1	1A
3B	15 year surveys; MSYR$_{1+}$=1%	**1%**	A, B, C	**15**	A	1	1B
4A	Survey bias = 0.5	2.5%	A, B, C	10	A	**0.5**	Y
4B	Survey bias = 0.5; MSYR$_{1+}$=1%	**1%**	A, B, C	10	A	**0.5**	Y
5A	3 episodic events	2.5%	A, B, C	10	A	1	1A
5B	3 episodic events; MSYR$_{1+}$=1%	**1%**	A, B, C	10	A	1	1B
6A	Stochastic events every 5 years	2.5%	A, B, C	10	A	1	1A
6B	Stochastic events every 5 years; MSYR$_{1+}$=1%	**1%**	A, B, C	10	A	1	1B
7A	Alternative future Canadian catches	2.5%	A, B, C	10	**B**	1	1A
7B	Alternative future Canadian catches; MSYR$_{1+}$=1%	**1%**	A, B, C	10	**B**	1	1B
9A	Alternative future Canadian catches	2.5%	A, B, C	10	**D**	1	1A
9B	Alternative future Canadian catches; MSYR$_{1+}$=1%	**1%**	A, B, C	10	**D**	1	1B
10A	Asymmetric environmental stochasticity	2.5%	A, B, C	10	A	1	??
10B	Asymmetric environ. stochasticity; MSYR$_{1+}$=1%	**1%**	A, B, C	10	A	1	??

Table 6

The *Robustness Trials*.

Humpback whales				Bowhead whales			
Trial no.	Factor	Need scenario	Conditioning option	Trial no.	Factor	Need scenario	Conditioning option
1A	Linear decrease in *K*; $MSYR_{1+}$=5%	B, D	1A	1A	Linear decrease in *K*; $MSYR_{1+}$=2.5%	A, C	1A
1B	Linear decrease in *K*; $MSYR_{1+}$=3%	B, D	1B	1B	Linear decrease in *K*; $MSYR_{1+}$=1%	A, C	1B
2A	Linear increase in *M*; $MSYR_{1+}$=5%	B, D	1A	2A	Linear increase in *M*; $MSYR_{1+}$=2.5%	A, C	1A
2B	Linear increase in *M*; $MSYR_{1+}$=3%	B, D	1B	2B	Linear increase in *M*; $MSYR_{1+}$=1%	A, C	1B
3A	Strategic Surveys; $MSYR_{1+}$=5%	B, D	1A	3A	Strategic Surveys; $MSYR_{1+}$=2.5%	A, C	1A
3B	Strategic Surveys; $MSYR_{1+}$=3%	B, D	1B	3B	Strategic Surveys; $MSYR_{1+}$=1%	A, C	1B
4A	Alternative priors; $MSYR_{1+}$=5%	B, D	4A*	4A	Canadian catch 'C'; $MSYR_{1+}$=2.5%	A, C	1A?
4B	Alternative priors; $MSYR_{1+}$=3%	B, D	4B*	4B	Canadian catch 'C'; $MSYR_{1+}$=1%	A, C	1B?
4C	Alternative priors; $MSYR_{1+}$=7%	B, D	4C*				
5D	$MSYR_{1+}$=1%	B, D	5D*				
6A	Include mark-recapture estimates in the conditioning; $MSYR_{1+}$=5%	B, D	6A*				
6B	Include mark-recapture estimates in the conditioning; $MSYR_{1+}$=3%	B, D	6B*				

*Trial which needs to be conditioned.

F. Statistics

The risk- and recovery-related performance statistics are computed for the mature female and for the total (1+) population sizes (i.e. P_t is either the size of the mature female component of the population, N_t^f, or the size of the total (1+) population, N_t^{1+}). P_t^* is the population size in year t under a scenario of zero strikes over the years t≥2013 (defined as t=0 below) Note that incidental removals may still occur in the absence of strikes. To emphasize this distinction, P_t^* (0) is used to denote the population size in year t under a scenario of zero strikes or removals of any kind, and P_t^* (inc)= P_t^* reflects the case when there are zero strikes but some incidental removals may occur. K^* is the population size in year t if there had never been any harvest or incidental removals???.

The trials are based on a 100-year time horizon, but a final decision regarding the time horizon will depend *inter alia* on interactions between the Committee and the Commission regarding need envelopes and on the period over which recovery might occur. To allow for this, results are calculated for T=20 and 100 (T^* denotes the number of blocks for a given T; T^* is 3 and 19 respectively for T=20 and T=100).

Statistics marked in bold face are considered the more important. Note that the statistic identification numbers have not been altered for reasons of consistency. Hence, there are gaps in the numbers where some statistics have been deleted.

F.1 Risk

D1. Final depletion: P_T/K. In trials with varying K this statistic is defined as P_T / K_t^*.

D2. Lowest depletion: $\min(P_t / K) : t = 0,1,...,T$. In trials with varying K this statistic is defined as $\min(P_t / K_t^*) : t = 0,1,...,T$.

D6. Plots for simulations 1-100 of $\{P_t: t = 0,1,..,T\}$ and $\{P_t^* : t = 0,1,..,T\}$.

D7. Plots of $\{P_{t[x]}: t = 0,1,..,T\}$ and $\{P^*_{t[x]}: t = 0,1,..,T\}$ where $P_{t[x]}$ is the xth percentile of the distribution of P_t. Results are presented for x=5 and x=50.

D8. Rescaled final population: P_T / P_T^* . There are two versions of this statistic: D8(0)= P_T / P_T^* (0) and D8(inc)= P_T / P_T^* (inc).

D9. Minimum population level: $\min(P_t)$: t=0,1,…,T.

D10. Relative increase P_T/P_0.

F.2 Need

N1. Total need satisfaction: $\sum_{t=0}^{T-1} C_t / \sum_{t=0}^{T-1} Q_t$

N2. Length of shortfall = (negative of the greatest number of consecutive years in which $C_b < Q_b$) / T^*, where C_b is the catch for block b, and Q_b is the total need for block b.

N4. Fraction of years in which $C_t = Q_t$

N7. Plot of $\{V_{t[x]} : t = 0, 1, T-1\}$ where $V_{t[x]}$ is the xth percentile of the distribution of $V_t = C_t / Q_t$

N8. Plots of V_t for simulations 1-100.

N9. Average need satisfaction: $\frac{1}{T}\sum_{t=0}^{T-1}\frac{C_t}{Q_t}$

N10. AAV (Average Annual Variation): $\sum_{b=0}^{T^*-1} \left|C_{b+1} - C_b\right| / \sum_{b=0}^{T^*-1} C_b$

N11. Anti-curvature: $\frac{1}{T^*-1} \sum_{b=0}^{T^*-2} \left|\frac{C_b - M_b}{\max(10, M_b)}\right|$ where $M_b = (C_{b+1} + C_{b-1})/2$

N12. Mean downstep (or modified AAV): $\sum_{b=0}^{T^*-1} \left|\min(C_{b+1} - C_b, 0)\right| \; / \; \sum_{b=0}^{T^*-1} C_b$

F.3 Recovery

R1. Relative recovery: $P_{t_r^*} / P_{t_r^*}^*$ where t_r^* is the first year in which P_t^* passes through *MSYL*. If P_t^* never reaches *MSYL*, the statistic is P_T / P_T^*. If P_0>*MSYL* the statistic is min (1, P_T/*MSYL*).

The following plots are to be produced to evaluate conditioning:

- Time-trajectories of 1+ population size in absolute terms and relative to carrying capacity, along with the fits to abundance estimates. This plot allows an evaluation of whether conditioning has been achieved satisfactorily.
- Histograms of the 100 parameter vectors for each trial. This plot allows an evaluation of whether and how conditioning has impacted the priors for these parameters.

H. References

International Whaling Commission. 2013. Report of the Standing Working Group on the Aboriginal Whaling Management Procedure (AWMP). *J. Cetacean Res. Manage.* 14 (Suppl.): 137-171.

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Annex F

Report of the Sub-Committee on Bowhead, Right and Gray Whales

Members: Walløe (Convenor), Baker, Bannister, Baulch, Bell, Brandão, Broker, Brownell, Bickham, Butterworth, Childerhouse, Chilvers, Cooke, Double, Dupont, Edmondson, Efimchuk, Fortuna, Funahashi, Gaggiotti, Galletti, George, Givens, Goodman, Hoelzel, Holm, Iñíguez, Jackson, Kanda, Kasuya, Kato, Kelly, Kim, H., Kishiro, Kitakado, Kock, Lang, Legorreta-Jaramillo, Litovka, Marzari, Mate, Matsuoka, Murase, Øien, Palsbøll, Perrin, Punt, Reeves, Rojas-Bracho, Rosa, Rose, Rosenbaum, Rowles, Sakamoto, Scheidat, Scordino, Simmonds, Skaug, Stachowitsch, Suydam, Tajima, Tiedemann, Tyurneva, Urbán, Víkingsson, Vinnikov, Vladimirov, Waples, Wilson, Witting.

1. INTRODUCTORY ITEMS

1.1 Opening remarks, election of Chair and appointment of rapporteurs
Walløe welcomed the participants and was elected Chair. Skaug, Suydam, George and Thomas were appointed to act as rapporteurs.

1.2 Adoption of Agenda
The adopted agenda is given as Appendix 1.

1.3 Review of available documents
The documents available for discussion by the sub-committee included SC/65a/BRG01-11, SC/65a/BRG14-29, SC/65a/O03, SC/65a/O07, SC/65a/O09, SC/65a/IA08, Carroll *et al.* (2013a); Carroll *et al.* (2013b), Galletti Vernazzani *et al.* (In press).

2. BOWHEAD WHALES

2.1 Bering-Chukchi-Beaufort (B-C-B) Seas stock of bowhead whales
SC/65a/BRG11 presented an overview of the spring 2011 bowhead whale abundance survey conducted near Point Barrow, Alaska. Recognition was given to the many technicians and analysts that made this survey possible. It was also pointed out that the survey was greatly improved from the inclusion of Inupiat/Yupik traditional knowledge regarding on-ice logistics and bowhead whale behaviour. The 2011 survey was unique in that it included multiple simultaneous data collection efforts, these included: ice-based visual observations, an independent observer (IO) survey (to estimate detection probabilities), acoustic surveillance, and an aerial photo-identification survey. The visual survey began on 4 April and ended on 5 June. The observation perch was on heavy grounded ice but farther from the lead than most seasons. Every attempt was made to make observations and generally conduct the survey in a manner consistent with past seasons – with the exception of the IO watches, which was a departure from previous methods. Bowhead whales arrived on 9 April which is earlier than most past surveys. A total of 3,379 new and 632 conditional whales were seen in 858.6 hours of watch from the primary (south) perch. This essentially ties the record for new whales seen in a single season of 3,383 in 1993 – however in that year (1993), it was estimated that 93% of the whales passed within view of the perch in sharp contrast to 58% in 2011. A total of 1,230 new and 237 conditional whales were seen from the secondary IO perch. Total IO effort was about 180 hours.

Regarding photo-id surveys, approximately 4,594 photographs containing 6,801 bowhead whale images were obtained (not accounting for resightings) in 143.7 flight hours. The number of photos/flight hour as much as three times higher than past surveys in 2003 and 2004. Seven acoustic recorders were deployed, of which six provided useful data between 12 April and 29 July. A total of 2,500 hours of 4-channel (484 hours) and 6-channel array data (2,067 hours) was recorded during the 2011 season. A subsample of 331 hours of data was analysed yielding 22,426 bowhead sounds within the zone where reliable locations are possible.

SC/65a/BRG09 reported much higher levels of bowhead acoustic activity in comparison to recording efforts in past seasons that included high rates of singing and call sequences. In fact, the calls were so dense that the analysts had considerable trouble isolating calls to make locations and eliminating duplications caused by 'singing' whales. The mean rate of acoustically located events in 2011 (calls/hour) increased approximately 5.7 times compared to 1993. Viewing conditions were similar to past surveys including substantial periods of watch missed due to poor visibility and closed leads. As an example, during a lead closure from 19 to 21 April, two of three satellite tagged whales passed the study area. The tag and acoustic data strongly suggests many 100s of whales passed without any chance of visual detection during that period. Regardless, sufficient visual effort occurred during periods of open leads to allow an abundance estimate to be calculated (SC/65a/BRG01). Analysis of aerial photo-id data is underway to allow a capture-recapture estimate, as is analysis of the 'post-season' acoustic data. The authors concluded by noting that the 2011 survey was among the most successful ever, the data provides evidence of a strong recovery of the B-C-B bowhead stock and a well-managed subsistence hunt. The authors noted that the Scientific Committee should feel some satisfaction in being part of this great conservation success. Bowhead whales seem to be increasing near their biological maximum and the subsistence hunting quota meets the need of the Inuit communities.

The sub-committee thanked the authors of both SC/65a/BRG09 and SC/65a/BRG11, and noted the high quality of the work. It was noted that the large number of observations at 20km distance seen in SC/65a/BRG09 is a truncation effect that does not influence the abundance estimate.

SC/65a/BRG01 presents a new estimate of the total abundance of the Bering-Chukchi-Beaufort Seas population of bowhead whales. The estimate is based on two large datasets: visual sightings and acoustic locations from spring 2011. A Horvitz-Thompson type estimator is used, based on the numbers of whales counted at ice-based visual observation stations. It divides sightings counts by three correction factors. The first adjusts for detectability (specifically, the probability of sighting a whale given that it was available to be sighted within visual range) using the results of Givens *et al.* (2012), who estimate detection probabilities and their dependence on offshore distance, ice lead condition, and whale group size. Estimation of these detection probabilities proceeds by fitting the Huggins (1989) model for capture-recapture data using a weighted approach that adjusts for various uncertainties inherent in the process of matching independent visual sightings to generate the capture-recapture dataset.

The second correction factor adjusts for whale availability using the acoustic location data in SC/65a/BRG09 to estimate a time-varying smooth function of the probability that animals pass within visual range of the observation stations. This approach fits a generalised additive model for the binary data (indicating that the whale is within/beyond visual range), weighted to account for the varying precision of individual whale locations.

The third correction factor accounts for missed visual watch effort. This factor is obtained by integrating an estimated smooth whale passage rate function over the time periods when visual watch was operational, and expressing the result as a fraction of the total integrated passage.

Variance estimates for these factors are obtained using a variety of techniques including analytic lognormal derivations, block bootstrapping, and the delta method.

The mean correction factors are estimated to be 0.501 (detection), 0.619 (availability) and 0.520 (effort). The resulting 2011 abundance estimate is 16,892 with a 95% confidence interval of (15,704, 18,928). This estimate is also appended to a time series of past visual abundance estimates to estimate the rate of increase of the population replicating the method of Zeh and Punt (2005). The annual increase rate is estimated to be 3.7% with a 95% confidence interval of (2.8%, 4.7%). These abundance and trend estimates are consistent with previous findings and are indicative of very low conservation risk for this population under the current indigenous whaling management scheme.

The sub-committee thanked the authors, and noted the large amount of work that underlies the new abundance estimate. In the discussion it was noted that there has been a substantial change in the statistical methodology that underlie the abundance estimate. The reasons for switching to a Horvitz-Thompson type estimator include that the new survey design with completely independent observation platforms allowed the use of this type of estimator, which is more statistically efficient than the previous estimator. Among other advantages of the new estimator is that it avoids the binning of observations that was previously necessary. Regarding the variance calculations it was questioned whether treating the effort correction factor and the number of sighted whales as independent is an adequate approximation. The authors gave some theoretical justification for this approximation, and it was also noted that since the correction factor has low variance, the presence of correlation would under no circumstance contribute much to the total variance. The sub-committee endorsed the new estimate of 2011 abundance as the best available estimate for this population and agreed that it was acceptable for use with the *Bowhead Whale SLA*. It further noted that under the guidelines outlined in the proposed Aboriginal Whaling Management Scheme, which has not been agreed by the Commission, endorsement of this abundance estimate would reset the 10-year survey window requirement so that the next survey should be completed by 2021.

A discussion of the future feasibility and usefulness of ice-based visual sighting surveys followed. Such surveys depend very much on the availability of suitable ice conditions. The ice conditions may change within and between years. Aerial photographic surveys, which also were conducted during 2011, can form the basis of an independent mark recapture estimate of abundance. However, it was noted that the 2011 estimate based on visual sightings has much greater precision than a previous aerial photo-id mark recapture estimate (Koski *et al.*, 2010).

SC/65a/BRG22 presented a study of DNA sequence variation for X- and Y-chromosome linked genes (USP9X and USP9Y) in bowhead whales using two methods to discover variable sites. A targeted gene approach called Exon-primed Intron Crossing was used to sequence 21,750 base pairs (bp) of USP9Y with 6.3X coverage (average of 6.3 individuals sequenced per region of the gene) and 11,150 bp of USP9X with 8.4X coverage. Two variable sites were discovered in the Y-chromosome and 8 variable sites were discovered in the X-chromosome. Variable site discovery for the 3' Untranslated Region (UTR) of USP9X and USP9Y was explored using the transcriptome sequence already produced for bowhead whales (Bickham *et al.*, 2012). A total of 3,800 bp of the 3'UTR was examined for two male whales (2X coverage) for both the X and Y genes. There were 7 variable sites found in USP9X and 1 variable site found in USP9Y. In order to assess population variation a complex microsatellite region in intron 43, 7 variable sites of intron 45, and 7 variable sites of the 3'UTR of USP9X were sequenced from 15 whales, and the 2 variable sites from intron 37 and one variable from the 3'UTR of USP9Y were sequenced from 19 whales. Haplotype diversity was H=0.935 for USP9X, and H=0.11 for USP9Y. Haplotype diversity of the USP9X gene is comparable to that of the mtDNA, and much higher than that of USP9Y, despite theoretical mutation rates being higher for Y loci than X loci. The level of Y-chromosome diversity in bowheads is lower than that reported for humans, the only species with adequate data for meaningful comparison, and indicates there must have been selective sweep in bowheads in which all paternal lineages trace their ancestry to a relatively recent ancestor. With the PCR and sequencing primers reported in this paper the X and Y chromosomes can be used to assess population variation in bowheads and other great whales to provide new perspectives on genetic issues such as stock structure, male reproductive success, gene flow, and evolution.

The sub-committee thanked the authors for their work. In the discussion it was noted that a population study has not yet been conducted, but that this is work in progress. It was further noted that markers are to some extent applicable to other mammal species which allows for cross species validation of the method. It was also noted that bowhead whales have a relatively low level of variation in the Y chromosome due to skewness in male reproductive success.

2.1.1 New catch information

Harvest data from the aboriginal hunt for bowhead whales (*Balaena mysticetus*) in Alaska were presented in SC/65a/BRG19. In 2012, 69 bowhead whales were struck resulting in 55 animals landed. Total landed of the hunt for 2012 was higher than the past 10 years (2002-11: mean of landed=38.9; SD=7.1) but similar for efficiency (no. landed/no. struck; mean of efficiency=77%; SD=0.07%). Of the landed whales, 29 were females, 24 were males, and sex was not determined for two animals. Based on total length, six of the 29 females were presumed mature (>13.4m in length). All five of the mature females that were examined were pregnant.

Paper SC/65a/BRG25 reported the results of the Russian aboriginal whaling in the Chukotka region for the period of 2008-12. The paper states that four bowhead whales were struck and landed out of a possible quota of 25 animals for that period. No bowhead whales were reported as struck and lost.

2.1.2 Management advice

The sub-committee **endorsed** the abundance estimate of 16,892 (95% CI: 15,704-18,928) conducted in spring 2011 (SC/65a/BRG01). It was noted that the next survey should be completed by 2021 based on the provisional guidelines in the AWS.

The sub-committee **agreed** with their past advice that the *Bowhead Whale SLA* continues to be the most appropriate way for the Committee to provide management advice for the B-C-B population of bowhead whales.

2.2 Other bowhead stocks

Okhotsk Sea

Shpak gave a verbal presentation of SC/65a/BRG28 and SC/65a/BRG29 describing information collected on bowhead whales in the Okhotsk Sea in summer 2011 and 2012, collected during a beluga whale study. The study area was limited to Ulbansky Bay. Local observations indicate bowheads appear in early May and were present in the area during the study from early July to early September. The largest number (51) of observed bowheads was seen on 4 September 2012. In summer 2011, a similarly large group of 43 whales was observed in the middle part of Ulbansky Bay.

Regarding distribution of bowheads in other Shantar region bays, the literature indicates that summer concentrations are highest in Academy Bay and Tugursky Bay where intensive whaling was conducted in late 19th and mid-20th centuries. The authors' observations in 2009-12 indicated that bowheads are also present in Nikolaya Bay and Udskaya Gulf. In Nikolaya Bay, they observed up to 13 whales in July 2009 and in August 2011; with one whale observed at the mouth of the bay. In Udskaya, the bowheads are seen throughout the summer numbering in the low teens (based on interviews with local residents) and stay there as late as early November. Killer whale predation on bowhead whales is recorded in the Shantar region. The boat captains of the gold mining fleet reported killer whales attacking young bowhead whales at least three times; the last time on 1 September, 2012, north-western coast of Udskaya gulf. The authors often observed the scars on bowhead whales that were likely to have been caused by killer whale teeth. In 2012, they have found a beachcast bowhead whale (780cm in length) with its tongue missing and a 'torn' lower jaw. A second carcass with an estimated length of 8.5m was found floating in the water. From what could be seen from the surface, the body was intact, but there were the tooth scars on the flukes and lateral surface.

SC/65a/BRG29 presented to the sub-committee described a bowhead whale biopsy/genetic study in the Okhotsk Sea. The genetic analyses were conducted by Meschersky and Chichkina at the Russian Academy of Sciences (IPEE RAS, Moscow). Samples collected in Ulbansky Bay in 2011 resulted in 38 samples from 37 individuals (20 male, 17 female) and in 2012, a total of 30 samples were collected representing 29 individuals (17 male, 12 female). Genetic analyses included sex determination, 14 microsatellites loci, and mtDNA.

The level of heterozygosity for 62 individuals genotyped in 2011-12 is similar to the OS samples (1995-2001) presented in MacLean (2002) but lower than that for bowhead whales of the B-C-B stock (Givens *et al.*, 2010).

Regarding genetic recaptures between 1995-2001 and 2011-12, one individual biopsied in 2001 was recaptured in 2012. Rough abundance indices of bowheads in the Shantar region summer group based on the 2012 genetic recaptures (105 whales genotyped in 1995-2011 with five recaptures in 31 whales biopsied in 2012) suggest values about twice that of the earlier estimate of ~300 animals. However, false negatives resulting from differences in lab analyses for earlier samples could result in fewer recaptures and upward bias to any estimates.

For mtDNA analyses, complete sequences of the control region were obtained for 64 individuals. Seven haplotypes were found including one not found in the earlier study by MacLean (2002), who also identified seven haplotypes.

Research suggested by the authors included:

(1) continuing biopsy collection in the Shantar region during summer;
(2) calibrating the samples collected in 1994-2001 and 2011-12 via an exchange of samples between US and Russian laboratories;
(3) determining if whales in the various bays of the Shantar region represent an homgeneous group; and
(4) investigating how the bowhead whales observed in spring in the Shelikhov Bay may be related to the Shantar bowhead whales.

In discussion, the Committee **commended** Shpak for her good work and **encouraged** further research on this small and little-studied stock of whales. It was further noted that combining data from bowhead whale genetic studies conducted in the 1990s would allow updated capture-recapture (minimum) population estimates.

Brownell reported on new plans for offshore oil and gas development in the Northern Okhotsk Sea. It was noted that oil and gas exploration lease blocks have been purchased approximately 50 to 140km offshore of the city of Magadan in water depths of 120-180m. It is expected that exploration will start in 2017 and drilling by the mid-2020s. This area is north of Sakhalin Island and likely in the areas used by Okhostk Sea bowhead whales when they migrate back and forth across the north Okhotsk Sea.

A question was asked about the presence of bowhead whales in the northeastern Okhotsk Sea. Shpak responded that bowhead whales use the region in Shelikhov Gulf in spring. Ilyashenko reported there were no bowhead whale sightings off Magadan, but there were reports of gray whales.

2.2.1 New catch information

CANADA

The Committee did not receive official catch data from the Canadian Government in 2012.

GREENLAND

Witting reported that no bowhead whales were taken in West Greenland in 2012.

2.2.2 Management advice

The sub-committee **agreed** that the Secretariat should follow up with the Canadian Government on obtaining recent harvest information, and encourage the Government to continue research on the eastern Canadian bowheads.

The sub-committee **agreed** that the current annual limit of two strikes for Greenland will not harm the stock. It was also aware that catches from the same stock have been taken by a non-member nation, Canada. It noted that should Canadian catches continue at a similar level as in recent years, this would not change the sub-committee's advice with respect to the strike limits agreed for West Greenland.

3. GRAY WHALES

3.1 Stock structure and movements

3.1.1 Information from tagging experiments

No new information was provided about tagging of gray whales.

3.1.2 Genetic information

Genetic information (SC/65a/BRG16 and some additional data) was presented in the SD sub-committee. A summary of that information can be found in Annex I.

Bickham noted that SC/65a/BRG16 and additional data were presented in the SD sub-committee and discussed there extensively (see Annex I). The papers presented stock structure hypotheses that were meant to represent the range of plausible hypotheses about the western gray whale population that summers in the Sea of Okhotsk near Sakhalin Island. The purpose of SC/65a/BRG16 was not to promote any particular hypothesis but rather to initiate dialogue about the issue and to suggest genetic methods that might be employed to resolve the issue. The outcome of these discussions was the development of a list of seven hypotheses, presented in Appendix 4, by a small group including Bickham, Lang, Jackson and Scordino.

During discussions it was noted that current stock structure hypotheses should consider conditions during the Pleistocene interglacial periods. For example, when Beringia (the Bering Sea land bridge) was in place, marine mammal populations would have been spread along the Pacific Rim which could explain the origin of Okhotsk Sea belugas and bowheads. It was further noted that similar events affected Steller's sea lions. During the Pleistocene they were pushed south where they tended to diverge genetically. Therefore, one might hypothesise that ancestral western gray whales should be readily differentiated from eastern gray whales by genetic markers.

The sub-committee commended the authors and noted the need for additional genetic and photo-id studies. They also noted the usefulness of satellite telemetry inter alia for designing genetic sampling schemes and developing and refining stock structure hypotheses. It can also provide valuable information on movements to inform mitigation measures if required. The sub-committee reaffirmed its previous advice to conduct additional telemetry studies provided that the appropriate safeguards developed previously are followed.

Cooke offered some words of caution about interpreting nuclear DNA, as demographic discreteness can be maintained even if gene flow is occurring.

3.1.3 Photo-identification

SC/65a/BRG04 summarises the results of the second year of the collaborative Pacific-wide study developed under the auspices of the IWC on the comparison of the gray whales photo-identified off Sakhalin Island and the Kamchatka Peninsula with the Mexican gray whale catalogue. The comparison was done based on 232 individuals from Sakhalin Island, 150 individuals from Kamchatka Peninsula and 4,352 from the lagoons in Mexico. The Sakhalin, Kamchatka and Mexico catalogue comparison resulted in a total of nine confirmed matches of individuals. Three of them were also reported in previous years (Urbán R. *et al.*, 2012), including one male, three females and five of unknown sex. Two whales were observed in all three places, three in Sakhalin and Mexico and four in Kamchatka and Mexico. Eight of the nine whales in Mexico were sighted in Laguna San Ignacio and one in Bahía Magdalena. Seven of the nine whales were photographed in Mexico only in one year, one in two years and one in three years. Five whales were sighted in consecutive seasons. These results offer the first complete migratory information for some gray whales that summer off Russia adjacent to the Sea of Ohkostk and provide new information important to the evolving understanding of gray whale population structure in the North Pacific.

The sub-committee thanked all the collaborators for the exciting progress on this project. The comparison of photographs between Sakhalin Island and Kamchatka, Russia with photos from lagoons in Baja California Sur, Mexico, will provide an improved understanding of the connections between feeding and breeding/calving areas and interactions between western and eastern gray whales. Some sub-committee members commented that it would be helpful to have a comprehensive summary of all photographic and genetic matches that have been made to date. Weller responded that some additional photographic comparisons were just being completed and a summary should be available soon. Based on published reports, at present there are 22 photographic matches made between the Sakhalin gray whale catalogues and the eastern gray whale catalogues. Urbán also reminded the sub-committee that a summary of photographic matches was in last year's report.

3.1.4 Future work

Donovan introduced a proposal for a rangewide review of the population structure and status of North Pacific gray whales with the initial focus on an international workshop. Details are given in Appendix 2. The rationale for the Workshop is that recent information obtained from telemetry, genetics and photo-id studies has led to the need for a reappraisal of the population structure and movements of gray whales throughout the North Pacific. Particularly given the completion of the initial phase of the IWC's study (Weller *et al.*, 2012), sufficient new information now exists to justify an international Workshop dedicated to developing a new modelling framework to evaluate the question of North Pacific gray whale stock structure in a conservation and management context[1]. As part of the output of this Workshop, suggested revisions can be developed to the background information sections of the draft Conservation Management Plan for western gray whales that has been developed by IUCN and the IWC. Appendix 2 provides information on the main topics to be considered at a five-day Workshop in spring 2014, which is proposed to be held under the auspices of the IWC and co-sponsors will be sought from (at least) IUCN, relevant stakeholders and range states.

The sub-committee **endorsed** the holding of this workshop recognising its importance to the work of the Scientific Committee as well as IUCN and others. It **recommends** that funding of £16,000 be allocated as the IWC contribution to the Workshop. Appendix 2 documents the need for a steering group to be established that will: *inter alia* complete logistical details; finalise an agenda and invited participants; and identify recommended analyses and new papers. The sub-committee **agreed** that Donovan and Punt should co-convene the Steering Group and finalise its membership before the end of July.

[1]This will build upon the modelling framework developed by the IWC Scientific Committee on the eastern side of the Pacific.

3.2 Western North Pacific gray whales

3.2.1 Distribution and abundance

The sub-committee had a brief discussion about gray whales in the northern Sea of Ohkotsk after Ilyashenko mentioned that gray whales have been seen near the areas in the northern parts of the sea where new oil and gas exploration is planned by Rosneft. He mentioned that additional information should be available at next year's meeting about Rosneft's plans and additional details about sightings of gray whales in that area.

SC/65a/BRG03 reviewed findings from the ongoing 18-year collaborative Russia-US research programme on western gray whales summering off north eastern Sakhalin Island, Russia. This paper summarised results from 2012 research activities and combined such with data from previous years, in some cases ranging back to 1994. Photo-identification research conducted off Sakhalin Island in 2012 resulted in the identification of 88 whales, including five calves and four previously unidentified non-calves. One new reproductive female was recorded in 2012, resulting in a minimum of 30 females known to have produced a calf at some point during the study. When 2012 data are combined with results from 1994-2011, a catalogue of 214 photo-identified individuals has been compiled.

There was some discussion about where the newly seen 'non-calves' might have come from. Weller responded that it was not clear where they came from but they were probably recruited into the population. Cooke added that most new non-calves are recruited into the population. Some calves are only seen once, but not again and presumably died. The new non-calves may have been calves that were missed (i.e. not photographed) during their first summer. Also, not all whales are seen every year but typically the non-calves do return and are seen again. Scordino asked what the influence might be on the population dynamics of western gray whales if the non-calves had emigrated from other areas. Cooke reiterated that the new non-calves may not be immigrants but simply were not photographed as calves.

Given the amount of good data, the sub-committee discussed the possibility of estimating annual productivity or any changes in productivity that might have occurred. Cooke mentioned that it is a bit complicated to estimate the calving rate, especially because mature females have a lower sighting probability. To estimate the rate of calving, a model would need to be developed.

Information was presented in SC/65a/BRG08 about the total number of western gray whales identified off northeast Sakhalin Island and Olga Bay (Kamchatka Peninsula), Russia, in 2012. This study was conducted by the Institute of Marine Biology (IMB) as part of the ENL-Sakhalin Energy-funded Joint Monitoring Program. The number of whales seen was the highest since the start of the photo-identification program in 2002. A total of 144 individual gray whales were identified off the coast of Sakhalin Island; 14 individuals, including nine calves, were identified as new whales. Seventeen gray whales, including three calves, were identified in Olga Bay in 2012; six of these whales have been sighted offshore Sakhalin in earlier years. The Sakhalin photo catalogue now contains 219 individual gray whales over the period of 2002-12. At present the Kamchatka Gray Whale catalogue contains 155 gray whales identified in 2004 and 2006-12. A total of 85 of these gray whales were also photographed offshore Sakhalin in previous years, and are therefore considered to be part of the Sakhalin feeding aggregation. It is as yet unclear to which population the other 70 Kamchatka gray whales belong. Of the 219 gray whales recorded in the IMB Sakhalin catalogue, 150 individuals were documented off Sakhalin and Kamchatka in 2012; a total of 189 whales have been sighted either in Sakhalin or Kamchatka in the period 2010-12.

In 2012, whales actively used the main feeding areas off the north-eastern coast of Sakhalin: 74 individuals were identified in the Offshore feeding area (54 recorded only in that area); 87 individuals were seen in the near-shore Piltun feeding area (61 recorded only in that area); and 10 whales were seen in the Chaivo Bay area (three of them recorded only in that area). In 2012, 14 gray whales, including one nursing female, were identified to be in poor body condition, comprising 9.7% of the total number of gray whales identified offshore Sakhalin. Nine of the 17 gray whales identified in Olga Bay off Kamchatka in 2012 were also thin. Based on the number of animals observed, reproductive success, body and skin condition and use of feeding grounds, it can be concluded that the individuals in the population are in good health.

The sub-committee discussed the health status of western gray whales. While the population remains small and therefore vulnerable, individual animals appeared to be in good body condition in 2012 compared with indicators from previous years. Few skinny whales were observed and those that were had restored their body condition to normal over the course of the summer feeding season. Also there were good numbers of calves observed in 2012.

Results of the shore- and vessel-based surveys conducted in August-September 2012 under the Western Gray Whale Monitoring Program, co-funded by the Exxon Neftegas Limited and Sakhalin Energy Investment Company Ltd. were presented in SC/65a/BRG18. The maximum observed number of gray whales was 111 individuals in the nearshore Piltun area and 55 in the offshore area. Whale distribution in 2012 was consistent with the majority of earlier years. For example, in the Piltun area, most whales were observed in the central and adjacent northern parts, forming a single large aggregation. In the offshore area, the majority of gray whales were sighted in its shallower central part at depths of 40-50 m. The results of the 2012 distribution surveys and photo-identification studies presented in SC/65a/BRG08 indicate that the Sakhalin gray whale feeding aggregation is gradually increasing in size and that the distribution of the whales remains similar to previous years.

During questioning, Vladimirov commented that only results from full surveys were used. Thus, there was not a need to correct sightings for effort. Broker also mentioned that the density estimates were plotted over time during the season and were not just a summary of the entire season.

The sub-committee appreciated receiving the updates on the photo-identification projects and the shore- and vessel-based surveys near Sakhalin and Kamchatka. The sub-committee **thanked** the authors of SC/65a/BRG03, SC/65a/BRG08 and SC/65a/BRG18 and **strongly recommended** that the studies continue.

SC/65a/BGR20 reported on the status of conservation and research on North Pacific gray whales from May 2012 to April 2013 in Japan. During sighting surveys, no gray whales were observed in waters off Japan during this period. Also, no stranding or entanglement of a gray whale was reported. A study on the skeletal morphology of five gray whales that had beached along the coast of Japan between 1995 and 2005 was conducted. The results showed similarities between the beached animals in Japan and eastern gray whales suggesting the possible expansion of the eastern stock into the western region of the North Pacific.

The sub-committee **thanked** Japan for the survey results concerning gray whales and the comparison of skeletal morphology. Continuing the comparison of skeletal morphology of North Pacific gray whales was encouraged. Weller also mentioned that he had received a photograph of a juvenile gray whale sighted off Japan in March 2012. That photo was compared with the catalogues from Sakhalin and the eastern Pacific but no matches were found. The sub-committee also **thanked** Japanese scientists for contributing photos of gray whales for comparison.

SC/65a/BRG26 reported on sighting surveys in Korean waters. Three shore-based and five vessel-based sighting surveys were conducted during the winter season from 2003 to 2011 for the purpose of finding gray whales. The survey area and timing of the surveys were determined based on historical whaling records of gray whales in Korea. In total, 226 hours of observation occurred at the two shore stations. During the vessel based surveys, 808.5 n.miles were navigated from 2006 to 2011. Minke whales, common dolphins, Pacific white sided dolphins, Dall's porpoises and several unidentified species were sighted, whereas gray whales were not observed. Korea intends to continue to survey for them.

The sub-committee **thanked** Korea for the extensive efforts to conduct gray whale surveys. The information was helpful even though no gray whales were seen. One hypothesis that was discussed by the sub-committee at the 2012 annual meeting was that the Korean migratory corridor had been abandoned by western gray whales. Results from the Korean surveys are consistent with that hypothesis.

An updated population assessment of the Sakhalin gray whale aggregation was presented in SC/65a/BRG27, using photo-id data collected from 1994 to 2011 in the Piltun area by the Russian-US team. A stage-structured population model was fitted to the data. The mature female population was divided into three stages – pregnant, lactating and resting – with transition probabilities between the three stages. The immature stages by age and the males were also included. The results showed strong evidence of sighting heterogeneity both between stages and between individuals (with some whales visiting the study area more regularly than others), which was included in the model. The results showed substantial evidence for between-year variability in both calving rates and calf survival rates. The calving rate was found to be correlated with the calf survival rate subject to a two-year time lag. The results also showed that there had been essentially no immigration in recent years, and that the population has, therefore, been demographically self-contained, consistent with a high degree of maternally-directed feeding site fidelity. Male-mediated genetic interchange with other feeding aggregations in the North Pacific is to be expected, given the contact opportunities during migration to common breeding grounds in the eastern North Pacific. The 1+ (non-calf) population size in 2012 is estimated at 140 (±6) whales, increasing at 3.3 (± 0.5) % per annum. Average calf survival rate is estimated to be 0.67 (±0.07), and non-calf survival rate 0.975 (±0.005).

There was some discussion by the sub-committee about the low percentage of female (35%) western gray whale calves. Cooke acknowledged that the result was surprising and mentioned that the sub-committee had discussed this issue extensively at previous meetings. The imbalance in ratio of the sex of calves may be due to some unknown pressure on the population that is selecting for more males or perhaps the result may just be due to chance (p=0.02). More data may resolve the question.

The sub-committee discussed the lack of congruence in the observed number of gray whales by the Western Gray Whale Monitoring Program off Sakhalin Island and the population estimate computed from sighting data collected by the US Russian Team. Cooke explained that there are two parallel research programs, and the two data sets give different results. The analysis in SC/65a/BRG27 estimates a 3.3% rate of annual increase, whereas an analysis of the data from the parallel photo-id team of the Vladivostok Institute of Marine Biology gave a less optimistic projection with a high probability of future population decline. There is a need for a better understanding of the differences in the data sets. Some members requested that future updates provide an explanation of the differences in the two data sets, including the geographical areas where the photographs are obtained. Broker further emphasised that there are two different photo-id programs off Sakhalin plus a photo-id program off from Kamchatka. The sub-committee agreed that all of the photographs should be used for population analyses.

The sub-committee further discussed the model and whether it incorporated body condition. Cooke has thought about adding those types of information to the model but they have not yet been incorporated. There was also some discussion about whether the abundances of each sex had been estimated. The abundances were not modelled separately but sexes and the relatedness of mother/calf pairs have been verified genetically. Even though the sex has been determined for some animals not all have been sexed. Differences in the availability of being sampled between males and females have already been taken into account in the model.

Finally the sub-committee discussed the broader implications of immigration. How robust is the conclusion that there is no immigration given the assumptions of the model? Cooke responded that there is a need to look at a variety of hypotheses with a variety of assumptions. To date the issue of immigration has not been thoroughly evaluated.

3.2.2 Other issues

SC/65a/BRG23 reported on the progress of a program funded by Exxon Mobil to analyse biopsy samples of western Pacific gray whales. The biopsy analyses will include:

(1) pregnancy testing using a progesterone enzyme immunoassay;
(2) determination of stable isotope ratios for carbon, nitrogen, and either mercury or sulphur; and
(3) genetics, including molecular sexing and mitochondrial DNA (control region, CR, and cytochrome *b*, cyt *b*) analysis.

Six western gray whale biopsy samples (WGW 011, 019, 119, 129, 139, and 141) were collected off Sakhalin Island, Russia, in the autumn of 2011. These included a single male (WGW139) and five females with four CR haplotypes and three cyt *b* haplotypes. The four CR haplotypes (A, AI, B, E) have all been previously reported in western gray whales. Optimisation of pregnancy testing in this species, using a progesterone enzyme immunoassay, is underway using eastern gray whale samples obtained from the Marine Mammal Center. Biopsy samples collected from western gray whales will be analysed upon completion of assay optimisation and validation. Stable isotope analyses are currently underway.

Reeves provided an update on the progress of the Western Gray Whale Advisory Panel (WGWAP), which is convened by the International Union for Conservation of Nature (IUCN) (Reeves *et al.*, 2013). Two formal meetings have been held since SC/64. These were WGWAP-12 in Busan, South Korea, on 5-7 November 2012 and WGWAP-13 in Tokyo on 15-17 May 2013 (both chaired by Reeves). The reports of these meetings, as well as the reports of two meetings of the Panel's Noise Task Force (NTF-3 in Busan on 2-3 November 2012 and NTF-4 in Tokyo on 12-13 May 2013, both chaired by Donovan) and one meeting of the Joint Programme Task Force (JPTF in Gland, Switzerland, on 11-12 February 2013, chaired by Reeves), are (or will be within the next few months; the WGWAP-13 and NTF-4 reports were not yet final at the time of writing) available on the IUCN website (*http://www.iucn.org/wgwap/*). Additional details can be found in Appendix 5.

3.2.3 Conservation advice

The sub-committee again acknowledged and welcomed the important work of the IUCN WGWAP as reflected in the update report provided to this meeting (see Appendix 5) and encouraged its continuation. Also as previously, the sub-committee recommended that oil and gas development activities (including exploratory seismic surveys) in areas used by gray whales be undertaken only after careful planning for mitigation and monitoring. This should include, in the case of new development projects such as the construction of offshore platforms, pipelines, and other infrastructure on or near whale habitat, a credible environmental impact assessment process prior to final decision-making. Finally, the sub-committee welcomed the efforts by Japan, as described in SC/65a/BRG20, for the conservation work and research on gray whales and encouraged these efforts to continue. The sub-committee also welcomed the report on whale surveys in South Korea (SC/65a/BRG26) even though the results have been negative in terms of finding gray whales in areas of former abundance.

3.3 Eastern North Pacific gray whales

3.3.1 New information

SC/65a/BRG02 presents new estimates of abundance for eastern North Pacific gray whales. Shore-based counts of southbound migrating whales off California have formed the basis of abundance estimation between 1967 and 2007. These assessments have estimated detection probability (p) from the detection-non detection of pods by two independent observers. However, tracking distinct pods in the field can be difficult for single observers; resulting in biased estimates of pod sizes that needed correcting, and matching observations of the same pod by both observers involved key assumptions. Due to these limitations, a new observation approach has been adopted wherein a paired team of observers work together and use a computerised mapping application to track and enumerate distinct pods and tally the number of whales passing during watch periods. This approach has produced consistent counts over four recently monitored migrations (2006/07, 2007/08, 2009/10 and 2010/11), with an apparent increase in p compared to the previous method. To evaluate p and estimate abundance in these four years, we compared counts from two independent stations of paired observers operating simultaneously using a hierarchical Bayesian 'N-mixture' model to simultaneously estimate p and abundance without the challenge of matching pods between stations. The overall average detectability p_o=0.80 (95% Highest Posterior Density Intervals [HPDI]=0.75-0.85), which varied with observation conditions, observer effects and changes in whale abundance during the migration. Abundance changes were described using Bayesian model selection between a parametric model for a normally distributed common migration trend and a semi-parametric model that estimated the time trends independently for each year; the resultant migration curve was a weighted compromise between models, allowing for key departures from the common trend. The summed estimates of migration abundance ranged from 17,820 (95% HPDI=16,150-19,920) in 2007/8 to 21,210 (95% HPDI=19,420-23,230) in 2009/10, consistent with previous estimates and indicative of a stable population size.

The sub-committee **welcomed and accepted** the updated population estimates.

SC/65a/BRG05 reports the results of photographic identification research in Laguna San Ignacio, Laguna Ojo de Liebre and Bahia Magdalena, Mexico, during the 2012 and 2013 winters. The results demonstrate that gray whales move between these three main breeding and calving areas on the west coast of the Baja California Peninsula, Mexico. Comparison of photographs in Laguna San Ignacio and Bahia Magdalena yielded 45 recaptures, 29 female-calf pairs and 16 adults, between these two lagoons. There were nine recaptures of female-calf pairs between Laguna San Ignacio and Laguna Ojo de Liebre and two recaptures from Bahia Magdalena and Laguna Ojo de Liebre. These results demonstrate a greater amount of movement between different breeding and calving lagoons for female-calf pairs than for single adult whales.

One question was asked about why the number of single whales compared to cow/calf pairs in Ojo de Liebre was very different from the other lagoons. Photographs from Ojo de Liebre are only from the end of the season, in March, so the result is likely to be an artefact of the timing of sampling.

Results of the census of gray whales in Laguna San Ignacio and Laguna Ojo de Liebre were presented in SC/65a/BRG06. Boat surveys utilising a standardised methodology were used in each area to obtain comparable counts of the number of gray whales in these lagoons during the winters from 2007 to 2013. In Laguna San Ignacio 107 boat surveys to count gray whales were conducted from 2007 to 2013. Surveys typically began in mid-January and the last surveys were conducted the first or second week in April each year. Counts of female calf pairs increased during January and February to their highest numbers in March and April during the 2011 to 2013 winters, and averaged 108 pairs in those years. In contrast, female-calf pair counts averaged only 40 pairs during the 2007 to 2010 winters. Female-calf pairs were basically absent from the lagoon by April during the 2007-10 winters, but during 2011 to 2013 winters counts of these whales continued to increase throughout the winter season and between 81 pairs (2013) and 133 pairs (2011) remained in the lagoon at the end of the season in April. In Laguna Ojo de Liebre the surveys began on 9 January 2013, and continued until 12 April 2013. As seen in Laguna San Ignacio, survey counts for all whales increased during January and reached their highest number (729 adult whales) in late February (25 February 2013). Survey counts for adult whales declined to their lowest by mid-April. Unlike Laguna San Ignacio, there was no late season increase in gray whale counts during the last month of the winter.

Urbán was asked if there was a way of estimating the turnover rate in the lagoon. In part this was asked because the count of calves in the lagoons did not represent all of the calves in the population. Other calves must be located offshore. The counts of whales in the lagoons do not reflect the total number of individuals using the lagoons over the season. There is good information about how many whales use lagoons and know how long they use the lagoon. Single animals only use the lagoon for 3-5 days. Females with calves use lagoons for up to 18 days. In one season with the highest counts, there was an estimated total of ~2,500 whales that used Laguna San Ignacio.

The sub-committee **thanked** Urbán and his colleagues for the interesting results from the studies in the breeding lagoons and **encouraged** the continuation of those studies.

SC/65a/BRG21 presented information on the body condition of gray whales in north western Washington, USA, from 2004-10. This work was conducted to see if body condition would help improve understanding on the observed variability of gray whale fidelity to the region. This study was conducted using the methods developed by Bradford *et al.* (2012). Body condition was evaluated for 119 whales. From these whales, a total of 472 monthly composite scores were estimated, but only 58% of these contained post cranial scores. Complete monthly composite scores were estimated for 94 individuals. Of these composites, 49% were in good body condition, 35% were in fair condition, and 16% were in poor condition.

Multinomial logistic regression with ordinal response was used to determine what factors most affected observed body condition in northwest Washington. The most parsimonious model of gray whale body condition was an additive model of month and year with month modelled as a continuous variable. Only three years, 2007, 2009, and 2010 had significantly worse body condition than the reference year of 2004. Month was also modelled as a categorical variable to replicate the methods of Bradford *et al.* (2012) and found that significant improvement in body condition did not occur until September but continued through November. Based on the most parsimonious model, with each successive month of the feeding season, gray whales were 1.4 times more likely to be in improved body condition. The modeled predicted probabilities of gray whales being in poor, fair, or good body condition show yearly variability in body condition of whales when they are first observed in June and in the slope of the recovery of body condition.

The study also assessed if body condition affects gray whale fidelity to northwest Washington. Strong evidence was found that whales were more likely to be seen in year Y+1 if they were in good condition in year Y (p<0.001). However, body condition of whales when they were first observed during the year was not a good predictor for the number of days gray whales were observed within a feeding season. Interestingly, the average body condition of whales in a year was highly correlated with the number of whales observed in that year.

In the context of the IWC, what is most interesting about this study is how it compares to the results of body condition studies of the Sakhalin Island feeding group. Two lines of evidence were found that suggested gray whale body condition in northwest Washington is generally not as good as at Sakhalin Island. The research season at Sakhalin generally extends from July through September. Bradford *et al.* (2012) found that whales had generally achieved good body condition by September in contrast to Washington where about 40% of whales were still in fair to poor condition in September. Bradford *et al.* (2012) also found significant improvements in body condition in August and September as compared to July. In Washington, when June was used as the reference month, there were no significant improvements in body condition until September. Currently it is unclear why body condition scores are generally lower for whales feeding around north western Washington as compared to Sakhalin Island.

Scordino was asked whether the 40% that remained in poor or fair condition in September remained that way until November. Most whales improved their body condition by November but some were still in poor condition; however, this may have been due to new whales arriving in the area that were in poor condition in the autumn. There was some discussion about Pacific Coast Feeding Group (PCFG) animals having a large home range compared with those near Sakhalin. Mate suggested that gray whales near Sakhalin probably have much better feeding opportunities compared to PCFG animals. The area in northwest Washington might not be as productive as the area near Sakhalin. Scordino mentioned that mysid shrimp may be the main food source for gray whales in the area. Mysids may be impacted by a variety of oceanographic conditions, thus their distribution may be patchy. It is also possible that gray whales deplete prey in the area resulting in there being less available prey in future years.

SC/65a/BRG12 presented information on harvested gray whales in 2012. In June and September 2012, scientists examined 23 gray whales caught near Mechigmensky Bay and collected other aboriginal whaling information. Females averaged about 10m in length. Four out of five of the examined whales were between 7.7 and 9.5m and were sub-adults. More than a half of whales (67%) had full or half-full stomachs. Yearlings had the highest body condition index and immature animals had the lowest. There were no 'stinky' gray whales in the Mechigmensky Bay. An immature, female gray whale 7.7m long had traces of milk in an almost empty stomach. The hunters did not see a large whale escorting this small one. They observed that the whale was feeding independently. The largest number of whales (n=63) was landed in the Native village of Lorino in the Mechigmensky Bay. From June to August, 40 coastal counts of gray whales were conducted in the Mechigmensky Bay. Up to eight whales were seen per observation and average number seen was close to the number of whales seen in previous years.

The sub-committee discussed the circumstances where the small whale with milk in its stomach was harvested. There were questions about how long milk would stay in a whale's stomach. It is likely it would probably remain in the stomach for several hours or a bit longer. There was some disagreement about how long weaning might take. The process may be as short as a day or perhaps a bit more drawn out. Ilyashenko mentioned that hunters in Chukotka choose to take small whales as much as possible. They do not know if the whale is a calf if the mother is not in the near vicinity. The hunters do not take calves when accompanied by mothers because of the increased danger to the hunters.

George asked how body condition was determined. Litovka stated that it was estimated as the thickness of blubber relative to the body length of the whale (blubber thickness/body length).

SC/65a/BRG13 presented information about gray whale feeding and prey structure in 2007-09 off of Chukotka, Russian Federation. Stomach contents of 82 individual gray whales taken for subsistence in Mechigmensky Bay in the Bering Sea were analysed. Animals of 12 taxonomic groups were revealed in the food boluses of whales; amphipods and polychaetes prevailed by biomass and frequency of occurrence. The average specific biomass of amphipods was from 54 to 72% and the frequency of occurrence reached 96-100%; those of polychaetes were 30 and 85%, respectively. The comparison of the gray whales feeding in 2007-09 versus 1998-99 displayed that the taxonomic composition of the prey remained the same, but the sizes of the groups changed. In 2007-09, 68 species of amphipods were recorded in the whale stomachs; the input to biomass was counted mostly from six species of *Ampeliscidae*. It may be assumed that the stocks of food organisms were fairly stable in the Mechigmensky Bay and surrounding water areas.

The sub-committee **thanked** the authors for this very interesting and important work examining harvested gray whales. In addition to the collection of measurements and stomach samples, photographs of harvested whales were also taken. The photo comparisons are just now beginning.

3.3.2 Catch information

Ilyashenko presented paper SC/65a/BRG25 on aboriginal harvest of gray and bowhead whales in Russia in 2012. He also provided additional details about measurements of gray whales landed in Russia. The IWC at its Annual Meeting in May 2007 set a five-year Russia-USA block quota of 620 gray whales, with an annual cap of 140 animals landed. The IWC regulation does not address the number of allowed strikes of gray whales. A total of 143 gray whales were struck in 2012. Of those, 139 gray whales (50 males and 89 females) were landed, eight of the whales were inedible (due to a strong 'stinky' chemical smell), and four were struck but lost. In the Chukotsky region, 111 whales were landed while 26 were landed in Providensky region. Two more whales were landed in Iul'tinsky and Beringovsky regions. Hunters of Anadyrsky and Shmidtovsky region did not take part in the 2012 whaling season, due to technical reasons.

The farthest distance hunters had to travel was 49km, while the closest was 0.2km. Body length of whales varied between 7.7 and 14.5m, with the average of 10m. Body weights of those whales were between 5.8 and 32.4 tons with an average weight of 11.5 tons. The largest male was 14.5m long with a body weight of 32.4 tons and its meat had a specific chemical smell ('stinky'). The largest female was 13.9m long with a body weight of 27.4 tons.

About 10% of the whales are 'stinky'. If the wind blows into the face of hunters, they know it is 'stinky' and they avoid the animal. Sometimes a 'stinky' whale cannot be detected until the whale is landed. Sometimes once a whale is butchered it is found to be 'stinky'. The 'stinky' whales are considered to be struck and lost.

Information was provided by Ilyashenko about aggressiveness in hunted gray whales. Once a whale is struck then it may become aggressive. Several years ago, three hunters in Chukotka died because of an aggressive whale. Scordino asked about the definition of an aggressive whale. The aggressiveness of whales is determined by Chukotka whalers. Experienced hunters have a good understanding of the behaviour of gray whales. They know to stay clear of whales once the whale is struck. Information from those hunters is likely to be very reliable; however, information from inexperienced hunters may not be. The inexperienced hunters may suggest that some whales are aggressive but in reality they may not be. The data on aggressiveness of gray whales probably cannot be used reliably.

In SC/65a/BRG24**,** information was presented on the aboriginal subsistence whaling catches within the Russian Federation. There was a five-year block quota on gray and bowhead whales for the period of 2008-12. The IWC allowed for a Russian catch (landing) of 600 gray whales, but no more than 135 per year (struck but lost gray whales are not counted against the quota) and 25 bowhead whales (five bowhead whales landed per year, taking into account that struck and lost will not total more than two whales per year).

Resulting from negotiations between Russian and US Commissioners and the representatives of the Makah Tribe (Washington State) the US agreed to transfer their unused portion of the block quota to Russia in 2012, which equals 20 whales. The total quota on gray whales for the Russian Federation was 620 landed whales for the five year block.

Russia stated multiple times during Commission sessions that there are inedible whales with a very strong 'medicine' odour ('stinky') among the landed gray whales. Ilyashenko stated that these whales were not counted against the quota by Russian authorities, since they do not meet the food needs of the people of the Chukotka Autonomous Region.

The general results of the quota implementation on aboriginal whaling for the period of 2008-12 are as follows. A total of 638 gray whales were struck, 11 were lost, and 627 whales were landed, including 24 inedible with a strong medicine odour ('stinky'). Hence, there were 603 edible whales struck and landed.

The sub-committee noted that the total number of gray whales struck during the 2008-12 period was 638 animals of which 24 of the 627 whales landed were inedible ('stinky') whales. The Commission expressed its limits for the 2008-12 period in terms of whales taken (620). While matters related to struck, landed and 'stinky' whales are matters for the Commission; the sub-committee noted that from an *SLA* perspective, all struck whales are considered removals and there is no discounting of 'stinky' animals removals irrespective of whether they are ultimately inedible.

3.3.3 Management advice

As was the case last year, the sub-committee agreed that the *Gray Whale SLA* remains the appropriate tool to provide management advice for eastern North Pacific gray whales. No new data were presented in 2013 to change that advice.

4. RIGHT WHALES

4.1 New information on southern right whales in South African waters

In SC/65a/BRG10, Best and Butterworth reported on the results of the aerial survey for right whales in South African waters funded by the IWC. The survey was carried out between 10 October and 4 November, 2012, and covered the entire coastline between Nature's Valley in the east and Muizenberg in the west. Unfortunately the survey's progress was badly affected by two major interruptions due to cold fronts (19-24 October, 28 October-3 November), during which time the helicopter relocated to Cape Town. In total, 340 cow-calf pairs and 59 additional adults or juveniles were seen on the survey (for a total of 739 whales), and all cow-calf pairs and 18 adults/juveniles were photographed. After matching, the total number of individuals was reduced to 224 cow-calf pairs and 16 adults/juveniles, implying that the number of same- or between-day duplicate sightings was 116/340 or 34.1% for cows and 2/18 or 11.1% for adults/juveniles. The number of unaccompanied whales was the lowest recorded since 1991, and follows a trend exhibited since 2008 (and possibly as early as 2001), from which latter date their numbers relative to the numbers of cow-calf pairs have declined from 2.0 to 0.16, or by about an order of magnitude. Reasons for this trend include the possibility that the unaccompanied animals have relocated themselves to other parts of the southern African coast (Roux *et al.*, 2013). The number of identified cow-calf pairs was the fifth highest since surveys began in 1979, and an exponential fitted to the data over the 34-year period provides a significant rate of increase (0.0625±0.0035 SE per annum). Nevertheless, the input data make no allowance for variation in the efficiency of detection, so that it is premature to reach conclusions on the population's trajectory before the data have been entered in an appropriate population model that estimates the annual detection efficiency (SC/65a/BRG17).

In discussion the lack of an apparent three-year cohort cycle in the time series, particularly in recent years, was noted. The same has been observed, though over a shorter period (1993-2012), in right whales off southern Australia (Bannister, pers. comm.). The sub-committee noted that this reflects the wider flexibility observed in the calving cycle in recent years.

SC/65a/BRG17 extends the analyses of Brandão *et al.* (2012) which applied the three-mature-stages (receptive, calving and resting) model of Cooke *et al.* (2003) to photo-identification data available from 1979 to 2010 for southern right whales in South African waters, by taking two further years of data into account. The 2012 number of parous females is estimated to be 1,321, the total population (including males and calves) 5,062, and the annual population growth rate 6.6%. This reflects a small reduction to the 6.8% increase rate estimated previously; this is a result of slightly lesser numbers in recent years than estimated previously. Information from resightings of grey blazed calves as adults with calves allows estimation of first year survival rate of 0.850, compared to a subsequent annual rate of 0.988. This information also suggests that 7% (SE 6%) of grey blazed calves are not recognised as such when adults; this estimate is much less than that of 27% obtained previously by Brandão *et al.* (2012), and is more compatible with the relative proportions of grey blazed animals amongst calves and amongst calving adults which suggest a value of 10% (SE 8%).

4.2 New information on New Zealand right whales

Carroll *et al.* (2013b) reports on evidence for a return of southern right whales to former habitat around the main islands of New Zealand. Historically, the range of the southern right whale included winter calving grounds around the North and South Islands (mainland) of New Zealand (NZ) and in the NZ sub-Antarctic Auckland and Campbell Islands. Due to intensive whaling in the 19th and illegal Soviet whaling in the 20th centuries, no southern right whale was seen around mainland NZ for nearly four decades (1928-63). To monitor any return or recovery of southern right whales around the mainland of NZ, the NZ Department of Conservation launched a public awareness campaign in 2003 to encourage the public to report sightings. In addition, the Department of Conservation, in collaboration with other researchers, has been opportunistically collecting photo-identification records and biopsy samples around mainland NZ since 2003. southern right whales have been sighted every year around mainland NZ since 1988, with 125 sightings during the focus of this work: from 2003 to 2010. There were 28 cow-calf pairs sighted around mainland NZ from 2003 to 2010, compared with 11 sightings from 1991 to 2002. Furthermore, two females, identified by DNA profiles, were sighted with calves around mainland at four-year intervals, providing the first evidence of female site fidelity to the mainland NZ calving ground. Individual identification from photographs of natural markings and DNA profiles provided information on within-year movements and residency around the mainland, and further evidence for exchange between the mainland and sub-Antarctic wintering grounds. Despite these promising signs, the authors noted that distribution of NZ southern right whales remains primarily concentrated in the NZ sub-Antarctic, a pattern that contrasts with the pre-whaling distribution.

Baker commented that, in his view, the results presented in Carroll *et al.* (2013b) supported the hypothesis that the stock or substock of right whales found around the mainland historically was probably extirpated and that the current sightings represent a reestablishment of primary habitat use by the remnant stock that survived in the NZ sub-Antarctic. In discussion, Chilvers thanked the authors of this paper and noted that right whale calving has been confirmed in the South Island of New Zealand in the past few years.

Carroll *et al.* (2013a) reports on methods to extend the 'superpopulation' capture-recapture model (POPAN) to explicitly account for heterogeneity in capture probability linked to reproductive cycles, such as the two-five year birth intervals observed in southern right whales. This model extension, referred to as POPAN-τ, has potential application to a range of species that have temporally variable life stages (e.g. non-annual breeders such as albatrosses and other baleen whales) and results in a significant reduction in bias over the standard model. The authors demonstrate the utility of this model in simultaneously estimating abundance and annual population growth rate (λ) in the New Zealand (NZ) southern right whale from 1995-2009. DNA profiles were constructed for the individual identification of more than 700 whales, sampled during two sets of winter expeditions to the NZ sub-Antarctic Auckland Islands in 1995-98 and 2006-09. The abundance of this stock had been estimated previously to be about 900 non-calf whales based on photo-identification records and DNA profiles collected during the first set of four surveys (1995-98, Carroll *et al.*, 2011). Due to differences in recapture rates between sexes in the full set of 8 winter surveys, only sex-specific models were considered for estimates of current abundance and trends. The POPAN-τ models, which explicitly account for a decrease in capture probability in non-calving years, fit the female dataset significantly better than standard superpopulation models (ΔAIC>25). The best POPAN-τ model for females gave a superpopulation estimate of N=1,162 for 1995-2009 (95% CL 921, 1,467) and an estimated annual increase of 5% (95% CL -2%, 13%). The best POPAN model for males gave a superpopulation estimate of N=1,007 (95% CL 794, 1,276) and an estimated annual increase of 7% (95% CL 5%, 9%) for 1995-2009. Combined, the total superpopulation estimate of abundance for 1995-2009 was 2,169 whales (95% CL 1,836, 2,563). Simulations suggest that failure to account for the effect of reproductive status on the capture probability would result in a substantial positive bias (+19%) in female abundance estimates. In his presentation on behalf of the authors, Baker noted that the POPAN-τ model does not require complete records of the reproductive cycle of females but does require identification of sex and documentation of the presence or absence of an accompanying calf. He also noted the utility of the POPAN-τ model and the importance of the long-term dataset of DNA profiles collected in the Auckland Islands in assessing the recovery of the NZ sub-Antarctic stock of southern right whales.

4.3 Recent observations of right whales from other stocks

SC/65a/O09 reported that four schools and five individuals of southern right whales were sighted in 2012/13 during JARPA II in the Antarctic. One southern right whale was photographed for photo-identification.

In July 2011, one North Pacific right whale was observed within Ulbansky Bay, western Okhotsk Sea. It was among a group of several bowhead whales. Photos were taken for photo-id; a biopsy sample was taken and analysed.

SC/65a/O03 reported that two schools and two individual right whales were sighted in 2012 during JARPN II in the western North Pacific. Two right whales were photographed for photo-id, and one biopsy sample was obtained from one of these right whales.

The 3rd annual IWC-POWER cruise was conducted from July to September, 2012 in the eastern North Pacific (SC/65a/IA08) using the Japanese research vessel *Yushin-Maru No.3*. A total of over 2,000 n.miles was surveyed in the research area. A solitary North Pacific right whale was sighted in the northern stratum 120 n.miles southeast of Kodiak Island, Alaska. Photo-id photos were taken and video recording was conducted. No biopsy samples were collected because of lack of permission to biopsy within the US EEZ. Photographs were compared with the US National Marine Mammal Laboratory's North Pacific right whale catalogue and there is the possibility that this is a newly documented individual (Sally Mizroch, onboard US researcher, pers. comm.).

The sub-committee thanked the Japanese scientists for providing this new information on North Pacific right whales. Noting that there was widespread interest in the conservation status of this endangered species and that significant new data had accumulated from survey work in recent decades, especially in the western North Pacific and Sea of Okhotsk, the sub-committee **recommended** that the survey data on North Pacific right whales (including search effort, sightings, photo-identification and biopsy results) be synthesised and presented by Matsuoka and colleagues as a separate report at next year's meeting.

4.4 Conservation issues

SC/65a/BRG15 reports on a workshop on the ongoing southern right whale (*Eubalaena australis*) die-off at Península Valdés, Argentina, held during the Annual Conference of the International Association for Aquatic Animal Medicine on 23 April 2013. The IWC Southern Right Whale Die-off Workshop in 2010 (IWC, 2011b) reviewed the significant number of right whale calf deaths ongoing at Península Valdés, Argentina, considered information on stranded animals collected by the Southern Right Whale Health Monitoring Program (SRWHMP), and developed three primary hypotheses to explain the high calf mortality: nutritional stress, biotoxins, or infectious disease, or a combination of these factors. That report drew attention to the increasing incidence of parasitic behaviour of kelp gulls (*Larus dominicanus*), which peck at the outer skin and then feed on the blubber of live whales at Península Valdés, and recommended that management measures be taken with respect to kelp gulls displaying this behaviour.

After three years of additional stranding and necropsy effort since 2010, the SRWHMP concluded after the 2012 season the data still do not definitively point toward any particular infectious pathology that could explain the high levels of calf mortality. At the 23 April 2013 Workshop 25-30 veterinary and pathology experts and biologists with expertise on mysticete strandings reviewed the 2010-12 stranding and necropsy results and additional information relevant to the causative hypotheses, and reconsidered the evidence on possible causes of mortality. The die-off has continued since 2010, at somewhat lower levels in 2010 and 2011, but at the highest ever in 2012, when 116 whales stranded, including 113 calves (97%). From 2003 to 2012, 598 strandings have been recorded, 91% of them calves, and the SRWHMP conducted 262 necropsies, 151 of which yielded samples for pathological and histological analysis. Participants noted that similar die-offs have not been reported from other western South Atlantic right whale breeding areas nor from other mysticete populations.

Currently there are no consistent gross or histological findings or ancillary diagnostic results from the stranding, necropsy and diagnostic investigations from 2003-11 within or between years to explain the recurrent annual deaths at Península Valdés. No clear temporal associations between plankton blooms and mortality patterns have been identified and significant biotoxin or contaminant levels have not been found. Further investigations of possible hormonal and metabolite evidence of malnutrition are ongoing. The most consistent pattern in the gross necropsy findings was the presence of gull attack lesions. Preliminary information on the extent of gull lesions on the dorsal surface of live and dead whales showed that in years of high calf mortality (such as 2012) dead calves had a high or very high number of gull lesions and in 2010, the year of lowest calf mortality in this period, calves had fewer lesions. Aerial photos showed that the percentage of individuals with gull lesions increased steadily from 1974 to 2008. Right whale females can adopt postural changes to reduce the area of their backs exposed to gulls but calves have little behavioural recourse but to react to attacks with high energy alarm or flight and they continue to be pecked by gulls despite this energetic response. The increase in gull attacks from 1995 to 2011 has increased the amount of energy mother-calf pairs expend in gull attack response and, correspondingly, reduced the time spent resting or travelling slowly.

In light of the strong signal of gull attacks as a unique, increasing, and acute element of the lifecycle of young right whale calves at Península Valdés, Workshop participants focused on the possible mechanisms by which gull attacks could lead to death of right whale calves. Participants considered that the physical injury of extensive gull lesions can compromise the integrity and impermeability of the whale's surface layers and lead to dehydration, loss of thermoregulatory capacity, and increased energy outlay to wound healing and metabolic stasis. Behavioural consequences include increased high energy reaction or flight and reduced time resting and suckling. It is possible that some calves may be driven to death, leading to the high calf mortality levels observed since 2005. The Workshop developed an additional hypothesis on the possible contribution of gull attacks to calf mortality at Península Valdés, preliminarily stated as: high levels of harassment by kelp gulls that peck on a calf's exposed skin and then feed on the underlying blubber, cause significant physical injuries, energetically expensive avoidance behaviour, and reductions in suckling time. This syndrome may result in, *inter alia,* decreased food intake, increased energy expenditure, exhaustion, catabolism, dehydration, and thermoregulatory stress, with cumulative and cascading effects that can lead to calf death. Some participants suggested that an increasing factor of gull-attack mortality might overlie a 'normal' increase in the number of calf deaths in line with the rate of population increase of this population over the last several decades. Participants committed to further development of the gull-attack hypothesis and exploration of the possible contribution of injury, behavioural, and nutritional elements of gull attacks to calf decline and death to guide analyses of previous gull attack observations and assist in future research.

The Workshop participants voiced concerns over these gull attacks that amplified those of the 2010 Southern Right Whale Die-off Workshop and the 2010 meeting of the IWC Scientific Committee (IWC, 2011a; 2011b), and they noted the growing significance of the gull attacks as a welfare issue for right whale calves. There was strong support for gull-control efforts, such as those reportedly initiated in 2012 by the Provincial Government of Chubut. The Workshop participants noted the continued hard work of the SRWHMP team and agreed with the statement in the 2010 Southern Right Whale Die-off Workshop report that acknowledged 'the considerable efforts of the researchers in Argentina (and abroad) to investigate the die-offs and commended them on their accomplishments to date in the face of fiscal and logistical constraints and in view of the sheer number of dead whales.' Participants also noted that the SRWHMP has created the most complete necropsy data base and biological sample collection for this species, and strongly recommend support for the long-term continuation of the Program.

Iñíguez emphasised the importance of this new information on the southern right whale die-off and noted that solving the kelp gull harassment problem is one of the priorities under the Southern Right Whale CMP. He also recognised the high quality of the Southern Right Health Monitoring Program (SRWHMP) work. He also presented information on the progress made by the province of Chubut led by Dr. M. Bertellotti (Centro Nacional Patagónico) on kelp gull harassment of southern right whales. A feasibility study was carried out last year at Península Valdés, when 27 boat trips were done. Three guns were tested, an air rifle, a 22-caliber rifle, and a 12-gauge shotgun, the last being the most successful gun. The reactions of the southern right whales to gun discharge were also recorded and no changes in their behaviour were observed. For the 2013 southern right whale season the objective is to continue this program. Further information will be presented at the next Scientific Committee meeting.

Reeves suggested that an up-to-date demographic estimation of the population at Península Valdés and the western South Atlantic would be very useful in measuring any population-level impact of this die-off. Others noted that preliminary analyses indicated a slowing of the rate of population growth in the population. Several participants noted the major efforts of the SRWHMP over the past decade in investigating this die-off.

The sub-committee expressed concern over the continued large annual mortality of southern right whale calves at Península Valdés, and its significance to the population. They noted that the increase in gull populations is driven by anthropogenic factors such as open landfills and discharge from fisheries. They **recommended** that investigation of the causes of this mortality, including the hypothesis that gull attacks are contributing to calf deaths, should continue as a matter of priority and **recommended** that strategies and actions to reduce the risk of gull attacks on southern right whales at Península Valdés should be further developed and implemented. The sub-committee **commended** the SRWHMP for their hard work and diligence in trying to resolve this situation and **encouraged** continuation and further support of this important work.

Iñíguez presented the result of the IWC Conservation Management Plan for the Southern Right Whale Southwest Atlantic Population Workshop (SC/65a/BRG07). It was hosted by the Government of Argentina on the 23-24 April 2013. Representatives from the following CMP range states: Argentina, Chile and Uruguay; Lorenzo Rojas-Bracho (IWC Conservation Committee Chair) and Chris Schweizer presenting on behalf of Donna Petrachenko, (IWC CMP Standing Working Group Chair) attended the meeting. Funding support for the meeting was provided by the IWC Voluntary Fund for CMPs and the Argentinean Government. The overall objective of the CMP is to protect southern right whale habitat and minimise anthropogenic threats to maximise the likelihood that southern right whales will recover to healthy levels and re-colonise their historical range.

The following nine high priority actions were originally identified for the CMP:

(1) determination of movements, migration routes and location of feeding ground(s) through satellite telemetry;
(2) implementation of the CMP;
(3) development of a strategy to increase public awareness and build capacity in range states;
(4) development of a GIS database on information on human activities that might have an adverse impact on whales;
(5) ensuring long-term monitoring of abundance, trends and biological parameters through photo-identification and biopsy sampling;
(6) enhancing the existing stranding networks including the capacity for undertaking post-mortems;
(7) development of a regional entanglement response strategy;
(8) development and implementation of a strategy to minimise kelp gull harassment; and
(9) establishment of an expert advisory panel.

As part of the implementation of the CMP, Iñíguez was appointed Coordinator for a two-year period and a Steering Committee was set up including representatives from Argentina, Brazil, Chile and Uruguay, the IWC Conservation Committee Chair, IWC Scientific Committee Chair, IWC CMP Standing Working Group Chair and IWC Head of Science. They will serve for five years. Terms of reference were also discussed and agreed. Argentina also appointed a sub-coordinator. A panel of experts will also be established by the Steering Committee with the primary role of assisting the Steering Committee with scientific and technical issues as requested.

Within the priority actions the need to develop a workshop in the Province of Chubut, Argentina to develop and implement a strategy to minimise kelp gull harassment on southern right whales was highlighted. Iñíguez explained the interest of the Province of Chubut to carry out this workshop. Finally he also mentioned that Argentina had announced the availability of the 45m oceanographic motor vessel *Dr Bernardo Houssay* for research in 2014 in two feeding grounds area in the southwest Atlantic area.

After several statements in support, the sub-committee **endorsed** the holding of a workshop to develop and implement a strategy to minimise kelp gull harassment on southern right whales as proposed by the CMP. Such a workshop would be held in early 2014 and developed in consultation with the Province of Chubut. Support would be sought from the Scientific Committee, the Conservation Committee and outside sources.

SC/65a/BRG14 noted that the southern right whale, *Eubalaena australis*, is listed as 'least concern' in the IUCN Red List of Threatened Species. Although it is not a threatened cetacean species, it appears its occurrence on the Brazilian southeast coast is declining, possibly due to human development. In order to detect this possible reduction, data from strandings and sightings in São Paulo State (SPS) and

Rio de Janeiro State (RJS) coasts were gathered through literature review, journals, museums, aquariums and other institutions that had records of right whale occurrence from 2000 to 2011. Emphasis was given to records that allowed identification of date, location and species identification. Photos and videos found on the World Wide Web were also used when they met specifications. A comparison to data from 1981 to 1999 was conducted. A total of 36 records were found (n=59 individuals): 23 sightings and four strandings in the Rio de Janeiro State (RJS) coast, seven sightings and two strandings in the São Paulo State (SPS) coast. Records occurred between May and October. Mother and calf pairs represented 76% of all sightings, indicating the use of the southeast coast of Brazil as breeding and possibly calving areas. In the last 12 years, 0.58 sightings/year were observed for the SPS and 1.92 sightings/year for the RJS. Annual sightings were significantly reduced when compared to the period between 1981 and 1999, when the observed ratios were 0.74 in the SPS coast and 2.63 in the RJS coast. Considering the species' habit of using coastal bays as mating, calving and resting areas, the reduction in the number of sightings could be related to the urbanisation of the SPS and the RJS coasts, and the increase in boat traffic in the last ten years. Although the population is recovering after decades without whaling and the number of researchers collecting data on cetaceans has increased, a real reduction in the ratio of southern right whales records in the southeast coast of Brazil was detected and should be considered as a cause of conservation concern.

Galletti Vernazzani *et al.* (In press) reports on behaviour and habitat use patterns of eastern South Pacific southern right whale sub-population. This population is likely to contain less than 50 mature individuals, has been classified as critically endangered by IUCN, and in 2012 the IWC endorsed a Conservation Management Plan to ensure its long-term recovery. One of the highest priorities of the CMP is to identify a breeding area for this population where whales aggregate. It has been difficult, however, due to the extent of its range (i.e. more than 4,000km coastline off Chile and Peru) and the low number of individuals, to find such an aggregation. A compilation of sightings off Chile and Peru, from 1964 to 2011, was assembled and only 109 records have been reported. Only 18 sightings of 33 individuals included photographs that were useful for photo-identification. Not all of these individuals could be individually identified in each group and a total of 25 individuals were photographically identified. The first resighting between years of a known individual, the southernmost sighting of a cow-calf pair and the first documented record of likely reproductive behaviour in these whales has been reported in a small area off coastal waters off northwestern Isla Grande de Chiloe (Isla de Chiloe), southern Chile. The occurrence of sightings in this area represents about 6% of total sightings off Chile and Peru since 1964. All these new pieces of information highlight the importance of this area for this population and show that it is likely part of a breeding area. Isla de Chiloe is the northern limit of the Chilean fjord system and was a former whaling ground for southern right whales, therefore it seems that whales are reoccupying their former range. However, a large wind farm project and associated port is being proposed to be built at northwestern Isla de Chiloe and it is likely it will affect this important habitat for this critically endangered population.

One member noted the conclusions in earlier discussion of the New Zealand right whales that mainland New Zealand is being re-colonised by whales from the sub-Antarctic island populations and asked if this might be the case for the Chile right whale population. Galleti Vernazzani observed that there is a gap between right whale sightings in the Beagle Channel, Magellan Strait, and the western South Atlantic population and the more northerly eastern South Pacific population for which there are no sightings south of 47°S. Also, she speculated that the large proportion of gray-morph individuals within the 25 photo-identified individual eastern South Pacific right whales might indicate they are breeding among themselves.

The sub-committee welcomed this information and, in light of this critically endangered status and the importance of this area for the recovery of the population, it **strongly recommends** relocation of the wind farm project away from shore, and **reiterates** the need for the urgent development of environmental impact assessment that considers possible impacts on cetacean habitats.

5. UPDATED LIST OF ACCEPTED ABUNDANCE ESTIMATES

Table 1

Updated list of accepted abundance estimates.

Gray whales[1]				
North Pacific/ Arctic	E Pacific	2010/11	20,990	19,230-22,900
		2009/10	21,210	19,420-23,230
		2007/08	17,820	16,150-19,920
		2006/07	20,750	18,860-23,320
Bowhead whales[2]				
North Pacific/ Arctic	B-C-B Seas	2011	16,892	15,704-18,928

[1]SC/65a/BRG02; [2]SC/65a/BRG01.

6. WORK PLAN AND BUDGET REQUESTS

The sub-committee **endorsed** the following two budget requests. The first request was for an intersessional workshop presented in Appendix 2 entitled 'A rangewide review of the population structure and status of North Pacific gray whales' discussed in Item 3.1.4.

The second request was presented by Iñíguez regarding a proposal for a Workshop entitled: Develop and Implement a Strategy to Minimise Kelp Gull Harassment of Southern Right whales. After discussion (see Item 4.4) the sub-committee **agreed** that the request for partial funding of this Workshop should be carried forward. The Workshop proposal is appended as Appendix 3.

Thomas noted the Workshop was a good initiative regarding a serious conservation problem as well as one that affects the local economy and tourism. It is important that the Government of Argentina is reaching out for solutions to the problem. The Workshop concept received general support from the sub-committee.

7. ADOPTION OF REPORT

The report was adopted at 16:51 on 11 June 2013. The Chair thanked the sub-committee members and the rapporteurs for their excellent scientific contribution and hard work.

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Appendix 1

AGENDA

1. Introductory items
   - 1.1 Convenor's opening remarks
   - 1.2 Election of Chair
   - 1.3 Appointment of rapporteurs
   - 1.4 Adoption of Agenda
   - 1.5 Review of available documents
2. Bowhead whales
   - 2.1 Bering-Chukchi-Beaufort (B-C-B) Seas stock of bowhead whales
     - 2.1.1 New catch information
     - 2.1.2 Management advice
   - 2.2 Other bowhead stocks
     - 2.2.1 New catch information
     - 2.2.2 Management advice
3. Grey whales
   - 3.1 Stock structure and movements
     - 3.1.1 Information from tagging experiments
     - 3.1.2 Genetic information
     - 3.1.3 Photo-identification
     - 3.1.4 Future work
   - 3.2 Western North Pacific gray whales
     - 3.2.1 Distribution and abundance
     - 3.2.2 Other issues
     - 3.2.3 Conservation advice
   - 3.3 Eastern North Pacific gray whales
     - 3.2.1 New information
     - 3.2.2 Catch information
     - 3.2.3 Management advice
4. Right whales
   - 4.1 New information on southern right whales in South African waters
   - 4.2 New information on New Zealand right whales
   - 4.3 Recent observations of right whales from other stocks
   - 4.4 Conservation issues
5. Updated list of accepted abundance estimates
6. Work plan and budget requests
7. Adoption of Report

Appendix 2

PROPOSAL FOR A RANGEWIDE REVIEW OF THE POPULATION STRUCTURE AND STATUS OF NORTH PACIFIC GRAY WHALES

OBJECTIVES

Recent information obtained from telemetry, genetics and photo-identification studies has led to the need for a reappraisal of the population structure and movements of North Pacific gray whales. Sufficient new information now exists to justify an international Workshop dedicated to developing new models to evaluate the question of North Pacific gray whale stock structure[2]. The initial phase is to hold Workshop that focuses on developing a modelling framework to better assess the potential impact of human activities on the status of gray whales. Ultimately this should provide information that where necessary will allow the development of appropriate strategies and mitigation measures. As part of the output of this Workshop, suggested revisions can be developed to the background information sections of the draft Conservation Management Plan for Western Gray Whales that has been developed by IUCN and the IWC. Updating the full CMP is the responsibility of the range states and stakeholders and the outputs from the Workshop will also be of assistance to support those efforts.

CO-SPONSORS

The Workshop be held under the auspices of the IWC and co-sponsors will be sought from (at least) IUCN, relevant stakeholders and range states.

DRAFT AGENDA

A formal draft agenda will be developed by a Steering Group (see below). Major topics are outlined briefly below.

This will be a scientific Workshop aimed at reviewing the available information and developing a modelling framework to assess population structure and status throughout the North Pacific.

(1) Integrated consideration of population structure, mixing and movements in order to develop one or more plausible stock structure hypotheses for use in population modelling. Data sources include: genetic data; photo-identification data; telemetry data; whaling data; entanglement data – it may be appropriate to consider case-studies of other baleen whales (e.g. North Pacific humpback whales) to assist in this process.
(2) Abundance and trends in abundance – in addition to value in its own right it is important as input into population modelling in conjunction with information on stock structure hypotheses. Data sources include: sightings data (US west coast and Mexico); photo-identification data (many parts of the range).
(3) Population parameters, including age at first parturition, pregnancy rate, calving interval, survivorship. Data sources include: photo-identification data; historic and contemporary whaling data.
(4) Removals – this will collate information on past direct catches, incidental catches and ship strikes to assist in the assessment of status, in conjunction with estimates of scenarios for future projections (and see (5)).
(5) Anthropogenic activities (other than hunting) that may (or may in the future) affect the status of gray whales – this will collate and review the available information on activities and effects in the context of assigning a possible range in quantitative effects for modelling as well as assigning initial priorities for applying/developing mitigation measures (a number of modelling exercises have been undertaken or in development that can inform these discussions).
(6) Finalise an initial modelling framework/develop scenarios to allow results to be presented to the 2014 meeting of the Scientific Committee and/or a second Workshop – this will also inform future discussions by IWC/IUCN, range states and stakeholders on an updated CMP.
(7) Identify information gaps and population monitoring requirements.
(8) Provide suggestions for the scientific parts of the present CMP.

[2]This will build upon the modelling framework developed by the IWC Scientific Committee on the eastern side of the Pacific.

TIMING

The Workshop will require confirming invited scientists (see below) and ensuring the correct analyses/papers are available in advance of the Workshop; this will include developing a preliminary modelling framework. In order to allow sufficient time for this, it would seem that March 2014 would be the earliest practical period. A period of five days should be allocated to the Workshop.

VENUE

The first Workshop would require about 30 participants with regional or general expertise in population modelling, population structure and movement, population parameters, abundance estimation, anthropogenic activities and potential effects, monitoring. To minimise costs, a 'free to us' venue would assist.

STEERING GROUPS

It is suggested that the Steering Group for the first Workshop needs to include: scientists from IWC, IUCN, range states and specific expertise areas (e.g. modelling as well as population structure). Donovan and Punt will co-convene the Steering Group and finalise participation from the relevant categories before the end of July.

The tasks of the Steering Group will include:

(1) finalising the list of participants;
(2) compiling a list of available data and literature;
(3) identifying recommended analyses and new papers;
(4) finalising the venue and dates; and
(5) finalising the draft agenda (the Workshop will follow the usual format for an IWC scientific Workshop including provision for qualified observers).

OUTPUT

An agreed report including: prioritised recommendations for research to fill identified information gaps; a modelling framework with an initial list of scenarios for investigation; suggested draft text for scientific aspects of the draft CMP. A Special Issue of the *Journal of Cetacean Research and Management* including the report of the Workshop and selected papers.

We request £15,0000 from the Scientific Committee to cover the participation of eight external experts.

Appendix 3

PROPOSAL FOR A WORKSHOP ON DEVELOPING AND IMPLEMENTING A STRATEGY TO MINIMISE KELP GULL HARRASSMENT

M. Iñiguez, B. Galletti Vernazzani, F. Luna, Marzari and L. Thomas

Background

The IWC agreed to nominate the southwest Atlantic southern right whale population for a Conservation Management Plan (SWA SRW CMP) (Government of Argentina *et al.*, 2011). A Workshop to begin the development of the SWA SRW CMP was held in Buenos Aires, Argentina from 19-20 September 2011. Three documents were considered by the SRW CMP Workshop:

(1) Report of the Southern Right Whale Die-Off Workshop (IWC, 2011);
(2) Draft Proposal for an Action Plan for the Recovery of Eastern South Pacific Southern Right Whales in Chile (Palazzo and Galletti Vernazzani, 2011); and
(3) Conclusions and Outcomes of the IWC Southern Right Whale Assessment Workshop that was held in Buenos Aires from 13-16 September 2011 (IWC, 2013).

A second Workshop to begin the implementation of the SWA SRW CMP was hosted by the Government of Argentina in Buenos Aires from the 23-24 April 2013. A report of this Workshop was presented at SC/65a (SC/65a/BRG15). Another Workshop was held to discuss the ongoing southern right whale die-off at Península Valdés, Argentina, during the Annual Conference of the International Association for Aquatic Animal medicine (IAAAM) on 23 April 2013 hosted by the Marine Mammal Center, Sausalito, California. Both workshops, Buenos Aires and Sausalito, results were submitted to SC/65a (SC/65a/BRG07 and SC/65a/BRG15, respectively).

Following the CMP in its action MIT-02 which is a request to develop and implement a strategy to minimise kelp gull harassment on southern right whales and considering all the new information since the IWC's Southern Right Whale Die-off Workshop (IWC, 2011), it is proposed to hold a symposium to inform the public and then a Workshop to review options to address this issue.

Objectives

- Update information on die-off mortality since 2010.
- Recognise the threat and impact of kelp gull (*Larus dominicanus*) harassment on southern right whales.
- Consider concrete actions to address this problem.

Meeting outline

- Symposium for public to inform them about the die-off and threats from the gulls.
- Workshop to review gull control in other parts of the world and option of actions to reduce gull population.

Organisation

Argentinean IWC delegation and the Province of Chubut Government. The venue will be in Puerto Madryn, Chubut, Argentina.

Timetable

Early 2014.

Draft Workshop Agenda

1. Welcome
2. Appointment of Chair and rapporteurs
3. Review and adoption of Agenda
4. Workshop objectives and outputs
5. Review of stranding results
6. Review of other potential impact on SWA SRW
7. Review of 2010 IWC workshop and IAAAM
8. Review of gull control programs and available options
9. Review current gull program (Province of Chubut) for 2012 and 2013
10. Overview of gull behaviour, habitat, distribution, and foraging sites at Península Valdés area
11. Overview of wildlife control methods and programs
12. Develop concrete actions to address this issue
    12.1 Define short term priorities
    12.2 Define medium term priorities
13. Adoption of Report

List of participants

A total of 20-30 participants, including provincial and federal government authorities, researchers on southern right whales and kelp gulls, three external experts, etc.

Draft budget

The full budget for the Workshop will be developed in consultation with the Government of Chubut which has offered partial support including hosting the Workshop at its own facilities. Additional support will be requested from the Conservation Committee, NGOs and other organisations.

We request £6,0000 from the Scientific Committee to cover the participation of the three external experts.

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Appendix 4

POSSIBLE STOCK STRUCTURE HYPOTHESES FOR NORTH PACIFIC GRAY WHALES

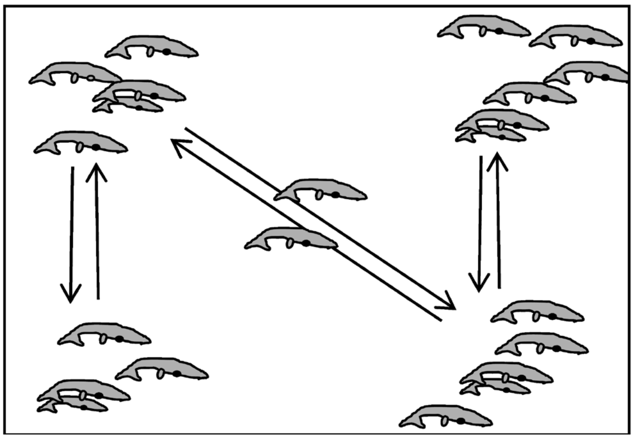
Aimee Lang, John Bickham, Jon Scordino, Jennifer Jackson

Here we present possible stock structure hypotheses for North Pacific (NP) gray whales, with the intent of facilitating discussion of methods to discriminate between hypotheses. Of note, discussion of these hypotheses is focused on evaluating the stock identity of the whales feeding off Sakhalin; no attempt is made to evaluate the Pacific Coast Feeding Group of whales.

Each hypothesis is accompanied by a description and a figure representing the scenario.

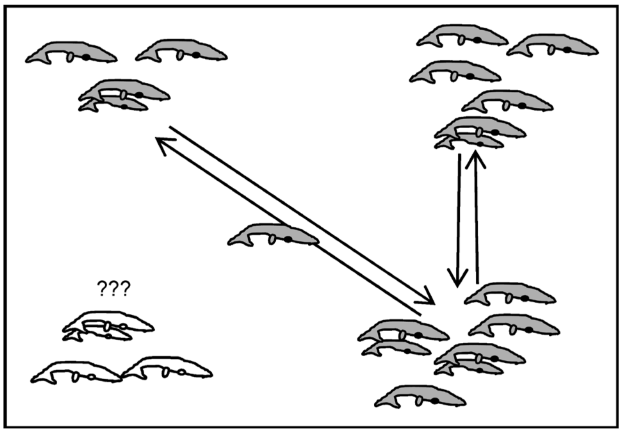
1. Panmixia – persistent

No population structure (e.g. panmixia) is present among feeding grounds used by NP gray whales; individuals move between feeding areas and exhibit random mating. Panmixia has been present over long time scales (prior to exploitation). Gray whales in the North Pacific use multiple migratory routes and wintering grounds with high levels of gene flow [animals randomly choose feeding grounds and randomly choose migratory routes and wintering grounds].



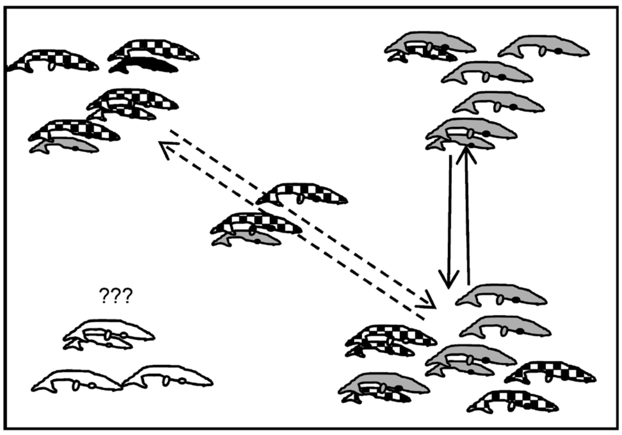
2. Panmixia – post-exploitation - [SC/65a/BRG16, Hypothesis 1]

No population structure (e.g. panmixia) is present among feeding grounds used by NP gray whales; individuals move between feeding areas and exhibit random mating. Panmixia developed post-exploitation, and the pre-exploitation population of western gray whales (e.g. 'true' western gray whales) is extinct or utilises unidentified feeding areas in the western North Pacific (WNP). Whales off Sakhalin represent a random (e.g. different each year) subset of Eastern North Pacific (ENP) whales. All whales feeding off Sakhalin migrate to the ENP during winter months and breed randomly with other ENP whales.



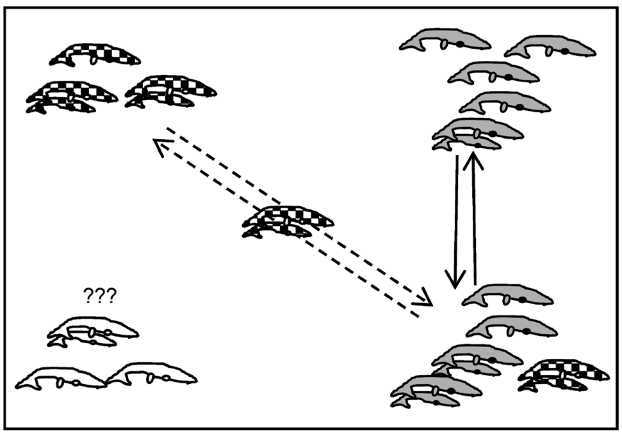
3. Maternal feeding ground fidelity, one wintering ground, random mating - [SC/65a/BRG16, Hypothesis 2 and Appendix 2, Hypothesis 3]

Utilisation of feeding areas is influenced by internal recruitment, with calves following their mothers to feeding grounds and returning in subsequent years. Mating is random with respect to feeding ground affiliation. The Sakhalin feeding ground is utilised by a subset of whales that show matrilineal fidelity to the feeding ground; these whales overwinter in the ENP and mate randomly with whales from other feeding grounds. The pre-exploitation population of western gray whales (e.g. 'true' western gray whales) is extinct or utilises unidentified feeding areas in the WNP.



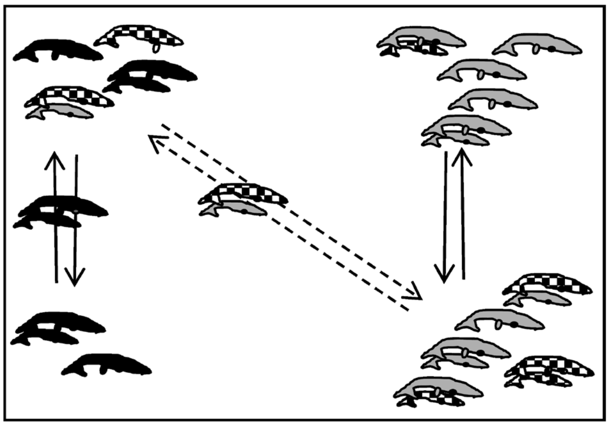
4. Maternal feeding ground fidelity, one wintering ground, assortative mating with respect to feeding ground - [Appendix 2, Hypothesis 2]

Utilisation of feeding areas is influenced by internal recruitment, with calves following their mothers to feeding grounds and returning in subsequent years. Mating is not random with respect to feeding ground affiliation. Whales using Sakhalin migrate to and overwinter in the ENP; however, some interbreeding occurs early in the migration when Sakhalin animals would be more likely to interbreed with each other than with animals feeding in other areas. The 'true'/pre-exploitation western gray whales are extinct or utilise unidentified feeding areas in the WNP.



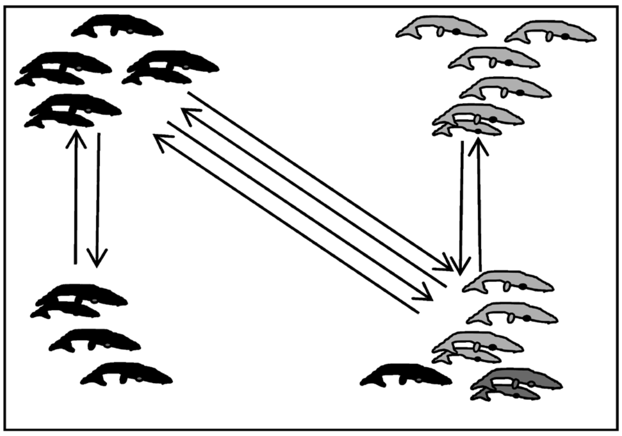
5. Maternal feeding ground fidelity, two wintering grounds, random mating with respect to wintering grounds - [SC/65a/BRG16, Hypothesis 3 and Appendix 2, Hypothesis 1]

The Sakhalin feeding ground is utilised by whales that show matrilineal fidelity to this feeding ground. Some proportion of these whales migrate to the ENP and interbreed with other ENP whales, while the remainder represent 'true'/pre-exploitation western gray whales that migrate in the WNP and interbreed with each other.



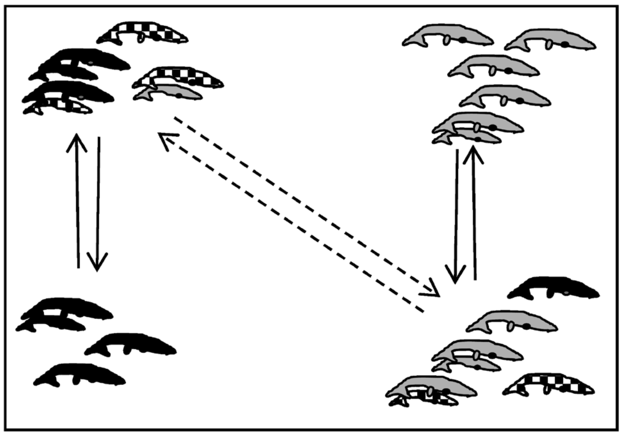
7. Maternal fidelity to feeding grounds, two wintering grounds, assortative mating with respect to feeding ground - [SC/65a/BRG16, Hypothesis 5]

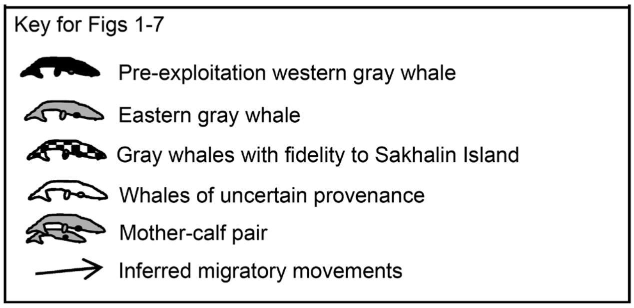
The Sakhalin feeding ground is utilised solely by whales that are the descendants of the 'true'/pre-exploitation western gray whales. They overwinter in both the ENP and the WNP with no interbreeding with the eastern gray whales.



6. Maternal feeding ground fidelity, two wintering grounds, random mating with respect to wintering grounds - [SC/65a/BRG16, Hypothesis 4]

The Sakhalin feeding ground is utilised by whales that show matrilineal fidelity to this feeding ground. These whales include 'true'/pre-exploitation western gray whales that migrate to and overwinter in both the ENP and WNP with some interbreeding with eastern gray whales (EGW) as well as EGW that have colonised this summer feeding ground (i.e. it is a mixture of eastern and western gray whales, and the latter migrate in either direction).





Appendix 5

PROGRESS REPORT ON IUCN WESTERN GRAY WHALE ADVISORY PANEL WORK FROM JUNE 2012 TO JUNE 2013

R. Reeves, D. Weller, G. Donovan, J. Cooke and R. Brownell, Jr.

This is part of an annual series of updated progress reports provided to the Scientific Committee concerning the work of the Western Gray Whale Advisory Panel (WGWAP), which is convened by the International Union for Conservation of Nature (IUCN) (Reeves *et al.*, 2013).Two formal meetings have been held since SC/64. These were WGWAP-12 in Busan, South Korea, on 5-7 November 2012 and WGWAP-13 in Tokyo on 15-17 May 2013 (both chaired by Reeves). The reports of these meetings, as well as the reports of two meetings of the Panel's Noise Task Force (NTF-3 in Busan on 2-3 November 2012 and NTF-4 in Tokyo on 12-13 May 2013, both chaired by Donovan) and one meeting of the Joint Programme Task Force (JPTF in Gland, Switzerland, on 11-12 February 2013, chaired by Reeves), are (or will be within the next few months; the WGWAP-13 and NTF-4 reports were not yet final at the time of writing) available on the IUCN website (*http://www.iucn.org/wgwap/*).

Sakhalin Energy operates the Sakhalin II oil and gas project under a production sharing agreement with the Russian Federation. The project extracts and exports oil and gas from two major fields on the north-eastern Sakhalin Shelf: Piltun-Astokhskoye and Lunskoye. Since 2002, Sakhalin Energy has co-sponsored (jointly with Exxon Neftegas Limited, ENL) a gray whale research and monitoring programme on the Sakhalin Shelf. Through 2012, this programme included: acoustic monitoring, photo-identification, benthic sampling, and shore- and ship-based surveys of whale numbers and distribution. At its meeting in November 2012 (WGWAP-12), the Panel was advised that the companies were considering elimination of the ship-based survey component and modification of the photo-identification component such that it would be entirely shore-based rather than vessel-based as in previous years. This led to the JPTF meeting held in February 2013. The Panel's recommendations concerning the joint programme were largely accepted and the field effort in summer 2013 will be essentially the same as in 2011 and 2012.

As a result of Task Force and Panel work, a successful mitigation and monitoring programme (MMP) had been developed for the 2010 Astokh 4-D seismic survey. The Panel has worked with Sakhalin Energy scientists to ensure that the results from the MMP are thoroughly and appropriately analysed and that the very large investment in planning and implementation of monitoring and mitigation contributes to the planning of similar future operations at Sakhalin and elsewhere. Sakhalin Energy has made good progress on those analyses and a series of scientific papers will be submitted for journal publication in the near future. In addition, a manuscript co-authored by a number of Panel and Sakhalin Energy scientists and that uses the gray whale monitoring and mitigation programme applied during Sakhalin Energy's 2010 4D seismic survey as a case study has been submitted for journal publication: 'Responsible Practices for Minimising and Monitoring Environmental Impacts of Marine Seismic Surveys with an Emphasis on Marine Mammals' by Nowacek *et al.*

The Panel reiterated its concern that considerable oil and gas activity by other companies occurs in the region and a great deal more is scheduled or on the planning horizon. For example, ENL has nearly completed construction of a new production platform between the near-shore (Piltun) gray whale feeding area and the whales' alternative 'offshore' feeding area. ENL is also making plans to construct a pier inside Piltun Lagoon, which will require movement of barges into and out of the narrow lagoon mouth (an area used by mother-calf pairs and recognised as important feeding habitat). Both Gazprom and Rosneft are actively developing hydrocarbon fields on or near the whale feeding areas as well.

There is urgent need for a robust assessment of the cumulative and aggregate impacts on gray whales of industrial development on the north-eastern Sakhalin Shelf, and this cannot be achieved without complete and timely information on the present and likely future activities of companies besides Sakhalin Energy. In consideration of this, Sakhalin Energy, IUCN and the Panel are continuing to seek ways to engage more effectively with additional industry operators as well as Russian regulatory bodies.

Last year's progress report noted that a major concern of the Panel has been Sakhalin Energy's plan to construct a third platform (South Piltun, or PA-C) directly offshore of the mouth of Piltun Lagoon and thus near the primary gray whale feeding area. A small-scale 2D seismic survey to assess shallow-gas hazards at the potential site of this platform proceeded as scheduled in the summer of 2012 with a monitoring and mitigation programme in place as prescribed by the Panel. Analyses of results from that programme are under way. Meantime, the Panel has been advised that Sakhalin Energy would not proceed with test drilling at the South Piltun site and that if platform construction was to take place it would not begin for at least another five years and possibly longer. Sakhalin Energy will inform the Panel well before any new activities occur.

A new issue facing the Panel with regard to Sakhalin Energy's activities is a large seismic survey of the Piltun and Astokh fields currently planned for 2015. The scale of this survey will exceed that of the 2010 survey. It will require considerable work by the Noise Task Force and the Panel to ensure that an appropriate mitigation and monitoring programme is in place by 2015. The Panel was also informed at its May 2013 meeting that Sakhalin Energy foresees repeat seismic surveys at 3-year intervals into the future, which is considerably more frequent than in the past.

Cooke presented an updated population assessment at the end of WGWAP-13 using an individual-based population model fitted to photo-identification data as in previous years. Two independent photo-identification research programmes have been ongoing since 1997 ('Russia-US') and 2002 ('IBM' – Institute of Marine Biology, Vladivostok) respectively. The assessment results using either the Russia-US data alone[3] or the combined data sets showed the population continuing to increase. The results using the IBM data alone were anomalous with a projected decline towards the end of the series. Priority will be given to investigating the cause of the difference between the results, in order to determine what implications, if any, there are for data collection and/or analysis methods.

Brian Dicks, the Panel's oil spill expert, made a site visit to Sakhalin in July 2012 to observe an oil spill response exercise at Piltun Lagoon. Dicks will continue to monitor all aspects of Sakhalin Energy's oil spill response planning and preparations (e.g. equipment stockpiles, training). In July 2013, he will be on-site to observe another large-scale spill response exercise.

In September 2012 IUCN and Sakhalin Energy jointly sponsored a workshop on western gray whales at the IUCN World Conservation Congress in Jeju, South Korea. IUCN also published two whale brochures for the Congress, one called 'Saving Western Gray Whales' and the other 'Marine Seismic Surveys'[4].

Plans for the next formal meeting of the Panel were still under discussion at the time of this writing, as was planning for a photo-identification/population assessment task force to address outstanding issues that stand in the way of efforts to use all available data for assessments.

REFERENCE

Reeves, R., Weller, D., Donovan, G., Cooke, J. and Brownell, R., Jr. 2013. Report of the Scientific Committee. Annex F. Report of the Sub-Committee on Bowhead, Right and Gray Whales. Appendix 10. Progress report on IUCN Western Gray Whale Advisory Panel work from June 2011 to June 2012. *J. Cetacean Res. Manage. (Suppl.)* 14: 194.

[3]An updated population assessment using only the Russia-US data has been submitted to this meeting as SC/65a/BRG27.

[4]See *http://www.iucn.org/wgwap/publications_and_reports*/.

Annex G

Report of the Sub-Committee on In-depth Assessments

Members: Hedley (Convenor), An, Baba, Bannister, Baulch, Bravington, Brownell, Butterworth, Childerhouse, Chilvers, Collins, Cooke, de la Mare, Diallo, Double, Elvarsson, Feindt-Herr, Funahashi, Gales, Goodman, Gunnlaugsson, Hakamada, Hammond, Hoelzel, Holloway, Hughes, Iñíguez, Kanaji, Kanda, Kato, Kelly, Kishiro, Kitakado, Kock, Lang, Legorreta-Jaramillo, Liebschner, Mate, Matsuoka, Miyashita, Morishita, Murase, Nelson, Øien, Palsbøll, K. Park, Pastene, Punt, Roel, Sakamoto, Santos, Skaug, Solvang, Tamura, Walløe, Williams, Wilson, Yasokawa, Yoshida.

1. INTRODUCTORY ITEMS

1.1 Election of Chair
Palka had convened the sub-committee intersessionally following SC/64, but was unable to attend the 2013 meeting. Hedley was elected as Chair for SC/65a.

1.2 Appointment of rapporteurs
Bravington, Cooke, and Kelly agreed to rapporteur.

1.3 Adoption of Agenda
The adopted agenda is given in Appendix 1.

1.4 Documents available
The documents considered by the sub-committee were SC/65a/IA01-IA12, SC/65a/IA14-IA15, SC/65a/O04-O05, and SC/65a/Rep01. Information in SC/65a/IA13 was presented to the sub-committees on other Southern Hemisphere whale stocks and small cetaceans.

2. ANTARCTIC MINKE WHALES

2.1 Statistical catch-at-age analysis
For over a decade, the sub-committee has been developing population dynamics models of Antarctic minke whales. The purpose is to study possible trajectories of abundance and demographic parameters since the 1930s in East Antarctica (Areas III-E, IV, V and VI-W), those being the times and places for which suitable data are available. Extensive efforts have gone into improving the realism and quality of fit of the models (Statistical Catch-at-Age Analysis; SCAA), but prior to 2013 the results were always somewhat tentative because of the lack of up-to-date agreed absolute abundance estimates from IDCR/SOWER (a key piece of input data). However, in 2012 the sub-committee did agree an updated set of IDCR/SOWER minke whale abundance estimates, so for the 2013 meeting it was possible for the first time to study the performance of the models using a fairly complete set of agreed inputs.

Estimates of age-at-length, obtained from reading annual rings in earplugs, constitute an important input to SCAA. It has been shown in previous applications of SCAA, and through experimental studies, that there is variability between readings for Antarctic minke whales, and that it is important to account for the consequent error in these age-estimates when applying SCAA.

SC/65a/IA04 presented an updated statistical method for quantifying age-reading error, i.e. the extent of bias and inter-reader variability among readers. The method assumed the availability of an independent control reader who produces reference ages for ageing structures which are also read by the subject readers. This control reader was assumed to provide unbiased age estimates. Linear structures in bias and variance were incorporated in a conditional probability matrix representing the stochastic nature of age-determination for each reader. A joint likelihood function for the parameters related to ageing bias, variance and nuisance parameters was defined based on observed ageing outcomes from both the control and subject readers. The method was applied to data for Antarctic minke whales taken during Japanese commercial (1971/72-1985/86) and scientific (1986/87-2004/05) whaling. 250 earplugs selected according to a predetermined protocol were used in the analyses to estimate the inter-reader variation for four Japanese readers. One of the authors acted as the control reader. The Japanese readers and the control reader differed in terms of both the expected age given the true age (i.e. bias), and variance in age-estimates. The expected age and random uncertainty in age-estimates differed among the Japanese readers, although the two readers in charge of age-reading for samples taken during Japanese scientific whaling (JARPA and JARPA II) provided quite similar ageing outcomes. The model in SC/65a/IA04 is also applicable to other situations besides Antarctic minke whales where a control reader is (even retrospectively) available.

In discussion, it was noted that the conclusions of SC/65a/IA04 were based on a careful experimental study to compare readers. To estimate the bias and variance, some assumptions are needed; in particular, that at least one of the readers produces age estimates which, although not necessarily exact, are either unbiased or have a known degree of bias, and that ageing errors between readers but on the same earplug are independent. These assumptions are unavoidable for any analysis of ageing error where no absolute ground-truth is available, and the sub-committee **agreed** that the approach and results of SC/65a/IA04 provide useable input data for SCAA analysis.

SC/65a/IA01 reported on the most recent application of SCAA to data for Antarctic minke whales. The SCAA model is an adaptation of the population dynamics estimation models widely used in fisheries, in particular taking specific account of uncertainty in age-reading data. The SCAA framework is spatially-structured, can model multiple stocks, and can use several data types for parameter estimation. In particular, for this application to minke whales in East Antarctica, there are assumed to be two biological stocks (I and P) distributed across five areas which cover Antarctic Areas III-E to VI-W. The parameters of the model (annual deviations about the stock-recruitment relationship, density-dependence parameters describing productivity and carrying capacity, and the parameters which determine growth by stock, age-specific natural mortality by stock, and vulnerability by area and 'fleet') were estimated by fitting the model to data on catches, catch-at-length, and conditional age-at-length data from the commercial harvests and both JARPA programs, plus estimates of absolute abundance (from IDCR/SOWER) and relative abundance (from the JARPA and JARPA II programs). A reference case analysis was selected (including that the control reader's age estimates are unbiased), and sensitivity explored by varying the assumptions on which the reference case analysis is based. The reference case analysis could match all the observed data sources adequately. New data included in the 2013 analysis include the agreed abundance estimates and CVs from IDCR/SOWER, plus a complete validated series of age readings up until 2011/12, as requested at SC/64 (IWC, 2013b, p.196). Most analyses (reference and sensitivity) indicate that Antarctic minke whale abundance in the assessed area increased from 1930 until the mid-1970s and declined thereafter, with the extent of the decline greater for minke whales in Antarctic Areas III-E to V-W than for those further east. Natural mortality was consistently estimated to be higher for younger and older individuals. The estimates of $MSYR_{1+}$ are 5.3% for minke whales in Antarctic Areas III-E to V-W and 3.6% for minke whales in Areas V-E and VI-W, but these estimates are less well determined than other model outputs, and are quite sensitive to the assumptions on which the SCAA is based.

In discussion of SC/65a/IA01, the sub-committee noted that the previous (2012) version of SCAA had still shown some lack of fit to some of the data. Now, though, following the modifications suggestions last year (IWC, 2013b, p.207, table 3) plus the addition of the new data, these problems had been ameliorated, and the fits shown in SC/65a/IA01 seemed largely acceptable. Admittedly, to achieve these good fits, some of the inferred demographic parameters (such as carrying capacity) were forced up against the built-in constraints on rates-of-change in certain cases. This does warrant further investigation but, since the parameters in question are to some extent artefacts of one particular mathematical formulation without a direct 'real-world' interpretation, it does not necessarily indicate a problem. A degree of pragmatism is required to be able to successfully implement and fit such a complex model with so many data inputs; as such, the current version of SCAA is a partly hierarchical-Bayes model, with informal estimates of prior variances, and hard-wired changepoints for some parameters (e.g. natural mortality at age). In principle, it might in future be preferable to move towards a fully hierarchical Bayesian implementation. In practice, though, the very complexity of SCAA that makes a fully-hierarchical approach attractive would also raise computational problems that are currently prohibitive. A similar comment pertains to exhaustive simulation testing. Notwithstanding these comments, the SCAA has received extensive scrutiny and improvement over the years of its development (far more than is usual for similar fishery assessment models used in management), and appears to have stood up well.

The sub-committee considered the interpretation of results in SC/65a/IA01 (plus additional runs of the model made during SC/65a), bearing in mind also the numerous sensitivity analyses and alternative formulations explored in previous years. Overall, some conclusions appear to be quite robustly supported, while others are more sensitive to details of model formulation or data selection. Table 1 shows the most important points, and Fig. 1 shows two qualitatively consistent conclusions: the general trends in abundance (somewhat different for the two stocks), and the U-shaped age-specific pattern of natural mortality.

There are several aspects of SCAA where further work might solidify some of the other conclusions, and a number of detailed technical suggestions were made for intersessional work to be undertaken by Punt, the senior author of SC/65a/IA01 (see the work plan in Item 8). With respect to input data, most of the datasets are now stable, but the time series of JARPA/JARPA II abundance estimates should be filtered to remove unsuitable estimates (e.g. when the Ross Sea was inaccessible), as recommended last year. For SC/65b, it would be helpful to have some narrative overview indicating which issues have been explored over the years, and the conclusions reached about the most appropriate models and scenarios to consider. An Intersessional Steering Group (Punt [Convenor], Butterworth, Cooke, de la Mare, Kitakado and Matsuoka) was re-established.

2.2 Abundance estimates from shipboard surveys

2.2.1 Simulated datasets

At SC/64, the sub-committee had noted that there were still some unresolved issues in the performance of the abundance estimation methods (OK and SPLINTR) used for the agreed abundance estimates. Also, the existing simulated datasets used during the development of OK and SPLINTR had

Table 1

Reliability of conclusions from SCAA.

Model output	Conclusion
Historic trends in abundance	Relative trends generally consistent - modelled through changes in carrying capacity over about four decades, with abundance peaking in around 1970. The early and peak abundances are not quantitatively reliable. Recent abundance fitted to CPII and CPIII estimates.
Extent of change from CPII to CPIII	Trends in abundance over the most recent 20 years are relatively flat. Differences can be explained as variability in distribution.
MSYR	Not robust.
M (natural mortality)	Weakly different by stock. CVs unrealistically low. Further investigation recommended.
Growth curves	Not reliable – a proxy for some unmodelled source of variation.
Stock identity	An input; variable spatial distribution used to account for variability in abundance estimates. Further exploration needed.
Errors in age-determination	Important to take into account.
JARPA/JARPA II abundance estimates	Biased low.
JARPA/JARPA II selectivity	Younger animals under-represented.

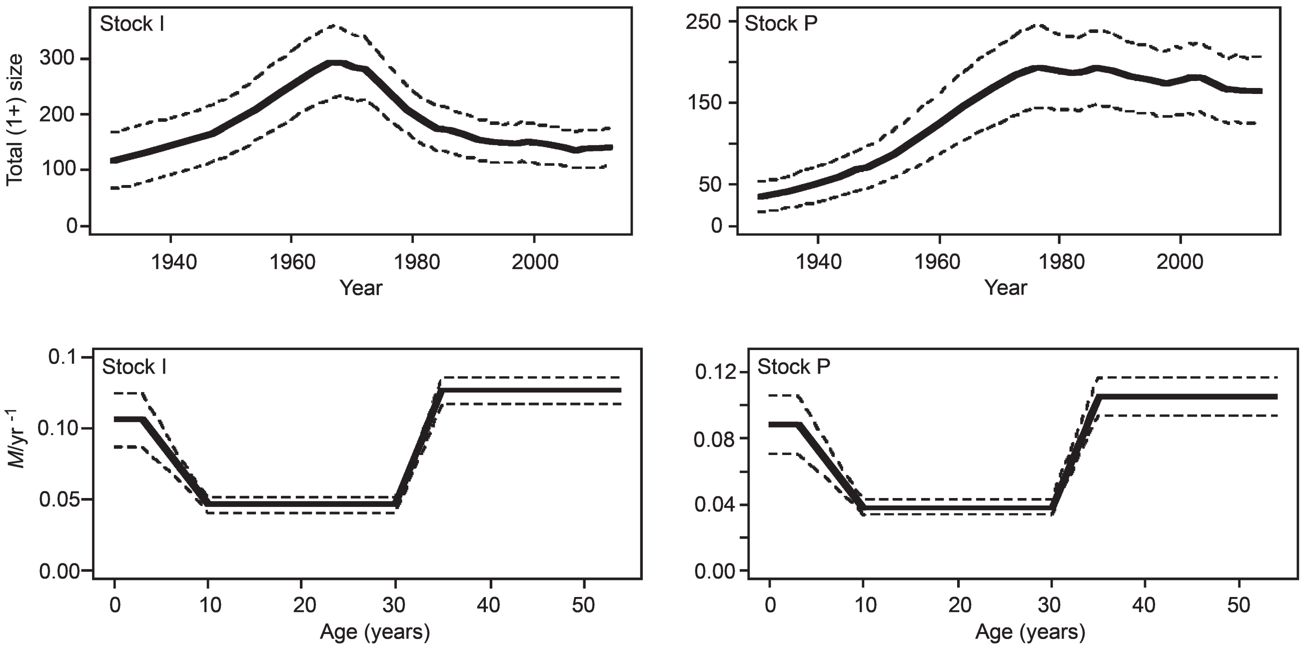


Fig. 1. Trends in abundance, and natural mortality (M) schedule with age, from SCAA reference case in SC/65a/IA01, with 95% CIs (derived from Hessian). 'Stock I' is western (III-E, IV, V-W) and 'Stock P' is eastern (V-E and VI-W). The ages at which M is allowed to change slope are pre-specified inputs.

been shown to be inadequate with respect to some important aspects of minke whale behaviour and the IDCR/SOWER sighting process; this is hardly surprising, because the most important aspects had only come to light during detailed scrutiny of abundance estimation diagnostics developed in the last couple of years, after the simulations were designed. Further work was therefore recommended to develop more appropriate simulated datasets, so that improved abundance estimation methods could be tested in future.

Paper SC/65a/IA15 reported on a new set of simulated datasets along these lines. Unlike previous simulated datasets, where the details of the simulation were deliberately hidden from the developers of abundance estimation methods, a full specification of the new simulations is now available, so that developers can check its appropriateness against the real SOWER/IDCR data.

The sub-committee welcomed the new datasets. Although it is unlikely that improved abundance estimation methods would be available by the 2014 meeting, further progress was expected by 2015. The results of this exercise (improved simulated data, and improved abundance estimation methods) should be of value not only to understanding more about estimating distribution and abundance of Antarctic minke whales, but also to many abundance estimation tasks faced by the SC.

The question of how well the OK and SPLINTR abundance-estimation methods perform in estimating variance has not been addressed, and there are no simulated datasets available that would adequately test this. It was **agreed** that the OK and SPLINTR models should still be tested for variance estimation in the future; one single realistic scenario needs to be developed in order to do this, but higher priority is for model development so that cue rate may be estimated internally. Such development is a substantial piece of work.

2.2.2 Interpretation of agreed estimates

Following the agreement on abundance estimates in SC/64, presented as several sets of numbers, some confusion was reported as to which numbers should be used for which purpose. It is an unavoidable fact that no single table can summarise the IDCR/SOWER minke whale abundance estimation results well enough to cover all possible questions that might be asked of the data. The surveys covered only a small part of the Antarctic each year (about half a *Management Area* in CP3), and boundaries did not always dovetail perfectly from one year to the next for logistical reasons, so any estimate covering a scale as large as a *Management Area* is inevitably a mosaic based on data from different years. Given that the statistical analysis also has to pool some of the data across years within a CP series (in order to estimate important properties of the sighting process that should not vary much in space or time), there is a complex pattern of correlation between estimates from different parts of the Antarctic and on different spatial scales.

The upshot is that some care is required in using the right set of estimates for the right question. Appendix 3 presents again the table of agreed estimates from IWC/64, adding explanatory notes on appropriate usage. In particular, the Table is designed to summarise information on the two questions 'recent best estimate' and 'trend between CP II and CP III' at both the *Management Area* and pan-Antarctic level so, for other questions or other spatial scales, a re-analysis (or at least re-extraction of results) may be required.

By way of summarising and providing clarity on what can be said at this stage in relation to trends, the sub-committee noted the following.

(1) At the scale of the circumpolar surveys, there is no statistically significant difference between the two population estimates. This of course does not mean that the number of Antarctic minke whales did not change at all. Rather, the uncertainty around the two estimates is sufficiently large that it is not possible to conclude with confidence whether the abundance increased, decreased, or remained about the same.
(2) The same is true at the scale of the *Management Areas*; there are no statistically significant trends detected.
(3) Nevertheless, the point estimate of change at a circumpolar level is quite large, and the same is true for some of the *Management Areas*. While not significant statistically, the differences are suggestive that some real

changes in abundance may have occurred, particularly in areas near the large embayments of the Ross and Weddell Seas. The Scientific Committee continues to investigate issues of habitat utilisation and movement patterns of Antarctic minke whales which may further inform our understanding and ability to interpret these survey results.

2.3 New methods or information

Paper SC/65/IA02 presented the first record of the Antarctic minke whale in Ecuador: a single stranding of a newborn calf, 3.43m in length. The species was identified based on morphological characteristics such as the number and colour of baleen plates, the number of ventral groves, and the chevron-shaped greyish light colouration pattern on the flanks. Although only a handful of records exist of this species in the eastern Pacific, it confirms that the breeding area of this species at least reaches the equator in this region.

SC/65a/IA11 proposed a method to estimate abundance of Antarctic minke whales within the ice field during the period of the CP II and CP III surveys using two-stage GAMs. Data from the IWC-SOWER Area IV surveys in CPIII (1994/95 and 1998/99) were used in the analysis for illustrative purposes. The two-stage GAM first estimates probability of occurrence of Antarctic minke whales; given this, the second GAM models their abundance. Limited abiotic environmental data are available as explanatory variables (particularly within the sea ice field) during the period of IDCR/SOWER; SC/65a/IA11 considered distance from shelf break and seafloor depth (as well as longitude) as covariates. Because the abundance of humpback whales increased from CPII to CPIII in Area IV, this was included as a potential covariate. The GAMs were first fitted to data in the surveyed area (open water); the fitted models were then used to predict the abundance of Antarctic minke whales within the sea ice field. The exact relationship between sea ice concentration (IC) and abundance of Antarctic minke whales cannot be estimated by the IDCR-SOWER data. Assuming that abundance decreases with increasing IC, three functional forms for this relationship were considered in SC/65a/IA11. Preliminary results were not conclusive, but the authors noted that the study indicates that the abundance of humpback whales may affect the abundance of Antarctic minke whales. They believe that it is necessary to consider environmental factors and the distribution of other whale species in open waters in order to estimate the abundance of Antarctic minke whales within the sea ice field. Furthermore, they suggest that their results imply that the data collected from recent aerial surveys in the pack ice region and in open water are insufficient to estimate abundance within the sea ice field during the period of the IDCR-SOWER. They note that the GAMs used in SC/65a/IA11 require some refinement but by combining data from IDCR/SOWER and these aerial surveys, rough estimates of minke whale abundance in the ice field may be obtainable.

In discussion, the sub-committee considered several aspects of SC/65a/IA11. The overlap or otherwise of humpback and minke whales is a question of interest to the sub-committee, and there are enough data in IDCR/SOWER to study it – though only outside the sea ice. In that respect, the idea in SC/65a/IA11 is promising, although the current results do show substantial misfit. Inside the sea ice, direct information on the present-day distribution of minke whales should emerge soon from recent and planned aerial surveys (see Item 2.4), avoiding the need to make assumptions in the absence of data– although if the relationship is not stable between regions and across years, then large-spatial-scale inference will be difficult. In any case, there is no similar within-ice data from the IDCR/SOWER period, and some members considered that quantitative retrospective extrapolation to estimate in-ice abundance of minke whales during the IDCR/SOWER period was unlikely ever to prove fruitful. More generally, members noted the difficulty of inferring a causal relationship between humpback and minke whale distribution based on data outside sea ice, extrapolating to minke distributions within sea ice (which humpbacks do not enter), and extrapolating those relationships back over decades to a time when humpbacks were much less abundant. Observations from the Antarctic Peninsula region suggest a very different distribution of minke and humpback whales with respect to ice concentration than proposed in SC/65a/IA11, pointing at least to strong regional variation: this will be an important issue if any extrapolation is contemplated in future. The authors indicated that they would pursue the work further.

SC/65a/IA12 described a study of Antarctic minke whales in their sea ice habitat during the austral summer of 2012-13, in two regions of the Antarctic: the Ross Sea and the Western Antarctic Peninsula. In less than a month of field work, of which only a portion was dedicated to minke whale research, the researchers deployed 16 satellite-linked data recorders and two short-term archival data recorders, obtained 19 skin and blubber biopsy samples, and took a large number of photo-identification images of well-marked individuals. Four types of biotelemetry tags were attached, using three different techniques: blubber-penetrating satellite tags, dorsal-fin-mounted satellite tags, dorsal-fin-mounted satellite and dive recording tags, and suction-cup-mounted multi-sensor acoustic tags. The authors considered that similar dedicated research efforts offer great promise to gain insight into many aspects of the movement patterns, habitat use, behavior and life history of Antarctic minke whales.

In discussion of SC/65a/IA12, the sub-committee congratulated the authors on their achievement: this is the first time that reliable tag deployment has been achieved on this species. The data obtained from satellite tags should in future prove very valuable to the sub-committee's investigation of factors governing distribution and movement; it was noted that the current sample size is of course very small, and that many more tags would be ultimately required to establish that the range of variability in behaviour had been captured, even in one specific region. Given the long duration of some attachments, if satellite tags can be deployed late enough in the breeding season, there is a good prospect that Antarctic minke whales may be tracked back to the breeding grounds, which (apart from one area off Brazil) are still unknown after decades of study. This in turn might inform future research into stock structure. The diving data is also directly relevant to the interpretation of aerial survey estimates of abundance in different sea-ice conditions. Continuation of this work will (logistic success permitting) undoubtedly contribute substantially to the in-depth assessment of Antarctic minke whales.

Since the study was fairly recent, there had not been enough time to fully write up the results before SC/65a, and discussions during this meeting were inevitably preliminary and incomplete. Nevertheless, a number of points were raised.

When asked why this study was so successful while other attempts in the past have failed, the author of SC/65a/IA12 suggested that the use of small boats, operating close to the ice edge on groups that were feeding or seemed relaxed, had been a crucial factor; trying to deploy tags on solitary animals in the high seas would be likely to result in a low success rate.

Tamura referred to results from JARPA which had shown a decline in stomach fullness from morning onwards, contrasting this with the SC/65a/IA12 results which showed near-continuous feeding throughout a 24-hour period.

The utility of the photo-id component was also discussed, in view of the high overall abundance of minke whales (thus low probability of recapture) and the low proportion seen with persistent marks in other parts of the Antarctic. The author noted that the aim of this component was not large-scale abundance estimation, but there might be prospects for smaller-scale site fidelity within and between years (as with biopsies); however, photo-id is not a core component of the research.

Discussion then turned to the comparative merits of lethal and non-lethal sampling for in-depth assessment of Antarctic minke whales.

Pastene and Tamura agreed that the advances in non-lethal technology and the data presented on Antarctic minke whales in SC/65a/IA12 are interesting, and welcomed the new information. At the same time, they recognised the limitations of such techniques and provided a table comparing the advantages and disadvantages of biotelemetry, biopsy and photo-id on Antarctic minke whales. On that basis, they suggested that the data obtained by the non-lethal techniques could complement the information obtained by lethal techniques obtained through systematic surveys, like those conducted under JARPA, and provided two examples, one on stock structure and the other on feeding ecology. The current hypothesis on stock structure of Antarctic minke whale in Areas IIIE-VIW is based on intensive and extensive genetic and morphometric analyses (lethal sampling) collected by JARPA (IWC, 2008b, p.347). It proposes the occurrence of at least two stocks which mix with each other in a part of Area VW. Movement of whales revealed by satellite tagged whales (non-lethal) can assist in the interpretation of the current stock structure hypothesis by:

(a) investigating the location of breeding grounds; and
(b) the pattern of movements in Areas IV and V.

Noting that tagging should also be carried out in wider areas including the offshore regions of Areas IV and V, where weather and sea conditions could be very different from those around the pack-ice (where it was possible to use small boats to tag successfully), Pastene and Tamura questioned whether current techniques can tag enough whales in offshore areas to get statistically meaningful results, and raised a similar question over biopsies. The Scientific Committee has on several occasions recommended the use of multiple techniques, genetic and non-genetic, to resolve questions on stock structure (IWC, 2013a, p.11). Non-genetic approaches include morphometric analysis, which require lethal sampling. The success of biopsy sampling, which could provide genetic information, depends on the target species. Biopsy sampling of Antarctic minke whales has proven to be difficult, particularly in offshore areas, and for small schools (see details in; Ensor *et al.*, 2001, p.14; 2004, p.17). Even if biopsy sampling became possible under more challenging conditions, they believed that it would still be difficult to collect the number of samples required for statistical analysis of stock structure. As to feeding ecology, prey consumption of Antarctic minke whales has been estimated under JARPA, based on the analysis of stomach contents (lethal sampling). Energetic requirements differ by sex and reproductive status, and estimates must be stratified accordingly. Estimates of individual daily consumption are then extrapolated to the whole population and for the period whales remain in the feeding grounds. Information on the period in the feeding ground can be provided by satellite tracking (non-lethal). Pastene and Tamura proposed this as another example of the complementary research benefits of non-lethal and lethal sampling. Further, they expanded on two limitations of non-lethal sampling:

(a) it cannot provide quantitative information on food consumed; and
(b) it cannot reveal which prey species are consumed in the Antarctic.

While it is true that Antarctic krill (*Euphausia superba*) is the main prey species of Antarctic minke whales, at least in the case of the Ross Sea both Antarctic krill and ice krill (*E. crystallorophias*) are consumed. Finally, Pastene and Tamura clarified that their intention was not to criticise the non-lethal data reported in SC/65a/IA12, but to note that the best approach to contribute to the assessment of Antarctic minke whale is the combination of data obtained by lethal and non-lethal approaches.

In response, Gales thanked Pastene and Tamura for their comments of support for the new results reported in SC/65a/IA12. He agreed that some of the issues raised, such as difficult weather conditions, are of course limitations, but noted that the same issues apply to all such research in the Southern Ocean, whether lethal or non-lethal. Gales did not agree that lethal techniques provide complementary approaches to those described in the paper. In relation to stock structure, he agreed that satellite tracking and genetic studies are indeed complementary and provide a powerful approach to understanding population structure, mixing patterns on feeding grounds, and locations of breeding grounds. However, be believed it was simply not plausible to argue that it is more feasible to collect molecules of DNA by harpooning and processing a whole whale, compared to using the established, proven and efficient methods of biopsy collection. Trials of biopsy collection from minke whales had occurred on IDCR and SOWER (Ensor *et al.*, 2002; 2008), including testing systems developed by the Japanese Institute of Cetacean Research (Kasamatsu *et al.*, 1991), and these had provided an empirical basis to show that the handling time of biopsy collection was (not surprisingly) less than handling times of whole whales (Ohsumi, 1979). SC/65a/IA12 had also reported efficient and straightforward collection of biopsies from Antarctic minke whales.

While Pastene and Tamura noted that lethal studies provide morphometric information on stocks, Gales noted that the genetic data and animal movement data were by far the most informative data for this issue, and that the morphometric data in itself was unnecessary. In relation to foraging studies, Gales reminded the sub-committee that the Scientific Committee had concluded at the 2007 Annual Meeting (IWC, 2008a, p.45) that stomach content analyses from lethal studies were limited in their ability to predict daily food intake or trends in food intake. It had been agreed that further progress on lethal feeding studies could only be made when information was available on diurnal feeding behaviour, length of the feeding season and rates of food passage through the stomach. The last of these is, for all practical purposes, immeasurable. The techniques described in SC/65a/IA12 can directly measure diurnal feeding behaviour and length of the feeding season, but also provide much more information. Measurements of lunge frequency can be combined with estimates of the volume of water contained in a lunge (a relatively simple thing to estimate) to provide a direct measure of daily ingestion. The additional complementary technique of prey field monitoring around the feeding whale provides further information on density and distribution of the prey. Prey identity is really not an issue for Antarctic minke whales, which feed almost exclusively on Antarctic krill. On the occasions when they do feed on ice krill, they do so in embayments and on shelf waters where the distribution of the two krill species have minimal overlap (Sala *et al.*, 2002). Whales tagged in waters near the ice-edge (as described in the paper) have been seen to move through many habitats, including the offshore environment. Thus, the mid-to-long range tags described in SC/65a/IA12 can collect foraging data across the range of minke whale habitats. Gales concluded that the techniques described in SC/65a/IA12 offer a new and exciting opportunity to fill important knowledge gaps about Antarctic minke whales, and that there is no scientific basis to conclude that lethal studies would add value to the data derived from these non-lethal techniques.

2.4 Possible reasons for differences between point estimates from CPII and CPIII

The difference in point estimates of minke whale abundance between CPII and CPIII is large (31% lower in CPIII), but not statistically significant even at a pan-Antarctic level (IWC, 2012b) given the inferred amount of annual variability in distribution (longitudinally and/or in sea ice). At smaller spatial scales, increased statistical noise would make it very hard to detect even a large change in abundance at a 5% level of significance. There is thus no longer any particular reason to concentrate exclusively on 'reasons for the decline in open-water abundance', given that there may not actually have been one. Nevertheless, there is also no particular reason to believe that abundance should remain completely static; the SCAA analysis (Item 2.1, Fig. 1), which draws on other data sources besides IDCR/SOWER estimates, suggests substantial *increases* in abundance in East Antarctica considerably pre-dating CPII (though not much change between CPII and CPIII). The key question for in-depth assessment of Antarctic minke whales is perhaps now better expressed as: what are the factors that drive minke whale abundance and distribution?

Variation in the proportion of minke whales within sea ice is one possible reason for fluctuations in open-water abundance estimates such as IDCR/SOWER (assuming the proportion in ice can be large enough). Recent German and Australian aerial surveys (IWC, 2012b), from two very different parts of Antarctica, have obtained data that allows some investigation at least of whether the proportion is likely to be high enough to matter when comparisons between open-water estimates are considered. There was insufficient time during SC/65a to properly discuss recent results from aerial surveys, but it was noted that there are now five years of German helicopter survey data available, with more data collection planned; notwithstanding that these are from somewhat different areas, they should provide some idea of the variation in proportion. To interpret the aerial survey density estimates relative to the absolute abundance estimates from SOWER, and in order to get some rough idea of magnitude, more information on availability (to aerial observation) across a range of conditions (related both to minke whale behaviour, and to sighting conditions) is really required. The planned deployment of depth-measuring satellite-tags (see Item 2.3 and Item 8, the work plan) would be helpful with interpreting existing as well as future aerial survey data. The sub-committee looks forward to a synthesis of aerial survey results in the 2014 meeting.

Without further information, the sub-committee did not attempt this year to update its previous tables on 'possible reasons for change', except for the title, as above. This renamed item remains on the Agenda for 2014.

3. NORTH PACIFIC SURVEYS

There are currently two series of annual survey cruises taking place in the North Pacific with IWC oversight: to the west a Japanese national series, and further east the IWC-POWER (Pacific Ocean Whale and Ecosystem Research) series, which began in 2010. The areas set out for the first five years of POWER cruises, which are intended as the first stage in a medium-to-longer-term programme of research, are shown in Fig. 2. Further background on the POWER programme may be found in IWC (2013c).

3.1 Report on the 2012 IWC-POWER cruise

The 3rd annual IWC-POWER cruise was successfully conducted from 13 July to 10 September 2012, in the eastern North Pacific (north of 40°N, south of Alaska, between 150°W and 135°W) using the Japanese research vessel *Yushin-Maru No.3* (SC/65a/IA08). The cruise was organised as a joint project between the IWC and Japan. The cruise plan was endorsed at SC/63. Researchers from Japan, Korea and the US participated in the survey. The cruise had five main objectives, to:

(a) provide information for the proposed future in-depth assessment of sei whales in terms of both abundance and stock structure;
(b) provide information relevant to *Implementation Reviews* of whales (e.g. common minke whales) in terms of both abundance and stock structure;
(c) provide baseline information on distribution and abundance in a poorly known area for several large whale species/populations, including those that were known to have been depleted in the past, but whose status is unclear;
(d) provide biopsy samples and photo-identification photos to contribute to discussions of stock structure for several large whale species/populations, including those that were known to have been depleted in the past but whose status is unclear; and
(e) provide essential information for the intersessional Workshop to plan for a medium-long term international programme in the North Pacific.

The sighting survey was conducted according to the guidelines of the Scientific Committee, and all predetermined transect lines were completed. The survey effort was stratified into two zones: a northern stratum within the US and Canada Exclusive Economic Zone (EEZ) and a southern stratum south of the US and Canada EEZ. Survey coverage was 80% in the northern stratum and 85% in the southern stratum. A total of 2,126 n.miles was surveyed in the research area in Passing-with-abeam-closing mode (NSP). Sightings of blue whales (four schools/four individuals), fin whales (149/210), sei whales (87/164), common minke whales (2/2), North Pacific right whales (one/one), humpback whales (21/33), sperm whales (50/57), Baird's beaked whales (1/6), Cuvier's beaked whales (1/4), Stejneger's beaked whales (2/8), *Mesoplodon* spp. (3/9), other beaked whales (23/44), killer whales (17/99), Risso's dolphins (1/16), common dolphins (3/135), Pacific white sided dolphins (3/27), northern right whale dolphins (1/10), Dall's porpoises (132/636), and unidentified large whales (59/93) were made. Fin and sei whales were the most frequently sighted species. Fin

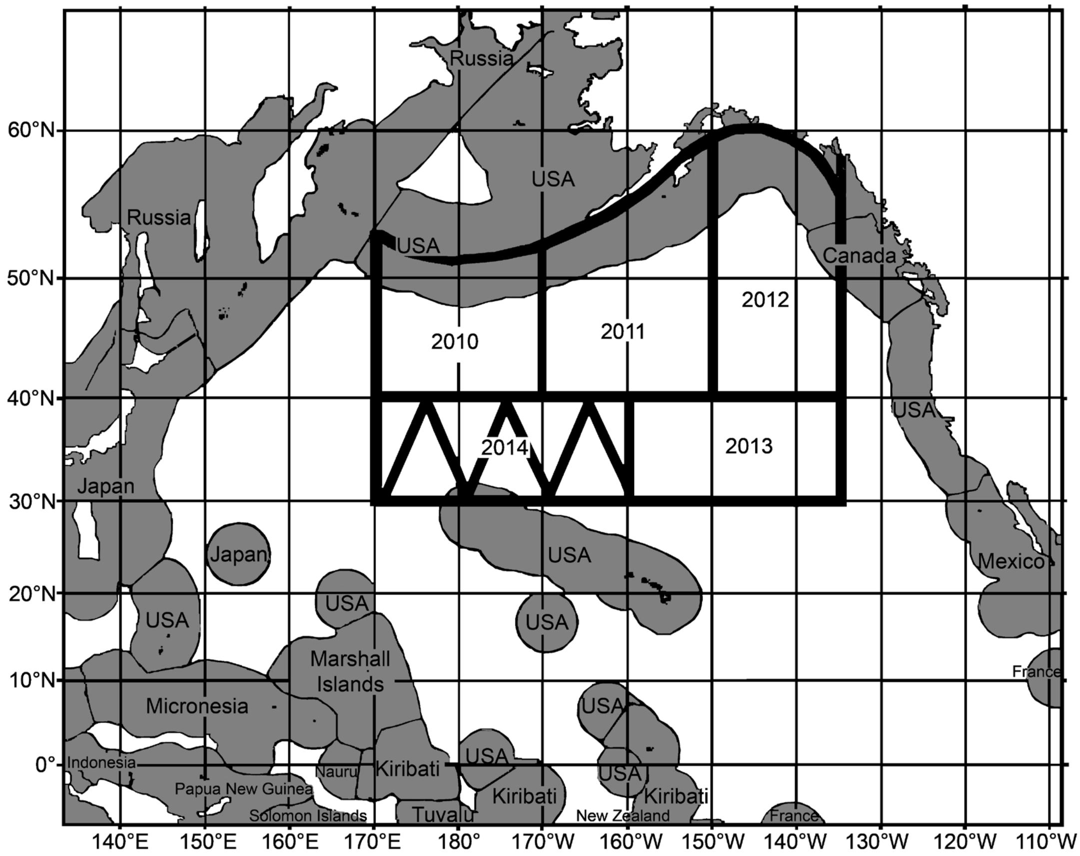


Fig. 2. Areas covered in the POWER plans for 2010-14.

whales were widely distributed in both strata. Except for two sightings in the Canadian EEZ, sei whales were sighted in only the southern stratum and were widely distributed, with some areas of higher densities. Blue whales were sighted in the southern stratum only. One common minke whale was sighted in each stratum. A solitary North Pacific right whale was sighted in the northern stratum, 120 n.miles southeast of Kodiak Island. Alaskan humpback whales were only sighted in the northern stratum. Most sperm whales were solitary large males and were sighted in both strata in some areas of higher densities. Killer whales were sighted in both strata. Photo-identification data were collected for four blue whales, one North Pacific right whale, 26 humpback whales, 60 fin whales, 51 sei whales and 47 killer whales. A total of 52 biopsy samples was successfully collected using the Larsen-gun system, from two blue whales, 12 fin whales, 37 sei whales and one killer whale. Marine debris (230 objects) was also recorded, and there were some dense concentrations. The Estimated Angle and Distance Training Exercise and Experiment were completed as in previous years. Sighting protocols were in accordance with the guidelines agreed by the Scientific Committee, and the survey objectives, procedures, and methods upon the vessel were fully understood by the Captain, officers, crew and international researchers before the start of the survey. The authors noted that the third cruise of this programme was completed successfully, and provided information on various baleen whale species and other cetacean species, indicating these were widely distributed in the research area where they had been depleted in the past; the results addressed the above objectives for the Scientific Committee.

On behalf of the sub-committee, Kato thanked the Cruise Leader, researchers, Captain and crew for completing the third cruise of the IWC-POWER programme. The Governments of Canada and the USA granted permission for the vessel to survey in their respective waters, without which this survey would not have been possible. The Government of South Korea provided one scientist, and the Government of Japan generously provided the vessel and crew. The sub-committee recognised the value of the data contributed by this and the other POWER cruises, collected in accordance with survey methods agreed by the Committee, covering many regions not surveyed in recent decades, and addressing an important information gap for several large whale species.

In discussion of the 2012 POWER cruise results, it was noted that rather few minke whales had been seen. Weather conditions in the North Pacific in summer tend to be windy and foggy, and the survey continues to operate up to Beaufort 5; such conditions are probably adequate for seeing larger cetaceans, but minke whale detectability undoubtable is lower in sea states as high as 5. It was therefore suggested that in future effort and sightings data should be presented by sea state as well as survey stratum. This is relevant both to the feasibility of estimating abundance of various whale species from current North Pacific surveys, and also for considering any changes in design required for subsequent iterations of POWER after 2014. Future distance-sampling analyses could also investigate pooling the distance-function across years but stratifying by sea state. These issues could be investigated further at the POWER Technical Advisory Group (TAG) Workshop scheduled for later in 2013 (see Appendix 2) for medium- and long-term planning.

3.2 Report on other North Pacific cetacean surveys

SC/65a/O04 reports on three systematic vessel-based sighting surveys conducted in summer 2012 by Japan to examine the distribution and abundance of large whales in the western North Pacific. The research area for 'Survey 1' was set between 35°N and 44°N and between 140°E and 150°E (sub-area 7). The research area for 'Survey 2' was set between 30°N and 40°N and between 140°E and 170°E. The research area for 'Survey 3' was set between 41°N and 44°N, and between 141°E and 147°E (sub-area 7CN). Survey 1 was conducted between 17 May and 30 June, 2012. Survey 2 was conducted between 20 August and 3 October, 2012, and the Survey 3 was between 14 September and 1 October, 2012. The research vessels were *Yushin-Maru* (Survey 2), *Yushin-Maru No.2* (Survey 2) and *Yushin-Maru No.3* (Surveys 1 and 3). A total of 2,728 n.miles, 5,292 n.miles and 728 n.miles were searched in Surveys 1, 2 and 3, respectively. Successful coverage of planned tracklines of each survey was 75%, 98% and 86%, respectively. One blue whale was sighted, in Survey 2 around 40°N. Fin and humpback whales were mainly seen in Surveys 1 and 3, sei whales mainly in Survey 1, and common minke whales only in Surveys 1 and 3. Sperm whales were sighted in Survey 2. In total, seven species were seen, including six baleen whales - blue whales (1 school/1 individual), fin whales (10/17), sei whales (12/15), Bryde's whales (137/183), common minke whales (61/74) and humpback whales (32/42) - and one toothed whale (sperm whales, 169/426). The small number of common minke whales may reflect insufficient searching effort in the offshore waters in Survey 1, and the authors suggested that such a small number of sightings would not be suitable for estimating abundance of this species from this survey sub-area. Higher-density areas were observed for common minke whales in the coastal waters of Surveys 1 and 3, and Bryde's whales in Survey 2. Photographs for photo-id were successfully taken from one blue whale and 10 humpback whales. Biopsy skin samples were also successfully collected from blue whales (1), fin whales (1) and Bryde's whales (42).

The sub-committee welcomed this report. As noted under Item 3.1, sighting conditions might need to be accounted for when estimating abundance in the North Pacific (particularly for minke whales), and indeed when designing surveys for that purpose. Although the small number of sightings of common minke whales in 7W and 7E might well be largely due to poor weather (windy and foggy), it would be premature to conclude that no abundance estimate could be made without first seeing a weather-stratified analysis.

3.3 Plans for cetacean sighting surveys

3.3.1 Report of the Intersessional Planning Meeting for the 2013 IWC-POWER Cruise

The Planning Meeting for the IWC-POWER research cruise programme was held in Tokyo, Japan, 25-26 September 2012 (SC/65a/Rep01). The purpose of the meeting was to finalise arrangements for the 2013 POWER survey; details of this meeting are given in SC/65a/Rep01, and were presented at SC/65a by Donovan. The meeting had received preliminary results from the 2012 IWC-POWER cruise and these were used, along with overall objectives of the first phase of the IWC-POWER surveys, to formulate a plan for the 2013 cruise. Also discussed was a suggestion to highlight the IWC-POWER surveys on the IWC website with the ultimate aim of inspiring multinational collaboration in the survey programme. Fortunately, there will be no problems arising from requirements for CITES permits during the 2013 survey as the tracklines do not enter any EEZs; however, the problems with this issue will return in 2014, when the planned survey design will take the vessel into US waters. There was also confirmation that a Mexican scientist will join the 2013 survey. Finally, Donovan also covered a number of items related to the short, medium and long-term objectives of IWC-POWER, which were later discussed by the POWER TAG (see Appendix 2).

During SC/65a, the short-term validation issues (concerning some discrepancies between the paper data sheets and the electronic versions) identified in SC/65a/Rep01 were resolved successfully; the broader issue of validation and database software remains on the agenda for planning future surveys. It was recognised that since the first, short-term phase of the IWC-POWER cruises would end next year (2014), planning for the medium-to-long term would need to start very soon. As a first step, members of the POWER TAG met at SC/65a under Kelly to discuss the data and analyses required for such planning (Appendix 2). The TAG will reconvene in Tokyo prior to the Planning Meeting for the 2014 IWC-POWER survey.

3.3.2 Plans for other cetacean sighting surveys in 2013

The plans for a systematic vessel-based sighting survey in the North Pacific by Japan (ICR) as part of JARPN II in 2013 are described in SC/65a/IA03. The main objective is to examine the distribution and estimate the abundance of common minke whales and sei whales for management. The survey will be conducted using the research vessels *Yushin-Maru* and *Yushin-Maru No.2* between 18 May and 26 June and will cover the area comprised between 35°N-46°N and 140°E-157°E (sub-areas 7W, 7E and 8). For abundance estimation, routine distance and angle estimation experiments will be conducted. Biopsy skin samples of blue, fin, humpback and right whales will be collected on an opportunistic basis. Photo-identification experiments on blue, right and humpback whales will also be conducted opportunistically. The report of the sighting survey will be submitted to the 2014 Scientific Committee meeting.

In sub-committee discussion, Hedley commented that while the equal-angle zig-zag design applied in SC/65a/IA03 covered most of the survey area adequately, this was not necessarily so in the far north, and suggested that the northern waypoints be re-checked. Noting this, the sub-committee **endorsed** the proposal in SC/65a/IA03, and appointed Matsuoka to provide IWC oversight.

3.3.3 Plans for 2014 IWC-POWER cruise

SC/65a/O05 outlines the plan for the IWC-POWER line transect sighting survey cruise in 2014. The research vessel, *Yushin-Maru No.3*, will be engaged. The proposed research area is the eastern North Pacific, between 170°E and 160°W, from 30°N to 40°N; this area has not been surveyed previously. Photo-id and biopsy experiments are also planned. The cruise will take place in July and August and will involve about a 15-day transit to and from the research area, and thus some 45 days of research. Information collected from this survey will provide essential information for the intersessional workshop to plan for a medium-long term international survey programme in the North Pacific. The data and report of this survey will be submitted to the Scientific Committee meeting in 2015.

The sub-committee **strongly recommended** that permission be sought to operate in the US EEZ far enough in advance for the 2014 cruise.

The sub-committee thanked the Government of Japan for its generous offer of providing a vessel for this survey. The Steering Group for IWC North Pacific Planning appointed last year was re-established, convened by Kato (see Table 2). Matsuoka was assigned responsibility for IWC oversight.

4. ANTARCTIC SURVEYS

4.1 Progress on IDCR/SOWER volume

4.1.1 Update

Last year (IWC, 2012b, p.40; 2012c) the Committee nominated an Editorial Board, tasked with responsibility for the volume's preparation. As Convenor, Bannister reported that in accordance with the Committee's wishes, a timetable has been developed, a contents list has been proposed and authors have been approached to prepare brief outlines of their contributions. The volume is intended to be a book reviewing the cruises: not a series of original scientific papers, but rather a series of review chapters bringing together all the work that has been accomplished so far. Where possible new analyses may be incorporated, especially of data not previously analysed, but also reviewing existing work in a more holistic manner.

In addition to a Foreword and Acknowledgements, the volume will provide an introduction to the programme and its fieldwork, including its original aims and objectives, and cruise narratives. There will be major chapters on whale distribution and movements, particularly of minke and blue whales, on taxonomy and population structure, on acoustics, and on abundance (including the development of DESS) with special emphasis on minke whales but also including blue, humpback, and other large whale species, as well as small cetaceans. An extremely important chapter will be devoted to conclusions and lessons for the future, with emphasis on achievements and lessons learned. Some 30 authors are involved so far, with a deadline for final contributions of 31 December 2013.

The sub-committee thanked Bannister and the Editorial Board, and looked forward to an update next year.

4.1.2 Production of standard datasets for non-minke species

Whilst the Secretariat will work towards the production of standard datasets that can be used for other species, e.g. comparable 'survey-once' datasets for estimating overall abundance, it was noted that there are still some inconsistencies in the 'standard' dataset for Antarctic minke whales identified during the development of the SPLINTR spatial models. Some are minke-specific, but others relate to effort and stratum data and thus are relevant to analyses of all species. A mechanism for improving validation and resolving inconsistencies is still required (see task 6 in Item 8, the work plan). Some of the validation issues are also relevant to the current POWER cruises (see Item 3), although the advent of automated data entry from on-board loggers will have alleviated some of the problems. If a new database system gets developed, then the process of populating it with existing IDCR/SOWER and POWER data from DESS is an opportunity to automate additional validation steps; however, this would not be in time to help with analyses for the IDCR/SOWER commemorative volume.

4.2 Report from the 2012/13 cetacean sighting survey

SC/65a/IA07 described events around a dedicated sighting survey for abundance estimation in the Antarctic over the 2012/13 austral summer season. The plan for the survey had been endorsed by the Committee at the 2012 meeting (IWC, 2012c). The intent was to use the research vessels *Yushin-Maru No 2* and *Yushin-Maru No 3* to survey Area III east, Area IV, and the western part of Area V, using the same methods as in the IWC-SOWER program, and in accordance with the guidelines agreed by the SC (IWC, 2005). The design of the tracklines was improved to cover each research area with uniform probability. Unfortunately, the research could not be conducted at all due to violent interference by an anti-whaling group. This group has directed violent sabotage activities against Japanese research vessels in previous seasons, and continued such activities throughout the 2012/13 season. In order to secure the safety of the research vessels and their crew members, the sighting vessels had to sacrifice most of the research time to security tasks, and the dedicated sighting survey was therefore completely cancelled. The authors expressed their disappointment at the waste of such a valuable opportunity, and the loss to Antarctic whale research and management under the Scientific Committee objectives.

On hearing this news the sub-committee noted and expressed its concurrence with the Commission's previous consideration of this issue and its 2011 Resolution on Safety at Sea (2011-2) (IWC, 2012a) in which the Commission and its Contracting Governments condemned any actions that were a risk to human life and property in relation to the activities of vessels at sea. In particular, the sub-committee expressed its regret that the actions of the anti-whaling NGO had prevented the sighting survey from being conducted, just as in 2011/12. Following the cessation of the IDCR/SOWER program in 2009 (and notwithstanding smaller-scale national projects to collect sightings data in particular regions), surveys such as in SC/65a/IA07 provide the only dedicated cetacean sightings that are synoptic over a wide area, and as such are extremely valuable for the work of the Scientific Committee.

4.3 Plans for cetacean sighting surveys in 2013/14

Paper SC/65a/IA06 presented plans for a systematic cetacean sighting survey for abundance estimation during the 2013/14 austral summer season in the Antarctic, forming part of JARPA II. The research area comprises Area IV, Area V and the western part of Area VI between 130°E and 145°E, south of 60°S. The research period is from December 2013 to March 2014. The research vessels *Yushin-maru No. 2* and *Yushin-maru No. 3* will be used and the survey procedures will follow those of IWC/SOWER. Distance and angle estimation training will be conducted, along with several other experiments. Abundance of Antarctic minke whales will be estimated after the cruise, using recent analysis methods of the Committee. Biopsy skin sampling of blue, fin, humpback, southern right, and sperm whales will be collected opportunistically for investigating stock structure. Photo-identification studies of large cetaceans such as blue, southern right and humpback whales will be also conducted. A cruise report will be submitted to the 2014 Scientific Committee meeting.

In discussion, the difficulty of fully reviewing a proposal without detailed design information was recognised, but that this seems unavoidable given security considerations (see Item 4.2). The use of consistent protocols over time makes this series of cruises a valuable resource, not least for analysing ice effects (an important point to allow for when studying long-term trends in abundance). The unpredictability of sea ice can in itself cause problems for standard analyses when designs have to be changed mid-survey, though careful analysis via spatial models can to some extent alleviate this. The sub-committee recalled that photos of blue, right, and humpback whales from similar surveys in the past have been submitted to the relevant catalogue-holders for those species (and will continue to be submitted in future), and have been used in analyses in the relevant sub-committees. The sub-committee broadly **endorsed** the proposal, **recommending** that the proposed trackline design be changed if a survey of the Ross Sea was actually able to proceed. Matsuoka was appointed to provide IWC oversight.

4.4 Photographic archiving

SC/65a/IA14 presented a progress report of a major archiving and cataloguing exercise for the photographic collections arising out of the IDCR/SOWER and continuing IWC-POWER cruises. The photographs have a wide range of potential uses ranging from photo-identification through education to contributing to assessments of human impacts. All photographs are being assessed for photographic quality and are:

(a) extensively keyworded to enable fast and accurate access for a variety of scientific and other purposes; and
(b) georeferenced in accord with the paper datasheets.

This is a major undertaking and to date over 31,000 have been examined and coded. The work began with already digitised photographs and the plan is then to move to digitising those photographs that exist only on film.

The sub-committee thanked the authors for their efforts, and looked forward to a further update next year. It was recognised that keywording the photos, e.g. to select those adequate for photo-id studies, is an essential but enormous task, exacerbated by the inordinate frame-rate of modern digital cameras.

5. IN-DEPTH ASSESSMENT ON NORTH PACIFIC SEI WHALES

5.1 Log book records

At SC/64, an issue had been identified with the division of Japanese catch records between sei and Bryde's whales in the period 1955-72. This year the sub-committee heard that this had been a misunderstanding: the division of the catch figures had already been accomplished in the context of the Bryde's whale assessment.

Corrected Soviet catch data are documented by Ivashchenko *et al.* (2013). The sub-committee agreed that these represent the best possible reconstruction of the Soviet catch history in the north Pacific at this time, and that they should be incorporated into the IWC database if they have not already been. The sub-committee requested that Allison complete the remaining catch history additions or revisions (such as the revised Canadian catch data) during the coming intersessional period.

5.2 Stock structure

SC/65a/IA05 presented the results of microsatellite DNA analysis conducted on the North Pacific sei whale samples obtained from 2010-12 IWC-POWER. The samples came from the IWC-POWER cruises that surveyed 173°E-172°W area of the central North Pacific in 2010 (*n*=13), 170°W-150°W area of the central North Pacific in 2011 (*n*=29), and 150°W-135°W area of the eastern North Pacific in 2012 (*n*=35). All of the areas were north of 40°N. The POWER genetic data from 14 microsatellite loci were then analysed with previously reported genetic data of the JARPN II samples (*n*=489) collected from the western North Pacific between 143°E and 170°E in 2002-07 and the commercial whaling samples collected from the central North Pacific between 180° and 150°W in 1972-73 (*n*=57) and from the eastern North Pacific between 150°W and 139°W in 1973 (*n*=64). Analyses of these samples allowed the authors to detect temporal (40 years apart) and spatial (143°E to 135°W area divided into western, central, and eastern) genetic differences of the North Pacific sei whales. The results showed:

(a) very similar level of genetic diversities among the POWER, JARPN II and commercial whaling samples;
(b) no evidence of the genetic differences among the three POWER samples:
(c) no evidence of the temporal genetic differences between the recent POWER and past commercial whaling samples collected from the same area; and
(d) no evidence of the spatial genetic differences among the western, central, and eastern samples.

This study supports the authors' previous view that the open waters of the North Pacific were occupied by the individuals from a single stock of sei whales.

This paper was discussed extensively in the sub-committee on stock definition, which made three recommendations: (i) an analysis of the power of the data set to detect subtle population structure that might nevertheless be important for management; (ii) a clustering analysis using STRUCTURE or a similar approach; and (iii) a relatedness analysis (at some point in the future when the sample size is sufficient to expect to find a reasonable number of close relatives).

Kanda stated that it would be possible to conduct the recommended studies, but not before 2016 because of other priorities. The sub-committee did not expect that these analyses would materially change the current understanding, and agreed that it was not necessary to await the results before proceeding with the in-depth assessment.

5.3 Analysis of sightings survey data

SC/65a/IA09 reported preliminary abundance estimates of North Pacific sei whales based on the 2012 IWC-POWER sighting data and standard line transect methodology. The surveyed area comprised the eastern North Pacific north of 40°N, south of the Alaskan coast including both the US and Canadian EEZ, and between 150°W and 135°W. The survey area was divided into northern and southern strata along the EEZ line of the USA and Canada. Cruise tracks were designed using the program *Distance* (Thomas *et al.*, 2010) following the principles outlined in the Scientific Committee's Requirements and Guidelines for Surveys (IWC, 2012d). Analyses were conducted using standard line transect methodology. The abundance estimate for sei whales was 12,180 (CV=0.327) for the base case scenario. This estimate was found to be fairly insensitive to alternative assumptions on stratification for estimation of mean school size and detection functions. The abundance estimate for sei whales will be refined using all IWC-POWER sighting data for the period 2010-12. Detection functions that incorporate covariates (such as Beaufort state and year) will be examined. Also, there will be further examination of stratification for estimating mean school sizes.

The sub-committee acknowledged the preliminary nature of these analyses, and looked forward to receiving the combined analysis of the 2010-12 data. The sub-committee requested the Secretariat to complete the data validation in time for the reanalysis to be completed before the 2014 meeting. The POWER TAG will consider how best to combine data across years.

SC/65a/IA10 presented a preliminary analysis of the spatial distribution of fin, sei and humpback whales in the offshore eastern subarctic Pacific, using data obtained by the POWER cruises in July and August from 2010 to 2012.

The spatial distribution of fin, sei and humpback whales was estimated using generalised additive models (GAM). Presence and absence of whales was used as response variable while sea surface temperature (SST), sea surface height anomaly (SSHa) chlorophyll-*a* concentration (chl) and seafloor depth were used as explanatory variables. Fin whales were mainly distributed in the north eastern part of the survey area. Sei whales were mainly distributed in the southern part of the survey area. Humpback whales were mainly distributed near the coast of the Aleutian Islands and Alaska. The main distribution areas of these three species were segregated although some overlaps were observed. The results fill gaps of information of recent distribution of baleen whales in this region. It is expected that additional sighting data obtained in the eastern North Pacific Transition Zone and the eastern subtropical North Pacific in the next POWER cruises will improve knowledge of the current distribution of baleen whales in the eastern North Pacific.

The sub-committee welcomed this analysis, and made a number of technical suggestions; it will consider an updated version in more detail at the in-depth assessment to proceed next year.

6. CONSERVATION MANAGEMENT PLANS

The populations currently under scrutiny by this sub-committee are Antarctic minke whales (at least two populations) and sei whales in the North Pacific. The sub-committee **agreed** that there was no need to develop Conservation Management Plans for these, and had no further suggestions for other species or populations.

7. UPDATED LIST OF ACCEPTED ABUNDANCE ESTIMATES

This item was discussed at SC/65a in response to a request from the Commission. Over recent years, this sub-committee has focused on Antarctic minke whales, for which agreed estimates were presented at SC/64. These estimates, along with their associated levels of uncertainty and caveats to their interpretation, are presented in Appendix 4.

Plans for an in-depth assessment of North Pacific sei whales are complete; if the remaining intersessional tasks can be completed, the assessment can proceed at SC/65b, but to date all estimates of this species should be viewed as preliminary so are not included in Appendix 4.

In discussion of this item, the sub-committee **recommended** that a further table be developed. This would inform the Commission of current gaps in our knowledge. It was suggested that the table include species/stocks for which: (i) there are no current data for assessment; (ii) data are available, but no suitable analyses exist; and (iii) some data/analyses exist, but covering such a small fraction of the species/stock in question that they are not useful for assessment.

8. WORK PLAN AND BUDGET REQUESTS

The sub-committee **agreed** that its main work items for the 2014 Annual Meeting would be as follows:

(1) further investigation and application of the SCAA models (details in Appendix 5);
(2) further work examining the factors which drive Antarctic minke whale distribution and abundance;
(3) complete preparations for an in-depth assessment on North Pacific sei whales, specifically:
   (a) update the IWC catch data to include new data from Canadian and Soviet catches; and
   (b) analyse available survey and genetic data from the North Pacific, including from the IWC-POWER surveys;
(4) investigate the distribution and density of baleen and toothed whales in the Antarctic relative to spatial and environmental covariates; and
(5) plan and undertake the fifth IWC-POWER survey in the North Pacific.

Budget requests were submitted to complete all items except item 3, and further information is given below. All four requests were **recommended** by the sub-committee for full funding.

For item 1, the detailed work plan may be found in Appendix 5. The budget request represents only partial salary for the researcher.

For item 2, satellite telemetry studies around the Antarctic Peninsula and in the Ross Sea have been proposed, which will elucidate our knowledge of movements, migration and diving behaviour of Antarctic minke whales. The proposed budget request does not cover salaries, nor ship time, but represents the costs of the tags themselves. A priority for the work of this sub-committee is to collect data that will enhance current knowledge of Antarctic minke whale distribution and abundance in the ice region, so that it can be compared to such in open water. The proposal covers two different types of tag, and the sub-committee noted that data from one type (TDR) in particular (successfully deployed on Antarctic minke whales this year, but on a very small sample size) would provide essential information on the surface availability of whales in and outside the ice, which is needed for estimating absolute abundance from the aerial surveys – these surveys are currently by far the most reliable data source on relative abundance within the sea ice, but cannot be compared with open-water ship-based estimates such as from SOWER until and unless there are estimates of surface availability. Data from the other type of tag would also be useful in terms of general usage of within- and outside-ice habitats, and on longitudinal and latitudinal movements. The proposer confirmed that all data would be made available to IWC in accordance with the usual procedures.

Item 3 remains on our agenda from last year. Although new analyses were presented this year (SC/65a/IA05, SC/65a/IA09, and SC/65a/IA10) the in-depth assessment could not proceed fully as the historical catch data had not been incorporated into the database due to other priorities within the Committee. In order to progress this work, these catches need to be given high priority intersessionally.

Item 4 relates to work required for a proposed chapter of the commemorative IDCR/SOWER volume, and may also contribute important information related to item 2 above. The budget request represents only partial salary for the researcher.

Item 5 is essential to further our understanding of distribution and abundance of many large whale species. The fifth cruise will mark the end of the 'short-term' initial scoping period of the IWC-POWER programme, necessary since most of the area has been poorly covered and not at all in recent decades. These data, and data from the 2010-13 surveys, will be essential for planning the medium and long term phases of the programme. The preliminary cruise and meeting budget is given in Appendix 5.

Since Antarctic minke whale abundance estimates had been agreed at SC/64, improvements to the OK and SPLINTR abundance estimation methods were deemed desirable (e.g. to estimate cue rates within the modelling framework rather than fix them externally), but were not high priority (see

Table 2

Intersessional groups and their membership.

Group	Terms of reference	Membership
SCAA (Working Group)	Assist with intersessional work (see Appendix 5)	Punt (Convenor), Butterworth, Cooke, de la Mare, Kitakado, Matsuoka
IWC-POWER Survey Planning (Steering Group)	Finalise plans for 2014 IWC-POWER survey	Kato (Convenor), An, Bannister, Brownell, Clapham, Donovan, Ensor, Matsuoka, Miyashita, Murase, Pastene, Wade
POWER Technical Advisory Group (Working Group)	Initial consideration of medium-term plans for IWC-POWER (see Appendix 2)	Matsuoka (Convenor); Bravington, Donovan, Hedley, Kelly, Palka, Kitakado
IDCR/SOWER Data Validation (Working Group)	Assist in resolving data discrepancies in IDCR/SOWER	Hedley (Convenor), Bravington, Burt, Donovan, Hughes, Kelly

tasks (5)-(7) in Item 8, Annex G, IWC, 2013b). No updated methods were presented this year, but modifications have been made to the IWC simulated datasets ready for testing new estimation methods in future (see SC/65a/IA15). More simulated datasets will be required at some future date, specifically to test the reliability of variance estimation.

Last year's work plan also included an item which aimed to tie up loose ends arising from the IDCR/SOWER Antarctic minke whale analyses. However, no progress can be made on this until specific details of the data validation issues are provided to the Secretariat. To facilitate progress on this task, an intersessional Working Group was established initially under Hedley; the Working Group will include Burt who has indicated that she is willing to assist with this (and may take over as Convenor intersessionally). Thus the remaining item on our work plan is:

(6) Data management:
- (a) further validation and correction of IDCR/SOWER data;
- (b) curation of experimental IDCR/SOWER data; and
- (c) production of standard datasets for analyses of species other than Antarctic minke whales.

9. ADOPTION OF REPORT

Hedley expressed her thanks to the sub-committee for their patience and to the rapporteurs for their hard work. Palka will convene IA intersessionally and will hopefully return to attend SC/65b. On behalf of the sub-committee, Kato thanked Hedley for stepping in as Chair. The report was adopted at 19:20 on 11 June, 2013.

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Appendix 1

AGENDA

1. Introductory items
   1.1 Election of Chair
   1.2 Appointment of rapporteurs
   1.3 Adoption of Agenda
   1.4 Documents available
2. Antarctic minke whales
   2.1 Statistical catch-at-age analysis
   2.2 Abundance estimates from shipboard surveys
      2.2.1 Simulated data
      2.2.2 Interpretation of agreed estimates
   2.3 New methods or information
   2.4 Possible reasons for differences between point estimates from CPII and CPIII
3. North Pacific surveys
   3.1 Report on the 2012 IWC-POWER cruise
   3.2 Report on other North Pacific cetacean surveys
   3.3. Plans for cetacean sighting surveys
      3.3.1 Report of the intersessional planning meeting for 2013 IWC-POWER cruise
      3.3.2 Plans for other cetacean sighting surveys in 2013
      3.3.3 Plans for 2014 IWC-POWER cruise
4. Antarctic surveys
   4.1 Progress on IDCR/SOWER volume
      4.1.1 Update
      4.1.2 Production of standard datasets for non-minke species
   4.2 Report from 2012/13 cetacean sighting survey
   4.3 Plans for cetacean sighting surveys in 2013/14
   4.4 Photographic archiving
5. In-depth assessment on north Pacific sei whales
   5.1 Log book records
   5.2 Stock structure
   5.3 Analysis of sightings survey data
6. Conservation Management Plans
7. Status of abundance estimates recently presented to the IA sub-committee
8. Work plan and budget requests
9. Adoption of Report

Appendix 2

REPORT OF THE TECHNICAL ADVISORY GROUP FOR IWC-POWER CRUISES

Members: Kelly (Convenor), An, Bravington, Donovan, Hedley, Hughes, Kitakado, Matsuoka

1. TERMS OF REFERENCE

The terms of reference for the group were to discuss matters arising from the Technical Advisory Group (TAG) meeting held in Tokyo in September, 2011 (IWC, 2012), from the outcome of the 2012 IWC-POWER survey and from the Tokyo Planning Meeting Report (SC/65a/Rep01). Immediate recommendations were needed in order to resolve data issues that had arisen during validation of data from the 2011 IWC-POWER cruise. The TAG was also tasked with discussing data and analysis requirements in order to facilitate initial planning for the medium-long term phases of the IWC-POWER programme at the forthcoming TAG meeting in September/October.

2. IWC-POWER OBJECTIVES AND PLANNING

The short, medium and long term objectives of the IWC-POWER programme were briefly reviewed. Some particular points were highlighted for further discussion; these are reported below. It is important that adequate data are available to allow timely consideration of options for refining the programme of the next phase of IWC-POWER. There are now only two remaining years in the first phase of IWC-POWER (including the survey due to take place this summer before the next TAG meeting). As the end of this initial phase of the programme is almost upon us, it is important to gather appropriate data and if necessary plan the development and implementation of new technology and/or equipment to take the programme forward efficiently into the medium and long-term phases. It is important to be considering this now, because of the timing of the cruises with respect to the SC meetings.

The following items arising from SC/65a/Rep01 were discussed by the TAG:

Data validation and archiving

At the end of the current phase of IWC-POWER cruises, efforts need to be made to ensure that all sightings, effort and associated data have been validated and are available, so that a review of objectives over the medium and long term can be undertaken. Analyses of these data will need to proceed prior to the beginning of the next phase of IWC-POWER, which is currently scheduled to start in 2015.

There are two points in regards to handling data from IWC-POWER cruises:

(1) resolving discrepancies between paper and electronic copies of data that are submitted to the IWC Secretariat after each cruise; and
(2) a medium term process of deciding whether DESS (as it is currently) is an appropriate system for long-term data storage and access, or whether a new system needs to be developed, encompassing newer mapping facilities and an easier way to cross-reference biopsy and photo-id data.

Hughes provided an update of the status of data validation from the IWC POWER cruises.

(1) Data from the 2010 cruise (paper data sheets) have been encoded and validated; uploading of these data into DESS is pending.
(2) Validation of data from the 2011 cruise is in progress, but many discrepancies between electronic and paper copies (which have been entered twice by IWC Secretariat staff) have been highlighted (discrepancies included columns that did not match between paper and electronic copies, and, furthermore, columns in the paper versions that were not completed). Progress on validating 2011 data has stalled because of these uncertainties; and
(3) the Secretariat have only very recently received the paper copies from the 2012 IWC-POWER survey so these data have not yet been validated.

The TAG reinforced the recommendation made in SC/65a/Rep01 that Matsuoka (Cruise Leader on the IWC-POWER cruises) and Hughes meet during SC/65a to investigate and resolve the data validation issues, particularly those regarding discrepancies between the electronic and paper forms[1]. This is important because the 2013 cruise will depart shortly. The TAG recommended that for data validation, use:

- electronic data for position data (as this takes a feed of data straight from a GPS, and as such, the time stamp for this data will also be accurate); and
- for the remaining fields, the paper copy should generally take precedence (unless it contains an obvious error) since these are the primary source, whereas the electronic versions may be subject to some transcription error.

Matsuoka and Donovan agreed to update the paper data forms in time for the 2013 cruise to remove fields (such as 'lat, lon') which were now being automatically recorded by the real-time data entry system on board the vessel.

Updating the onboard system for electronic data entry

Given the issues arising with discrepancies between data on electronic and paper sheets, there was discussion concerning updating the format of data entry for IWC-POWER surveys. Furthermore, there was a suggestion that going to an entirely electronic version would be much more efficient, both in terms of time on board, and subsequent data handling.

Donovan has been tasked to make inquiries about potential software/hardware systems for capturing cetacean sighting survey data. Ideally, this system would be in place for the 2014 cruise in order to begin testing for incorporating this into the medium-term POWER phase. It would be useful to bring along 'stand-alone' versions for consideration at the TAG meeting later this year.

Instructions for the automated data acquisition system on board the vessels are currently only available in Japanese. Matsuoka agreed to provide a translation of these instructions into English. (The 'Information for Researchers' document, describing the data forms and survey protocols is already available in both languages.)

Planned effort per day and appropriate sea states for surveying

During the initial phase of IWC-POWER, planned trackline coverage is based on achieving an average of 90 n.miles per day, with effort conducted in sea states up to and including 5. This enabled coverage of the whole survey area in as short a time as possible to gather data on sighting rates, sighting conditions, likely species densities and distributions. It was recognised that in higher sea states, minke and other small whales are very difficult to see, but these were not target species for this part of the programme at least. In future planning for IWC-POWER, the sea states suitable for surveying will need to be re-assessed both in the light of the medium-long term objectives (SC/65a/Rep01) and by using the data collected during the 2010-14 cruises. At this juncture, this does not mean that any changes to the conditions suitable for surveying will be made, simply that these will be revisited to allow an informed decision to be taken.

DESS review

The importance of reviewing DESS for the purpose of IWC-POWER surveys was discussed, and a number of options briefly canvassed. A review of DESS would consider whether it is adequate without changes; whether modification to DESS could be made to include broader IWC-POWER data objectives; or whether an alternative data access and archiving system should be pursued. It was noted that the latter two options would have budgetary implications and therefore a budget for a review of DESS should be discussed during SC/65b.

Regardless of the ultimate decision about the future of DESS, it is important to upload current IWC-POWER data into DESS as soon as possible. If a different system is later developed, it should be fairly straightforward to transfer the DESS data to it.

Angle and distance training and experiments

The angle and distance training which is conducted close to the beginning of the survey is supposed to train the observers in angle and radial distance estimation. During the training, observers receive immediate feedback on their estimates and may modify their estimates accordingly as the training continues. During the experiment, the observers do not receive feedback; it provides data for potential post-survey calibrations of sightings data to correct for bias in distance and angle estimation. Both the training and experiment are already part of the IWC-POWER protocol, but there is both the potential to update the technology/equipment used to estimate these vitally important components of the data needed to estimate density using line transect analyses, and to broaden the scope of those experiments – perhaps to make them more realistic to the process of 'seeing a whale cue'. New technology for measuring angles and distances is currently being developed by Russell Leaper, but is not expected to be ready before the medium-term phase of IWC-POWER. A summary and preliminary analysis of angle/distance experiment data from 2010, 2011 and 2012 POWER surveys will be undertaken by Matsuoka before the next TAG meeting to assist further discussions.

Survey mode

It was previously agreed that the most appropriate survey mode for the first phase of IWC-POWER is NSP (passing with abeam closing). The point of abeam-closing is to allow more accurate calibration of school size estimates made in future Passing or IO mode survey (even though those modes are not currently used in POWER); this is a lesson learnt from the analysis of SOWER data. The protocol used in SOWER post-2004, and in current JARPA II sighting surveys, is that estimates of minimum school size are made prior to the school coming abeam, just as they would be in Passing/IO mode, and then the true school size is established after Closing. There was some discussion as to whether observers were asked their opinions on school size and species after the first sighting was made, but before or as the vessel changed course to close (also known as SSII experimental survey mode under IWC-SOWER surveys). Ultimately, this data helps correct for potential errors in sightings when in IO-mode type of effort that does not allow for confirming school size and species. In order to avoid observers feeling like their abilities were being 'tested', there is a need to stress that collecting this type of data is not a matter of judging observers, but that it is a genuine attempt to account for errors in observations that can arise, particularly when sightings are far from the vessel/trackline.

There is an urgent need to check, for the 2013 cruise, whether during NSP mode that species and school size is recorded before the vessel breaks off the trackline to close (otherwise the point of abeam-closing is lost).

[1]Matsuoka subsequently reported to the sub-committee that he and Hughes had met, and that these issues were now resolved, so would not cause difficulties for data validation of the 2013 and subsequent data.

Analyses of IWC-POWER data for planning medium-long term programme

The TAG meeting in September/October this year will meet with a view to providing analyses useful for planning the medium-long term IWC-POWER programme, which will be discussed at SC/65b. The analyses will need validated sightings, effort and weather data from the 2010-12 surveys, tabulated effort by sea state (Matsuoka agreed to provide this), and estimated school sizes before and after abeam closing. There was little time to discuss this, but it was noted that it would also be valuable to provide species identification data on before-and-after abeam closing.

Donovan and Matsuoka agreed to consult on this and see if it was possible to include this on the modified data forms for the forthcoming (2013) IWC-POWER cruise.

TAG meeting dates and participants

It is preferable for the TAG to meet prior to the Planning Meeting for the 2014 cruise. The dates for the Planning Meeting are currently being finalised but will be around 1-2 October, so dates for the TAG meeting will likely meet from 29-30 September. As the meeting will be discussing future plans, then it is important to try to ensure the participation of a scientist familiar with modern data acquisition technology on surveys. Matsuoka agreed to contact Palka regarding her availability. He also offered to convene the meeting, with members: Bravington, Donovan, Hedley, Kelly, Palka and Kitakado.

REFERENCE

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Appendix 3

INTERPRETATION OF AGREED ESTIMATES

Table 1 below is reproduced from IWC (2012), and this accompanying text aims to clarify some points concerning which numbers are most appropriate for which purposes.

The 'Survey-once' estimates are the best estimates of the average number of whales in the *Management Area* (MA) stated during the CPIII period (whose midpoint is about 1998). Each *Management Area* took several years to survey, and because whales can move within and between *Management Areas* from year to year, it is necessary to allow for extra variability beyond the pure statistical noise associated with each annual survey when making inferences about time-averaged abundances. The CVs here include allowance for such movements via 'Additional Variance' (AV).

Some care is required in using the right set of estimates for the right question. The estimates in this Table are specifically tailored to the 'best average number' question in the previous paragraph. For other questions, it can be more appropriate to use a different set of estimates. In particular, to examine relative changes between CPII and CPIII at either an Area-specific or pan-Antarctic level, it is better to use the 'CNB' estimates of Table 1, which avoid the confounding effects of changing northern survey boundaries. The same CVs-with-AV are applicable to that case.

However, because of the complexity of the underlying statistical models and the complex pattern of surveys over space and time, it is not possible to provide a single summary table covering all questions that might be asked. More complex questions may require re-analysis, particularly to find the CV. For example, CVs for combinations of *Management Areas* cannot be deduced from these Tables alone, because there are correlations amongst the estimates for different survey blocks within each CP series. And if, for example, the focus is on year-to-year distributional variation in its own right, perhaps using a covariate such as sea-ice cover, then it may be better to avoid AV altogether, to work at the level of the annual survey block rather than the *Management Area*, and to use just the internal CVs, which pertain to the number of whales actually present in each year rather than to the average over the whole multi-year survey period.

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Table 1

Estimates of Antarctic minke whale abundance by *Management Area* from the OK preferred model (Okamura and Kitakado, 2012), adjusted by the factors agreed in IWC (2013, Annex G, table 1). Taken from IWC (2012).

		IWC *Management Area*						
CP		I	II	III	IV	V	VI	Total
II	Survey once	85,688	130,083	93,215	55,237	300,214	55,617	720,054
	CNB	84,978	120,025	86,804	51,241	285,559	49,885	678,493
	CV internal	0.16	0.14	0.20	0.17	0.13	0.22	0.08
	CV with AV	0.34	0.40	0.44	0.39	0.31	0.39	0.18
III	Survey once	38,930	57,206	94,219	59,677	183,915	80,835	514,783
	CNB	34,369	58,382	68,975	55,899	180,183	72,059	469,866
	CV internal	0.20	0.19	0.15	0.34	0.11	0.14	0.09
	CV with AV	0.39	0.38	0.35	0.49	0.36	0.37	0.18
CPIII:CPII		0.40	0.49	0.79	1.09	0.63	1.44	0.69

Appendix 4

ACCEPTABLE ABUNDANCE ESTIMATES

Table 1

Acceptable abundance estimates.

Population	Area	Category	Evaluation extent	Year	Method	Corrected	Estimate and approx. 95% CI	IWC reference	Original reference	Comments
Antarctic minke whales										
Southern Ocean	I	1	1	1998	DS with SM	P	38,900* [18,100-83,500]	IWC (2013b)	Okamura and Kitakado (2012); IWC (2013a); Bravington and Hedley (2012)	Parts of Area I surveyed in 1994, 2000 and 2001. 'Year' relates to mid-point in time of CPIII series.
Southern Ocean	II	1	1	1998	DS with SM	P	57,200* [27,200-120,000]	IWC (2013b)	As above	Parts of Area II surveyed in 1997, 1998 and 2000. 'Year' defined as above.
Southern Ocean	III	1	1	1998	DS with SM	P	94,200* [47,400-187,000]	IWC (2013b)	As above	Parts of Area III surveyed in 1993 and 1995. 'Year' defined as above.
Southern Ocean	IV	1	1	1998	DS with SM	P	59,700* [22,800-156,000]	IWC (2013b)	As above	Parts of Area IV surveyed in 1995 and 1999. 'Year' defined as above.
Southern Ocean	V	1	1	1998	DS with SM	P	183,900* [90,800-372,000]	IWC (2013b)	As above	Parts of Area V surveyed in 1992, 2002, 2003 and 2004. 'Year' defined as above.
Southern Ocean	VI	1	1	1998	DS with SM	P	80,800* [39,100-167,000]	IWC (2013b)	As above	Parts of Area VI surveyed in 1996 and 2001. 'Year' defined as above.

*These estimates are rounded versions of the 'survey-once' set of estimates in Table 2 of Annex G (IWC, 2013b). They are the best estimates of the average number of whales in the *Management Area* (MA) stated during the CP III period (whose midpoint is about 1998). Each *Management Area* took several years to survey, and because whales can move within and between *Management Areas* from year to year, it is necessary to allow for extra variability beyond the pure statistical noise associated with each annual survey when making inferences about time-averaged abundances. The CVs here include allowance for such movements via 'Additional Variance' (AV).

Some care is required in using the right set of estimates for the right question. The estimates in this table are specifically tailored to the 'best average number' question in the previous paragraph. For other questions, it can be more appropriate to use a different set of estimates. In particular, to examine relative changes between CPII and CPIII at either an Area-specific or pan-Antarctic level, it is better to use the 'CNB' estimates of Table 2 of Annex G (IWC, 2013b), which avoid the confounding effects of changing northern survey boundaries. The same CVs-with-AV are applicable to that case. However, because of the complexity of the underlying statistical models and the complex pattern of surveys over space and time, it is not possible to provide a single summary table covering all questions that might be asked. More complex questions (e.g. regarding the CV on several *Management Areas* combined) would entail re-analysis.

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Appendix 5

INTERSESSIONAL WORK PLAN ON STATISTICAL CATCH-AT-AGE ANALYSIS

The following items are the highest priority for intersessional development of the SCAA model.

(1) Investigate reliability of CV estimate for natural mortality, *M*, by:
  (a) down-weighting stock-recruitment function residuals in the likelihood (to check whether imposed model structure is overly constraining results), and investigating the Thompson method to determine the appropriate value for this variance;
  (b) investigating the use of an auto-regressive approach and a Siler function to estimate *M*(a) to avoid pre-specification of some parameters of its age-dependence;
  (c) using a likelihood profile to estimate CV of *M* at intermediate ages;
  (d) using a likelihood profile to check the justification for assuming a different relationship between natural mortality and age for the P and I stocks; and
  (e) performing retrospective analyses – does estimated CV increase as expected?

(2) Investigate alternative explanations for surprising results for growth increment estimates, by:
  (a) omitting lower lengths from the data fitted; and
  (b) allowing more flexibility in commercial selectivity at length relationship assumed.

(3) Other:
  (a) change to autoregressive basis to model time-dependence in carrying capacity *K*;
  (b) examine cases amongst existing fits that hit parameter constraints – would absence or an alternative value of the constraint have led to qualitatively different output; and
  (c) compile a narrative of the history of the SCAA development process, in particular to clarify the range of sensitivities explored over time.

TIMETABLE

Most of the work will be completed by September 2013. The final paper will be presented at SC/65b.

Appendix 6

PRELIMINARY BUDGET FOR 2014 IWC-POWER SURVEY AND MEETINGS

This preliminary budget covers, as usual, the cruise itself and the associated planning meeting (September/October 2013). Also, this year, the planning meeting will run back-to-back with a two-day POWER Technical Advisory Group meeting to consider medium-term planning, i.e. beyond the five-year series of cruises which will be completed in 2014.

Table 1

Preliminary budget for 2014 IWC-POWER survey and meetings.

Item	Grant	Travel	Insurance	Shipboard	Shore	Bank charge	Total
Cruise							
Cruise Leader	10,310	1,700	100	831	550	30	13,521
Scientist 1	6,200	1,700	100	831	550	30	9,411
Scientist 2	6,200	1,700	100	831	550	30	9,411
Japan	6,200	1,700	100	831	550	30	9,411
Sub-total							41,754
Equipment/communications							
Sighting:							1,500
PC software licenses							
Hard drive (1TB) (4)							
Repair/maintenance of data logging system							
Biopsy:							2,500
Repairs/maintenance Larsen guns (4)							
Ammunition x 500							
Darts x 50							
Photo-id:							2,000
Repair/maintenance cameras							
Camera batteries (4)/store cards (4)							
Video camera (1)/batteries (4)							
Official communications:							2,000
Communication with the Steering Group via Inmarsat							
Transportation of IWC data							300
Planning Meeting for 2014 cruise (3 days)							6,000
Travel and subsistence for 4 participants:							
TAG Meeting for middle and long term (2 days)							4,000
Travel and subsistence for 4 participants:							
Annual Meeting							
Cruise Leader travel and subsistence							2,500
Total							62,554

Annex H

Report of the Sub-Committee on Other Southern Hemisphere Whale Stocks

Members: Robbins (Convenor), Baba, Baker, Bannister, Baulch, Bell, Brandão, Bravington, Brownell, Butterworth, Childerhouse, Chilvers, Collins, Cooke, Currey, de la Mare, Diallo, Double, Feindt-Herr, Funahashi, Galletti, Goodman, Hammond, Hedley, Holloway, Holm, Iñíguez, Jackson, Kato, Kaufmann, Kelly, Kishiro, Kitakado, Kock, Lang, Liebschner, Luná, Marzari, Matsuoka, Miyashita, Murase, Nelson, Øien, Palacios, Palsbøll, Pastene, Péres, Punt, Rosenbaum, Sakamoto, Samaran, Scheidat, Siciliano, Simmonds, Solvang, Stachowitsch, Wadley, Williams, Willson, Yasokawa, Ylitalo, Yoshida.

1. INTRODUCTORY ITEMS

1.1 Opening remarks
Robbins welcomed the participants.

1.2 Election of Chair
Robbins was elected as Chair.

1.3 Appointment of rapporteurs
Double, Childerhouse and Holloway acted as rapporteurs.

1.4 Adoption of the Agenda
The adopted agenda is given in Appendix 1.

1.5 Review of documents
The following documents were available to the meeting: SC/65a/SH01-SH25rev; SC/65a/IA13; SC/65a/O09-O11; SC/65a/SCP01; Attard *et al.* (2012); Carroll *et al.* (2013); Kelly *et al.* (In review); Peel *et al.* (In review); and Rankin *et al.* (2013).

2. SOUTHERN OCEAN RESEARCH PARTNERSHIP

SC/65a/SH25rev reported on the meeting of the Southern Ocean Research Partnership (SORP) which was held before the Scientific Committee meeting from 31 May-2 June 2013. Forty-seven delegates from 16 countries attended. The aims of the conference were to: (1) present the scientific results from the five ongoing SORP research projects; (2) update the existing project plans and discuss new research proposals (refer to annex 1 of SC/65a/SH25 for details of these plans); and (3) make recommendations for the continuation and development of the SORP.

Of relevance to the sub-committee were four of the six project plans presented in annex 1 of SC/65a/SH25rev. In addition to refining the SORP project plans, the meeting participants made key recommendations in relation to the SORP initiative; these were:

(1) to ensure all SORP Partners are seeking funding from all suitable sources to ensure the five existing SORP research projects are resourced adequately;
(2) to improve communication to the Commission of the IWC on SORP-related outcomes to ensure that they are aware of the scientific products and to encourage financial support;
(3) to improve the dissemination of information on SORP projects and initiatives;
(4) for SORP Partners to encourage all platforms of opportunity and, where applicable, citizen science, to collect data for inclusion in SORP research projects, thereby reducing the logistic constraints of circumpolar coverage and overall expenditure;
(5) that all data and samples collected from international, collaborative research efforts such as SORP are stored and archived in recognised central repositories; and
(6) that the holders of large, long-term datasets that contain valuable information relevant to SORP, particularly acoustic data, should be strongly encouraged to analyse and publish these data as soon as possible.

The sub-committee congratulated the many scientists engaged in SORP for the significant progress and new information being delivered into the Scientific Committee. It **endorsed** the recommendations from the SORP pre-meeting and recognised that the science presented was being integrated into the broader work of the Scientific Committee.

The sub-committee acknowledged the preliminary objective of the Antarctic blue whale project had now been met; the identification of the most appropriate survey design method. This process drew heavily on existing data including the IDCR/SOWER sightings as well as historic catch information. Also the project has successfully developed a passive acoustic tracking technique that has ramifications for all future whale surveys in Antarctica. In addition it was noted that the data from this SORP project is key to the assessment of the Antarctic blue whale population and this should be recognised at all levels within the IWC.

In further discussion the sub-committee highlighted that the acoustic trends project was highly ambitious and will take many years to complete but may be the only way to assess the recovery of fin whales. In time it may become the most efficient way to describe the abundance and distribution of many Antarctic whale species.

The first objectives of the Oceania humpback whale project have been completed through the collaborative analysis of biopsy and photo-identification data and those results are being used in the current assessment of Breeding Stock E humpback whales. It was noted that the results of SC/65a/SH13 are also informative to this project.

SORP projects on minke and killer whales relate primarily to the work of other sub-committees, but in response to a question it was noted that proposed work on the abundance of minke whales in ice may be integrated into the existing SORP minke whale project. Further discussions next year will assess the feasibility of the research described in the proposal. The proposal did not consider a new synoptic circumpolar survey of Antarctic minke whales because of the high cost of such a project.

The SORP members and the sub-committee **agreed** that the delivery of data through ships of opportunity could be a highly effective way to collect data in the remote Southern Ocean and whenever possible this should be achieved through SORP in a coordinated, collaborative and standardised manner. If possible there should be a single website through which the data can be collated and this web site should be promoted by all projects operating in the region that would benefit from opportunistic data collection.

3. ASSESSMENT OF SOUTHERN HEMISPHERE HUMPBACK WHALES

The IWC Scientific Committee currently recognises seven humpback whale breeding stocks (BS) in the Southern Hemisphere (labelled A to G - IWC, 1998), which are connected to feeding grounds in the Antarctic. An additional population that does not migrate to high latitudes is found in the Arabian Sea. Assessments of BSA (western South Atlantic), BSD (eastern Indian Ocean) and BSG (eastern South Pacific) were completed in 2006 (IWC, 2007), although it was concluded that BSD might need to be re-assessed with BSE and BSF in light of mixing on the feeding grounds. An assessment for BSC (western Indian Ocean) was completed in 2009 (IWC, 2010) and for BSB in 2011 (IWC, 2012b).

3.1 Assessment of Breeding Stocks D, E and F

In 2011, the sub-committee initiated the re-assessment of BSD, and the assessment of BSE and BSF. As shown in Fig. 1, these stocks correspond, respectively, to humpback whales wintering off Western Australia (stock D), Eastern Australia (sub-stock BSE1) and the western Pacific Islands in Oceania including New Caledonia (sub-stock BSE2), Tonga (sub-stock BSE3) and French Polynesia (sub-stock BSF2).

3.1.1 Review new information

SC/65a/SH08 described the first photo-id and biopsy sampling surveys on humpback whales and small cetaceans around nine islands in eastern French Polynesia's Tuamotu and Gambier Islands. Surveys were primarily coastal around the islands but also pelagic between islands. Humpback whales of all age/sex classes were observed and/or acoustically recorded at every island, but in lower numbers than in the Society Islands, and often within tens of meters of shore. Seven photo-ids and ten biopsies were taken of humpback whales. One individual photo-identified at Raraka in 2010 was previously identified at Mo'orea in 2006. This first documented interchange between the two archipelagos is of interest because only one match has been made in more than 10 years between the Society/Austral Islands (*n*~400 IDs) and Rarotonga, Cook Islands (*n*~150 IDs), which is the nearest archipelago to the west. Additional sampling should ascertain whether whales in the Tuamotu/Gambier Islands also use the Society and Austral Islands.

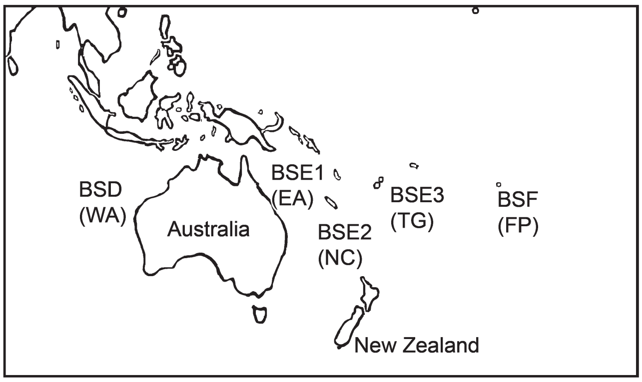

Fig. 1. Distribution of Southern Hemisphere humpback whales breeding stocks grounds BSD, BSE1, BSE2, BSE3 and BSF2. Note the following abbreviations: WA=Western Australia, EA=Eastern Australia, NC=New Caledonia, TG=Tonga and FP=French Polynesia.

This effort was welcomed by the sub-committee. It **recommended** further sampling from this remote Pacific region from which few data have been collected previously.

SC/65a/SH13 presented the results of a mtDNA analysis of 575 humpback whales obtained in the Antarctic during surveys of the JARPA/JARPA II and IDCR/SOWER, and 1,057 whales from low latitude localities of the South Pacific and eastern Indian Ocean. The analysis was carried out in response to a recommendation from the Scientific Committee in 2012 to calculate mixing proportion of breeding stocks D, E and F in the Antarctic feeding grounds of Areas IIIE, IV, V and VI. Genetic samples from breeding grounds were obtained mainly by biopsy sampling but also from sloughed skin and beachcast whales: Western Australia (WA, *n*=167, 1990-2002; *n*=185, 2007), Eastern Australia (Eden, Tasmania) (EA, *n*=104), New Caledonia (NC, *n*=243), Tonga (TG, *n*=240), Cook Islands (CI, *n*=56) and French Polynesia (FP, *n*=62). In the Antarctic feeding grounds, samples were obtained by biopsy sampling: Areas IIIE (*n*=106), IV (*n*=231), V (*n*=171) and VI (*n*=67). Genetic samples of both data sets were examined for approximately the first half of the mtDNA control region. Duplicated samples were excluded from the analysis. In the case of mother/calf pairs only one sequence was used. Sequences from both data sets were aligned to produce a single data set comprising 137 haplotypes. Two kinds of analyses were conducted: mixing proportion and F_{ST} under two stock structure hypotheses (six stocks and four stocks as baseline samples for the stocks proportion analysis). In general results were consistent with the geography. Under the six-stock hypothesis, the largest proportion in Area IIIE was of the WA stock. The largest proportion in Areas IVW and IVE was of the WA stock. The largest proportion in Area VW was of the EA stock. The largest proportion in Area VE was of the NC stock. The stock with the largest proportion in Area VI was the TG stock. None of the Antarctic Areas investigated was represented by whales of the FP and CI stocks, or just with a limited representation in Area VI (case of the CI stock). In general results of the mixing proportion analysis were consistent with the results of the F_{ST}, with a few exceptions.

The sub-committee had requested this updated analysis at the last meeting and thanked the authors for completing the work in time to be used in on-going assessment modelling. These applications are discussed under Item 3.1.2.

Rankin *et al.* (2013) estimated calving intervals of humpback whales at Hervey Bay, East Australia based on a long-term photo-id catalogue of 2,973 individuals. The study evaluated two methods to address the problem of ambiguity in the sex and age class of individuals in such estimates. One method truncated individual encounter histories to exclude sightings prior to the first observed calf. The second method utilised the multi-stage mark recapture framework and multi-event extension to include all re-sighted individuals and their entire encounter history. Both methods led to similar estimates of calving intervals: 2.98 years (95% CI: 2.27-3.51) and 2.78 years (95%CI: 2.23-3.68) respectively. However, the multi-event framework resulted in more precise estimates of other important life-history parameters such as apparent survival, and included a wider constituency of age and sex classes.

The sub-committee discussed these results in the context of the high rate of population increase indicated by sighting surveys off East Australia (Noad *et al.*, 2011b). The calving intervals were noted to be comparable to those reported in the historical whaling data (Chittleborough, 1958) but not as short as might have been expected for a rapidly increasing population. The source of this discrepancy has yet to be determined.

3.1.2 Assessment models

A three-stock model with feeding and breeding ground interchange was proposed at SC/64 for the assessment of Southern Hemisphere humpback whale breeding stock (BS) D (West Australia), E1 (East Australia) and Oceania (represented by breeding stocks in New Caledonia (E2), Tonga (E3) and French Polynesia (F2)), with the aim of addressing some inconsistencies that arose in the single-stock assessments. The two main inconsistencies of concern were:

(1) The model-predicted population trajectory for BSD was unable to simultaneously fit both the absolute abundance estimate (of some 28,000 whales in 2007; Hedley *et al.*, 2011) and the high growth rate suggested by the relative abundance series (Bannister and Hedley, 2001; Hedley *et al.*, 2011).
(2) For the Oceania group of breeding stocks (BSE2, BSE3, BSF2) it was found that the minimum population size the model predicted violated the N_{min} constraint (informed from haplotype data).

First, a two-stock (BSD+BSE1) and then a three-stock (BSD+BSE1+Oceania) model with only mixing of stocks on the feeding grounds were developed, but it transpired that neither removed these inconsistencies. It was found, however, that substantial improvements could be obtained by shifting the customary Antarctic stock boundaries eastward to allow for more of the Antarctic catches to be allocated to BSD and less to Oceania. SC/65a/SH01 presented the results of the single-stock, two-stock and three-stock models for both the original Antarctic boundaries, as well as the proposed new boundaries. The aim of the paper was to illustrate the effect of moving the boundaries and to provide a platform for further discussion and development at SC/65a. During SC/65a, a number of further models were attempted, aimed particularly at improving the model fits to the BSD data. This discussion took place in the context of extensive discussion about the aerial survey estimate of abundance in absolute terms for BSD (Hedley *et al.*, 2011). There were a number of unusual aspects of the observations from this survey (including observers not focussing search effort perpendicular and forward of the aircraft and therefore recording sightings behind the plane). The discussion led to the conclusion that it was very difficult to obtain a reliable absolute abundance estimate from these data, and that values from within a wide range, both higher and lower than the original value reported, could be possible. A single-stock BSD model which fixed the absolute abundance at a lower value of 20,000 was successful in providing a satisfactory fit to the relative abundance series. A further approach was tried, where the model was not fitted to any absolute abundance data, and an uninformative prior for the recent abundance level of U~[0;30,000] was assumed. This single stock model for BSD again produced relatively good fits to all the relative abundance series (see Fig 2). The sub-committee recognised that any abundance measurement method that could provide a lower bound to this prior (i.e. a value other than zero) would be useful in improving future model fits to BSD, and **recommended** that analyses to achieve this be attempted.

Further three-stock models were also developed and presented at the meeting. Valuable new information from

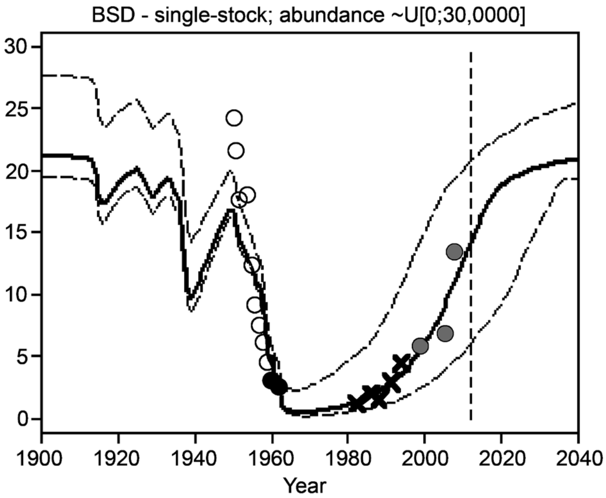

Fig. 2. Posterior median population trajectories for BSD, showing the trajectories and the 90% probability envelopes. Results are shown for a single-stock model using the original catch boundaries. Plots show fits to the Chittleborough (1965) CPUE series (open circles), the Bannister and Hedley (2001) relative abundance series (crosses), the Hedley *et al.* (2011) relative abundance series (grey circles). The model is fit to both the Hedley *et al.* (2011) and Bannister and Hedley (2001) relative abundance series only. The BSD abundance prior is set at U[0; 30,000]). The Chittleborough (1965) CPUE series is shown as consistency check. The trajectory to the right of the vertical dashed 2012 line shows projection into the future under the assumption of zero catch.

genetic studies on the mixing proportions of the sub-stocks on the various feeding grounds was provided (see Appendix 2). One of the key observations from model fits incorporating these data was that in order to fit the BSD relative abundance trends, the model removes more westerly Antarctic catches from BSE1, which in turn leads to the removal of more easterly Antarctic catches from Oceania to allocate to BSE1. Nevertheless, there remain insufficient whales being removed from BSE1 to deplete the population enough by the late 1960s (when most harvesting ceased) in order to be able to reflect the rapid recent increases shown later by the east Australian surveys. A set of three-stock models were run where again the absolute abundance for BSD was replaced with an uninformative prior (either ~U[0;100,000] or U[0;30,000]), and both the original Antarctic boundaries as well as those proposed in SC/65a/SH01 were considered. Even when using the lesser upper bound of 30,000 for the BSD abundance prior, the fit of the survey series to the BSE1 population trajectory remained poor (see Fig. 3). Furthermore, none of these model formulations was consistent with the genetics data from the feeding grounds: although the ratio of BSD and BSE1 whales in the feeding grounds from 70°E to 140°E were reflected well by the models, in the remainder of the region from 140°E to 110°W the model allocated more catches to BSD and fewer to Oceania than indicated by the genetics.

It was clarified in discussion that SC/65a/SH01 had used a photo-id based estimate of absolute abundance for Oceania. The sub-committee **agreed** that the available genetic mark-recapture estimate should be used because the photo-id estimate does not account for the lower probability of detecting females on breeding grounds (e.g., Brown *et al.*, 1995; Craig and Herman, 2003). Genetic data are able to provide male-specific recapture measurements, which can be scaled upward to take into account the differential capturability of males and females.

During the discussion of the assessment models and their lack of fit to observed data, Cooke presented a paper that

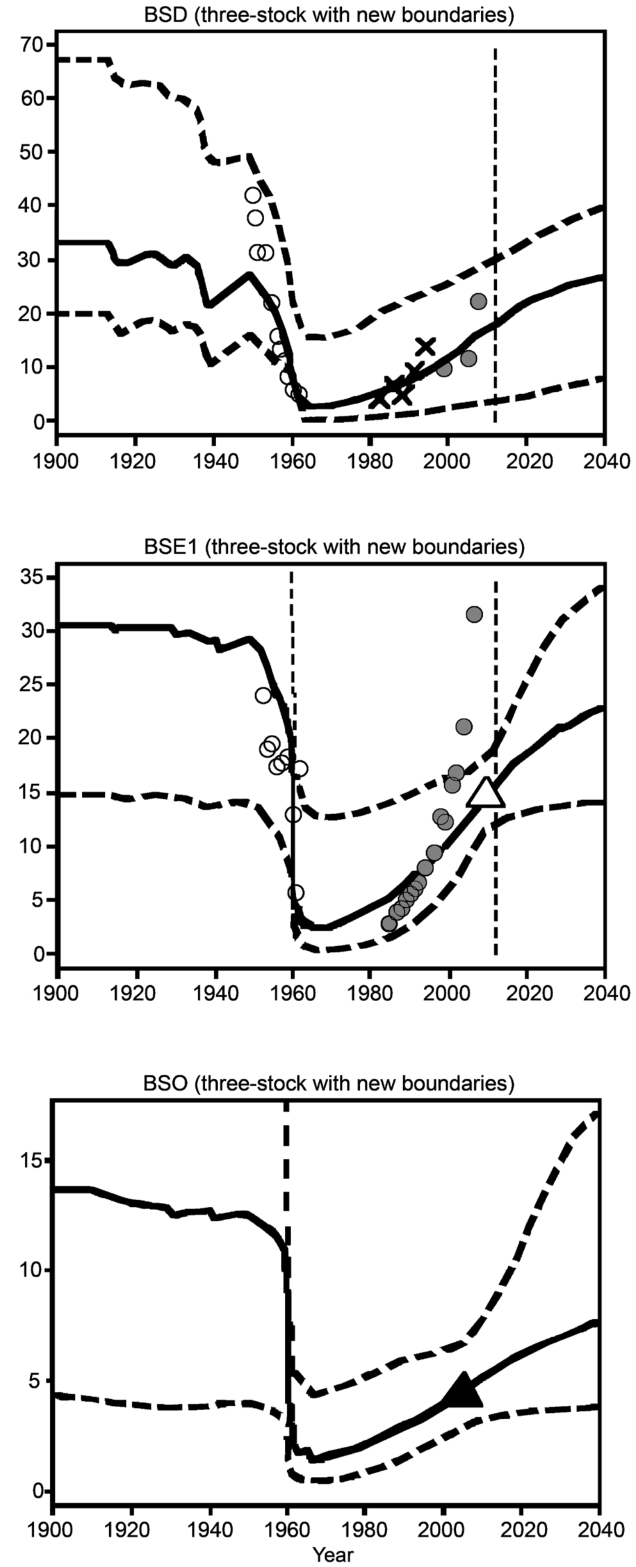

Fig. 3. Three-stock model results assuming 'new' Antarctic catch boundaries proposed in SC/65a/SH01. The BSD abundance prior is set at U[0; 30,000]). BSO refers to Oceania (New Caledonia (E2)+Tonga (E3)+French Polynesia (F2)). SC/65a/SH01 details the data fitted for each breeding stock but in essence these are the Bannister and Hedley (2001) and Hedley *et al.* (2011) relative abundance series for BSD (crosses and grey circles, respectively), the Noad *et al.* (2011b) abundance estimate and relative abundance series for BSE1 (open triangles and grey circles, respectively), and the Constantine *et al.* (2012) photo-id mark-recapture data for Oceania. The black triangle for Oceania is the separate abundance estimate from mark-recapture data reported by Constantine *et al.* (2012) and the open circles for BSD and BSE1 are the CPUE data from Chittleborough (1965); these data are not fitted directly, but shown as consistency checks.

was prepared previously for an MSYR Review Workshop (Cooke, 2009). This paper addressed the phenomenon in which attempts to fit a deterministic density-dependent population model to a recovering whale stock sometimes fail, because there are insufficient historic catches to account for the recent increase. Simulations using a population model with environmental variability showed that, for previously depleted stocks that are now beyond a certain level of recovery, this phenomenon (lack of fit to the deterministic model) was highly likely to occur, with up to 80% probability. When this paper was prepared, there were only three stocks with good data that met these depletion/recovery criteria, and all three showed this specific form of lack of fit. However, it predicted that Southern Hemisphere humpback whales would soon have recovered sufficiently to exhibit this phenomenon, and this now seems to be the case for BSD. The implications of this analysis are that the model lack of fit should not be regarded as an anomaly to be explained, but represents a normal situation that is to be expected beyond a certain level of recovery. The simulations undertaken showed that the deterministic model would lead to an overestimation of average population growth rates and MSY. Furthermore, attempts to repair the lack of fit by allowing an arbitrary increase in *K*, would make the overestimation worse. The author suggested that stochastic models should be explored, but cautioned that these will result in much more uncertain population projections. Simulations presented last year in Cooke (2011) showed that recovering whale populations are predicted to exhibit fairly smooth exponential growth up to about 70% of carrying capacity, after which they start to fluctuate unpredictably.

The sub-committee thanked Cooke for presenting this paper. Discussion centred on how best to accommodate possible changes in carrying capacity in the assessment models. It was concluded that this work will be progressed intersessionally by Butterworth and colleagues, as time permits.

SC/65a/SH07 presented progress toward modelling the population dynamics also within Oceania. This paper used logistic Bayesian FITTER models to co-measure population trajectories for pairs of South Pacific breeding grounds which share common high latitude feeding grounds. These are East Australia/New Caledonia (BSE1/BSE2), Tonga/ French Polynesia (BSE3/BSF2) and East Australia/Oceania (BSE1/BSE2+BSE3+BSF2). East Australia and New Caledonia population trajectories were fitted with relative abundance data from Noad *et al.* (2011a) and Garrigue *et al.* (2012) respectively, and absolute abundance estimates from Noad *et al.* (2011b, BSE1) and Constantine *et al.* (2010; 2012). For each pair, a shared feeding ground was assumed. Southern Ocean feeding ground catches were proportionally allocated to breeding grounds according to the ratio of model predicted breeding ground abundances each year. The East Australia/New Caledonia naïve model allocated feeding ground catches from 130°E-180° with a fringe model extending the range to 110°E-170°W. The Tonga/French Polynesia naïve model allocated catches from 180°-120°W, with a fringe model allocating catches from 170°E-100°W. The East Australia/Oceania naïve model allocated feeding ground catches between 130°E-120°W and 110°E-100°W. Naïve and fringe posterior results were similar for all two stock models. Results were broadly consistent with other available relative abundance and absolute abundance estimates from East Australia and with SOWER abundance estimates from Area V feeding grounds. East Australia carrying capacity varied between models (medians 26-42,000) while population increase rates were uniformly high. Median estimates of carrying capacity for New Caledonia ranged from 5,200-6,100, Tonga 5,600-8,700 and French Polynesia 4,000-5,700, with median recovery levels of 13-33%, 31-44% and 24-32% respectively.

The sub-committee thanked the authors for presenting this analysis and the progress in the development of a model that includes multiple stocks within Oceania. However, several technical issues still need to be addressed, including the use of a uniform prior on *K* which leads to a biased estimate of MSYR. During SC/65a, available abundance trends were plotted against the naïve population models for East Australia/New Caledonia (BSE1/BSE2) and East Australia/Oceania (BSE1/Oceania), to enable a visual determination of how closely these trend data fit the two base case models in SC/65a/SH07. These are provided as Appendix 3.

In conclusion, the sub-committee made the following final **recommendations** for BSD, BSE1 and Oceania modelling work.

(1) A lower bound on the BSD abundance estimate should be obtained.
(2) A single-stock model for BSD will be run for a range of choices of the Antarctic feeding ground catches between 120°E and 150°E.
(3) Two stock BSE1-Oceania models (with further breeding stock division within Oceania) will be explored.
(4) If time permits after sufficient exploration of the models above, more complex options may be examined. These could include a three-stock model covering all of BSD, BSE1 and Oceania, together perhaps with more complex models for the dynamics of BSD, as discussed above.

The sub-committee strongly **agreed** that the assessment of breeding stocks D, E and F would conclude at SC/65b. Two intersessional correspondence groups and a pre-meeting before SC/65b were **recommended** to ensure that this goal is achieved. This work includes items with financial implications (see Item 9.1, below).

3.1.3 Future work

SC/65a/SH09 described efforts by the South Pacific Whale Research Consortium to plan future sampling in the context of future assessments of Oceania humpback whales. Three primary goals were identified: (1) to determine population size with a coefficient of variation (CV) of <20%; (2) to detect if λ is significantly different from 1 (i.e. the population is increasing or decreasing); and (3) to detect if λ is significantly different from that of east Australia. To this end a power analysis was conducted to assess if the proposed surveys would meet the defined objectives. Simulations were undertaken for the combined regions of Oceania, in addition to individual wintering grounds of New Caledonia (NC, BSE2) and Tonga (TG, BSE3). The proposed survey designs included a capture probability of p=0.10 for new surveys and target the three core regions of New Caledonia, Tonga and French Polynesia. The proposed surveys should span the wintering period to reduce heterogeneity in capture probability due to the difference in migratory timing between demographic classes. Under the simulated scenarios for Oceania, incorporating data from the previous genotype surveys from 1999-2005 with three new survey years would give sufficient power to meet objective 1, detect if the growth rate is significantly lower than that of east Australia if the true $\lambda \leq 1.05$ and detect if the growth rate is significantly >1 if the true $\lambda = 1.05$. The simulations also suggested that the power to meet the objectives on a regional basis varies with the survey design and simulated scenario. However, in general, the biennial survey design was able to detect with ≥90% power if the growth rate is significantly lower than that of east Australia if the true $\lambda \leq 1.03$ for both NC and TG. Therefore, it was concluded that the proposed surveys would be able to determine whether population growth rates in these different regions are significantly different.

The sub-committee welcomed these plans for additional work, noting the value to future assessments of BSE2 and BSE3. It emphasised the importance of these types of analyses before any survey is conducted and welcomed the articulation of very clear objectives. This approach is particularly important when the survey is on the large scale described in this paper.

It was also noted in discussion that a modified POPAN model recently described by Carroll *et al.* (2013) explicitly accounts for heterogeneity in capture probability related to breeding cycles. Simulations in that paper suggest that failure to account for the effect of reproductive status on the capture probability would result in a substantial positive bias (+19%) in female abundance estimates. This type of model is likely to be relevant to the mark-recapture modelling of many species of interest to the sub-committee.

3.2 Review new information on other breeding stocks

SC/65a/SH04 described the results of small-boat surveys in the Gulf of Chiriqui (off western Panama) during the austral winter season from 2002-12. This breeding area is notable because whales undertake cross-equatorial migrations from Antarctica and Chile, likely prompted by warmer water temperatures. Panama is also a breeding area for humpback whales from the northeast Pacific Ocean during the boreal winter. Over 11,000km were surveyed during 105 effective sea-days. A total of 502 sightings were made of 999 individual whales, including 262 calves. The high percentage of calves was notable compared to other breeding areas. Of 246 individuals identified by fluke photo-id, 19 were seen in multiple years. Initial catalogue comparisons have established matches to southern Costa Rica, and to feeding areas off Chile and Antarctica. Future plans include genetic analysis to clarify exchange with other South Pacific breeding and feeding areas; comparison of mother-calf habitat use to other breeding areas; and long term acoustic monitoring.

The authors confirmed that the photo-identification data had been submitted to the relevant regional catalogues. The sub-committee noted with interest the high proportion of mothers and calf sightings in this study and the possible importance of the surveyed habitats to mothers. It was suggested that dorsal fin photographs could be used to investigate whether mothers were more likely to be seen on multiple occasions in the same year due to longer residency times on the breeding ground. However, this was not likely to be a significant factor given the short sampling period in most years. It was discussed that fluke photographs are more difficult to obtain from mothers, as relatively low fluking rates require a longer time commitment.

SC/65a/SH22 presented the movements of twelve humpback whales satellite tagged off northeast Madagascar during the peak of the breeding season. Mean tag duration was 21.9 days (3-58 days) and no individuals remained near the tagging site. Five males and two females travelled along a 500km stretch of the Madagascar central-east coast, not previously recognised as preferred habitat. Three females and one male travelled north, departing Madagascar on similar northwesterly trajectories. One mother and an adult female travelled over 1,100 and 2,300km in 13 and 23 days, respectively, ending beyond Aldabra. Two individuals travelled to east Africa: a mother travelled over 2,100km to north Kenya in 25 days; a male travelled over 2,800km to Somalia, crossing the equator (to 259.9°N), in 32 days. One adult female travelled 900km south of Madagascar, returned to Madagascar briefly, and then moved south again 700km, covering over 5,600km in 58 days. Despite these long range movements in relatively short periods, no whale travelled to the western coast of Madagascar, Mozambique, or the Mascarene Islands, where breeding aggregations are well documented. These results suggest that there may be more interchange between Madagascar and central-east Africa than previously thought. These movements were likely not detected previously because of the lack of data from northern BSC1. Tagging results, taken with population genetic and mark-recapture analyses, suggest that population substructure and interchange is more complex than previously thought. This new information will help to inform future assessments of this breeding stock.

The sub-committee welcomed this work and noted its value for helping to clarify stock structure within BSC. In light of the results, it was asked whether it is possible that the BSC3 abundance estimate in the recently completely assessment could have been underestimated. The authors commented that this is unclear, as whale distribution during this study appeared to be unusual relative to other years, with fewer whales observed in Antongil Bay, Madagascar than previously observed. The authors also clarified that although previous photo-identification studies detected limited interchange between BSC1 and BSC3, this may have been due to the more southerly distribution of sampling effort in BSC1.

The northward movement of one tagged whale to Somalia was surprising and the sub-committee discussed whether this movement fit expectations of humpback whale movement and distribution in relation to water temperature (e.g. Rasmussen *et al.*, 2007). The authors stated that the monsoon season would have resulted in cooler waters in the region at that time of year and so the distribution could still fit with predictions. Also it was noted that the Rasmussen *et al.* (2007) analysis was at the ocean scale and does not provide sufficient resolution to predict low latitude distribution at smaller scales.

SC/65a/SH02 described the results of satellite tagging 11 humpback whales in the Comoros islands (BSC2; Mohéli, *n*=6 and Mayotte, *n*=5) in October 2011 and 2012. Eight whales were successfully tracked for 24.3±12.4 days (range=8-49 days) and travelled between 146km and 5,804km. Whales either remained at their breeding site for several weeks after tagging (*n*=3), dispersed to the northwest (*n*=2) or to southwest (*n*=3) coast of Madagascar. Whales used the same two sites along the coast of Madagascar in both years, suggesting these might be regular stop-overs during migration. One followed the coast north before going south along the east coast, and its tag stopped 70km from Sainte Marie Island. This is the first report of whales visiting the Comoros archipelago (BSC2) and both the western and eastern coasts of Madagascar (BSC3) during the same breeding season, although interchange across breeding seasons is well-documented (Ersts *et al.*, 2011). Of two whales tracked toward their Antarctic foraging grounds, one followed a south-eastward direction towards the French Sub-Antarctic Islands while the other travelled to IWC Area III. This is the first time detailed movements of humpback whales from this breeding sub-stock have been described and their potential foraging areas in the Southern Ocean identified.

The authors were not present to discuss this paper, but the sub-committee thanked them for making their results available and looked forward to future information.

SC/65a/SH24 collated all available data on humpback whales in Namibia (~23°S) collected during small boat surveys from 2005-12. Photo identification images were compared with catalogues from Gabon (2000-06) and west South Africa (WSA, 1983-2007), including a photographic assessment of scarring and wounds from cookie cutter sharks (*Isistius brasiliensis*) and killer whales. The Nambia catalogue consisted of 132 individuals (69 by tail flukes only) photographed between 2008 and 2012. Only two possible matches were made to the WSA catalogue by dorsal fin ID, none to Gabon. The probability of re-sighting animals between these catalogues was likely reduced by their size and sampling period. The proportion of killer whale bite scars on flukes was similar in all sites. Healed scars from cookie cutter sharks were highest in Gabon and similar between Namibia and WSA, while fresh bites were highest in Gabon, intermediate in Namibia but almost non-existent in WSA. The authors concluded that hese results support the hypothesis of multiple migration streams within BSB, with animals at Namibia striking the coast directly from offshore warmer waters (where cookie cutter sharks are likely prevalent) on their northward migration. Animals encountered in WSA, where they were feeding after the southward migration, were likely to have followed a slow coastwise migration southwards within the cold Benguela Ecosystem, allowing time for cookie cutter bites to heal. A bimodal seasonality, with a lack of singing and low number of calves observed, suggests that the central Namibia coast acts primarily as a migration route. The authors concluded that these results do not support the concept of BSB2 lying within Namibian waters to the south of the Walvis Ridge.

The sub-committee welcomed this new study, noting the potential utility of indirect indicators of stock structure for the Namibia region where insights from photo-id and genetic data are still limited.

SC/65a/IA13 reported on cetacean sighting survey results in Gabon coastal waters from 4-10 September 2011 and in the Gulf of Guinea (Côte d'Ivoire, Ghana, Togo and Benin) from 23 March-6 April 2013. Researchers from seven African countries (Mauritania, Senegal, Ghana, Benin, Togo, Gabon and Cameroon) participated in the survey. In Gabon, 878 n.miles of zigzag track lines were set within three offshore and three coastal blocks. In the Gulf of Guinea, 1,200 n.miles of zigzag track lines were covered in seven survey blocks. A total of 30 groups of 191 humpback whales were recorded in the Gabon survey. No humpback whales were observed in the Gulf of Guinea survey.

The sub-committee thanked the authors for presenting these survey data.

3.3 Review new information on feeding grounds

SC/65a/SH10 summarised the occurrence of cetaceans in the Scotia Sea during February-March 2013 survey on board of the Oceanographic vessel ARA *Puerto Deseado*. Out of a total of 143 sightings, 91% were mysticetes and 9% were odontocetes. Sightings included fin whales, humpback whales, sei whales, southern right whales, Antarctic minke whales, hourglass dolphins, Gray's beaked whales and southern bottlenose whales. Humpback whales were the most frequently seen cetaceans in the surveyed area with a mean encounter rate of 0.073+0.115 whale/n.mile, followed by fin whales and hourglass dolphins. Some differences in spatial distribution among species were observed, mainly between humpback and fin whales. This was an opportunistic study and further research is needed in order to assess the status of cetaceans in the Southern Ocean and to understand spatial and temporal distribution of these species.

Iñíguez reported that Argentina had made a research vessel available for collaborative SORP research in the Antarctic in 2013-14. This is also reported in SC/65a/SH25.

SC/65a/SH20 described an aerial survey for cetaceans in the western Weddell Sea, Bransfield Strait and along the north coast of the South Shetland Islands in the Drake Passage from 25 January to 11 March 2013. Helicopters aboard the German research icebreaker *Polarstern* were used for a dedicated line-transect distance sampling survey with ad-hoc transect design in accordance with ship position and weather conditions. The survey area comprised ice covered waters as well as open water. In total 7,649km were covered 'on effort' and seven cetacean species were identified. This included 68 sightings of 130 humpback whales. Further analysis will include density estimation for fin whales and humpback whales, as well as habitat modelling, taking into account oceanographic and krill data obtained during the cruise.

The authors were asked whether krill was recorded as part of the survey. The authors responded that krill would have been recorded but were not observed from the helicopter. However, information on the distribution of krill would have been collected by the ship's sounders. The next cruise is scheduled for November 2013 and will go to the Weddell Sea region. The sub-committee welcomed this work and future updates.

SC/65a/O09 reported observations from JARPA II in the Antarctic including 227 schools and 412 individuals of humpback whales. Humpback whales were most common species observed, with sightings about 1.5 times more frequent than sightings of Antarctic minke whales. Humpback whales were distributed waters greater than 500m. Seven individuals were photo-identified and three skin biopsy samples were collected.

3.4 Antarctic Humpback Whale Catalogue

SC/65a/SH15 presented the interim report of IWC Research Contract 16, the Antarctic Humpback Whale Catalogue (AHWC). During the contract period, the AHWC catalogued 938 photo-id images representing 774 individual humpback whales from Antarctic and southern hemisphere waters submitted by 36 individuals and research organisations. Photographic comparison of submitted photographs during the contract period yielded 17 previously known individuals. The database contains records of 133 individuals identified in more than one area and 361 individuals with sightings in more than one year. Because of the long-term nature of the project, 40 individuals have re-sightings separated by spans of 10 years or more, with a maximum span of 27 years. These submissions bring the total number of catalogued whales identified by fluke, right dorsal fin/flank and left dorsal fin/flank photographs to 5,343, 414 and 409 respectively. Progress continues in efforts to stimulate submission of opportunistic data from eco-tourism cruise ships in the Southern Ocean and from research organisations and expeditions working throughout this region and the Southern Hemisphere. The AHWC provides a unique clearing house for these opportunistic data, facilitating public education and participation, and providing a valuable source of data to researchers for scientific analysis.

The sub-committee welcomed this update and recognised the contribution this catalogue has made to humpback whales studies in the Southern Hemisphere. It also acknowledged the significant in-kind contribution by those managing this catalogue.

The sub-committee **recommended** continued support for the AHWC. This is an item with financial implications (Item 9.1, below).

3.5 Other

SC/65a/SH05 reported preliminary results of study of Type 1 satellite tag performance and health impacts in humpback whales. Satellite tags were deployed in 2011 (n=19) and 2012 (n=16), and regular follow-up monitoring was performed to assess the state of the tag, wounds at the tag site and the overall condition of the whale. Tag site reactions were visually assessed as minor focal lesions to broad swellings. Broad swellings persisted over extended periods (at least 391 days in one case) and appeared to be related to tag breakage and/or body location. They were more prevalent for tags deployed on the lower flank (86.7%, n=13) versus the upper flank/dorsal fin (15.7%, n=3). All of the whales tagged in 2011 were re-sighted in 2012 and post-deployment coverage now spans more than 600 days in some cases. Females tagged in 2011 returned with a calf as frequently as females that were not tagged. Tag transmissions averaged 26.2 days (d) with a range of 0-97d. Fully implanted tags transmitted for significantly longer than partially implanted ones. Repeated re-sightings of tagged whales after deployment have revealed two design flaws that could explain the relatively short and variable tag transmission durations. Tag modifications arising from these observations have substantially increased tag duration and are expected to reduce impacts on individuals. Long-term effects will be studied via a well-established longitudinal research program. Results to date highlight the value of follow-up studies to evaluate and improve satellite tagging technology.

The sub-committee thanked the authors for this work, noting its value to future satellite tagging research.

4. REVIEW NEW INFORMATION ON THE ARABIAN SEA HUMPBACK POPULATION

SC/65a/SH06 reported recent information on the Arabian Sea humpback population (ASHW). Previous research and historical records have confirmed the presence of a discrete and non-migratory population of humpback whales in the Arabian Sea. A small vessel survey was conducted in Oman from October through to November 2012 from base camps at Hasik and Masirah Island. The survey covered a total of almost 3,000km (1,250km of survey effort) and resulted in three humpback whale sightings totalling five individuals. Three of these had been photographed during previous surveys off the coast of Oman. All of these sightings were located within the Gulf of Masirah, previously identified through habitat modelling as a critical area for the population. During surveys, 115 acoustic stations failed to detect any song but did result in 17 suspected baleen whale vocalisations. Passive acoustic monitoring units were also recovered from the southern study site at Hasik and redeployed in the Gulf of Masirah adjacent to a new port facility in Duqm. Three units will be deployed the site over the next year with all data to be analysed into the future. Three individual humpback whales accounted for 27% of all sightings. Thus, the data are not sufficiently robust to revise population estimates as requested in IWC (2012a). Set net fisheries are considered the biggest threat within critical habitat with a 29% increase of operational vessels between 2007 and 2011, with 79% of these vessels being registered with the directorate of the Gulf of Masirah. Infrastructure development within this area includes a multi-purpose dry dock port, a new fishing harbour and crude oil loading terminal. These will increase threats from navigation within this area. Progress has been made in briefing port management team on sensitivities of whale habitat. Proposed work includes conducting vulnerability mapping in the area to guide management plans, changing the survey approach through use of satellite telemetry (to address constraints implicit in the vessel surveys) and promoting a regional approach to research. Support has recently been received to initiate regional conservation efforts that may support a Conservation Management Plan (CMP) in the future. A shift in approach is required for research and management to be effective in conserving the population.

In 2010 the Scientific Committee recommended the development of an ASHW CMP. The plan could address concerns for ASHW as well those for other species of large whale. Neither of the two range state members of the IWC (India, Oman) has yet volunteered to lead the implementation of a CMP, although there is some recognition of urgent conservation concerns and research needs.

The sub-committee received a detailed update on progress toward the regional conservation initiative, as mentioned in SC/65a/SH06. Members of the intercessional correspondence group on the ASHW, together with regional NGO partners have begun work to establish a regional research and conservation programme for the ASHW. The programme would help to initiate and foster collaborative research amongst range state partners, increase local capacity and generate awareness of ASHW conservation issues. WWF International and local offices in the UAE, Pakistan and India have committed to facilitating the initiative and will liaise with national stakeholders. A network of regional specialists, with leading support from the Wildlife Conservation Society (WCS), will focus on completing scientific priorities identified by the Scientific Committee. Significant progress has been made on a project implementation plan, with funds currently being sourced for programme implementation. The work will continue to secure guidance from the ASHW intercessional correspondence group and progress updates will be provided to the Scientific Committee.

The sub-committee welcomed this update and was encouraged by this ambitious project. This regional conservation initiative was strongly supported as a positive opportunity for range states to work together towards improving the status of this population. Such work could also benefit a CMP, should one ultimately be established for this population. In discussion, it was clarified that there is solid funding to support this work from within Oman and from WWF over the next year which has allowed this project to proceed.

The sub-committee also received additional detail on the plans to satellite tag Arabian Sea humpback whales using implantable tags. This proposed work was explained by the proponents in the context of conservation concerns and identified research needs presented in SC/65a/SH06, as well as past reports and recommendations of the Scientific Committee.

The objectives of the tagging will address priority research questions identified previously by the Scientific Committee. These include: (1) improving available data on habitat use, including confirmation of suspected areas of importance, as well the potential for identification of other important areas; (2) improving available information on regional migrations; and (3) identification of areas where humpback whales are likely exposed to identified threats.

It was explained that the safeguards that have previously been identified for tagging efforts on other large whales would also be applied to this tagging effort. These would include due consideration of concerns raised for western grey whales (Weller *et al.*, 2009) as well as knowledge gained from other humpback whale tagging studies that use the same tag design – see Zerbini *et al.* (2011; 2006), SC/65a/SH05 and SC/65a/SH22. The tagging will be led by highly experienced practitioners with relevant experience, supported by researchers with relevant experience in Oman including familiarity with the Arabian Sea humpback whale catalogue. All work will be conducted under permit and in conjunction with relevant stakeholders in both Oman and the wider region.

The proponents of this work anticipated that no more than 20% of the population would be tagged over the period of the study, given the current population estimate of 84 (Minton *et al.*, 2011). Even this goal is likely ambitious in light of low encounter rates. The Environment Society of Oman (ESO) has recently received funding to facilitate this work, and it will be initiated as soon as is reasonable and feasible (2013-14). Existing funds are sufficient for seven tags and their associated costs, with further financing expected over the coming two years. Tagging attempts would focus on areas and times of highest sighting density and be timed to maximise tagging success and subsequent re-sighting data. Tagging efforts will be supported by ongoing small vessel surveys, during which photo-identification, video, biopsy, acoustic and behavioural records will be collected. High re-sighting rates for some individuals will provide a further opportunity to assess any impacts of tagging. It was further explained that tagging data would be analysed using standard methods and would prioritise questions of chief management importance for Arabian Sea humpback whales.

The sub-committee noted the importance of the proposed work, especially given how little is known about the Arabian Sea humpback whale population. While the sample size is modest, even a small number of tags has the potential to significantly increase what is known about movement patterns, habitat utilisation and migratory destinations of this population. This project addresses a critical issue that requires immediate conservation action. There have been a minimum of seven dead humpbacks observed from a population of 84 over the last 10 years and this minimum is already considerably higher than the estimated Potential Biological Removal (PBR). In Oman, there has also been a rapid increase in the development of fisheries, high speed ferries and coastal infrastructure projects, many of which overlap with known humpback habitat. Given the observed high mortality in this endangered population and known threats, there is an urgent need for better information on movement and habitat use. This project has the potential to considerably improve our knowledge in the short term and is in fact the only way to collect this information given the nature of this population and the available resources.

When considering the likely outputs of this project, it is important to carefully consider issues such as average tag duration and whether the existing tag technology will address the research questions posed. The authors noted that they have carefully reviewed the present state of tag development and will be following international best practice including using a well-designed and tested tag and include a very experienced expert tagging team (also involved in the SC/65a/SH05 study). The project team has been considering this project since 2002, and there have been long and careful deliberations about the feasibility, applicability and a consideration of potential impacts.

It was noted in discussion that the results of recent tag assessment studies (SC/65a/SH05) will be available in the next few years and consideration should be given to awaiting the outcomes of this recent work to the degree possible. However, the sub-committee also recognised the urgency of this issue and the potential benefit to the conservation management of this endangered species. It was **recommended** that this work be undertaken as a high priority, with the caveat that any new tag modifications be evaluated on other populations and not used first on Arabian Sea humpbacks.

In conclusion, the sub-committee welcomed these important updates on the Arabian Sea humpback whale population and looked forward to receiving further information next year. Given the critical status of this population, the sub-committee **recommended** that this research be allocated a high priority. Rosenbaum reported that genetic analyses of this population are continuing and an update will available at next year's meeting.

5. ASSESSMENT OF SOUTHERN HEMISPHERE BLUE WHALES

5.1 Review new information

5.1.1 Antarctic blue whales

The sub-committee received several papers reporting the first results from the SORP Antarctic Blue Whale Project.

SC/65a/SH21 was the cruise report of the 2013 Antarctic blue whale voyage of the Southern Ocean Research Partnership (SORP). The ultimate objective of the Antarctic Blue Whale Project is to estimate the circumpolar abundance of Antarctic blue whales. A mark-recapture approach can deliver a precise estimate with reasonable effort if the sighting rate of blue whales can be elevated relative to line-transect surveys using passive acoustic methods (Kelly *et al.*, In review; Peel *et al.*, In review). The Australian Government chartered the 65m FV *Amaltal Explorer* to conduct a 47-day voyage to Antarctic waters focussing on an area south of 60°S between 135°E and 170°W. An acoustic tracking system using DIFAR sonobuoys operated continuously during the voyages recording 626 hours of audio. Acousticians processed 26,545 Antarctic blue whale calls in 'real-time'. During the voyage 51 groups of vocalising blue whales were acoustically 'targeted' which led to 33 visual sightings of groups of one or more whales. Photographic identification data were collected for 50 individuals (33 left flank; 44 right flank; 33 left and right flanks) from 33 groups. Preliminary results from the 23 biopsy samples collected showed a strong male bias (0.79) although the sample includes duplicates. Two satellite tags were deployed on Antarctic blue whales for the first time in the Antarctic region. This voyage has shown that acoustic tracking can increase the sightings rate of blue whales and should be employed on future voyages contributing to the Antarctic Blue Whale Project.

SC/65a/SH18 provided additional detail on the long-range acoustic tracking of Antarctic blue whales as part of the Antarctic Blue Whale Project. Passive acoustic monitoring has been identified as a potential means of increasing blue whale encounter rates, and thus facilitating mark-recapture abundance estimates through photo-identification and biopsy. DIFAR sonobuoys were used to detect, localise and track Antarctic blue whales on a research cruise from 140°E to 165°W and south of 60°S between January and March 2013. Antarctic blue whales make loud and distinctive calls, known as 'Z' and 'D' calls. The loudest element of the 'Z' call (a 26Hz tone) was detected at a range of hundreds of kilometres. 26Hz calls were detected on all sonobuoys deployed south of 52°S (n=298). Whilst overlapping calls sometimes merged into a continuous tone, it was still possible localise and track individual calls. Multiple sonobuoys were used to triangulate the location of individuals and groups. Received levels of detections increased with decreasing range to several acoustic 'hotspots' in the survey area, where whales were sighted. At these closer distances, full 'Z' calls and 'D' calls were also detected. 85% of acoustic targets resulted in visual encounters, yielding 32 encounters with groups of blue whales. The results demonstrate the ability of acoustic tracking to locate Antarctic blue whales that are widely dispersed over a large area as well as the capacity to acoustically track whales for days at a time. These abilities may assist with characterising their behaviour in their Antarctic feeding grounds. The results from this study may serve as a benchmark for future acoustic surveys of Antarctic blue whales, and may also be useful for quantifying the effects of acoustic tracking when designing future surveys.

In discussion of these two papers, it was noted that the authors have demonstrated that their research goals are achievable and that this represents a significant advance in researching blue whales in the Southern Ocean. Confirmation that blue whales can be detected acoustically up to distances of several hundred kilometres (potentially up to 600km) highlights the utility of this technique for increasing encounter rates. An important finding from this cruise was that no encounters were made with blue whales other than with those that were detected acoustically first. It was noted that while an understanding of vocalisation rates are required for density estimation, they are not necessary for the acoustic localisation of whales to facilitate the collection of biopsy and photos.

SC/65a/SH03 reported on the movements of Antarctic blue whales on their summer foraging grounds based on satellite tagging in 2013. Movements have previously been described using data from the Discovery marking program, photo identification studies and acoustic recordings. However, these data are unable to provide a continuous time-series of actual movements, instead inferring movement from two (or more) known locations at two (or more) separate points in time. As such, the detailed large and fine scale movements of Antarctic blue whales remains poorly understood. Satellite tags capable of providing detailed, long-term movement data were deployed on two Antarctic blue whales during the first voyage of the Southern Ocean Research Partnership's (SORP) Antarctic Blue Whale Project. The tags collected movement data for 14 and 74 days tracking each whale over 1,433 and 5,300km respectively. Both tagged whales performed long scale movements interspersed with patches of searching, often in close association with the ice edge. These satellite tag derived movements are at the upper range of the within season scale of movement suggested by the Discovery marking program and photo-identification studies and corroborate movement between IWC Management Areas. Given the valuable data that can be collected by satellite tags, additional satellite tag deployments on future Antarctic Blue Whale Project affiliated voyages will contribute to a better understanding of both the fine scale and large scale movements of Antarctic blue whales.

SC/65a/SH11 reported on 50 Antarctic blue whales photo-identified during a 47-day research voyage in the Southern Ocean between 135°E-170°W. Eight whales were re-sighted during the voyage; the re-sighting rate was 16%, similar to the re-sighting rates from recent IWC SOWER cruises. Time intervals between re-sights in 2013 ranged from 1 to 27 days. Straight-line distances between re-sights ranged from 15km to 1,172km with minimum daily movements ranging from 15km/day to 93km/day. One whale was initially photographed 1,172km from where it was satellite tagged (and re-photographed) 27 days later. Photographs of three whales from the voyage were matched to individuals in the circumpolar Antarctic Blue Whale Catalogue with time intervals of three, five and six years. These three whales exhibited long-range movements of thousands of kilometres between sighting locations including one whale that moved a minimum of 6,550km and 145° of longitude. The 2013 voyage was the first voyage of the Antarctic Blue Whale Project under the Southern Ocean Research Partnership (SORP). The photo-identification data collected during the voyage will contribute towards a new abundance estimate of Antarctic blue whales using mark-recapture methods.

The sub-committee discussed SC/65a/SH03 and SC/65a/SH11 largely in the context of the ultimate aim of the Antarctic Blue Whale Project to estimate abundance through mark-recapture methods. It was reiterated that the large movements detected through satellite tagging and photo-id are consistent with what is known from other data sources but that it is very useful to confirm such movements on the feeding grounds. Sex information is also available for some of these individuals which will allow an investigation of whether there could be a sex bias in movement patterns or habitat use. The latter could be a concern in an acoustic-assisted project, in light of the fact that only males are thought to be calling. Finally, the encounter success and photo-id sample sizes reported in SC/65a/SH11 provide further support of the feasibility of this approach for maximising photo-id data for planned abundance estimation.

The sub-committee welcomed these results from the SORP project and noted the success of this first voyage in meetings its objectives. It was noted that this research represents a significant advance in non-lethal research on whales in the Southern Ocean. The sub-committee welcomed further updates of this work in the future.

SC/65a/O09 summarised sightings of blue whales during JARPA II of 2012/13. Four schools of six individuals were sighted but these were only distributed in the northern part of Prydz Bay. Three blue whales were photo-identified but no biopsy experiments were conducted.

5.1.2 Pygmy blue whales

SC/65a/SH12 reported on the photo-identification of 18 blue whales from coastal waters of the North and South Islands of New Zealand from 2004-13 in five different months of the year. No photographic matches were found. The photo-id collection has provided a foundation for future study on this little-known population. Fourteen of the photo-identifications were obtained in January and March 2013 during transits of the SORP Antarctic Blue Whale Voyage from Nelson, NZ to Antarctica and return. This voyage also allowed for observations of the external morphology and behaviour of the blue whales encountered. Body length and proportion, head shape, body condition and skin condition were similar to blue whales seen off Australia but not Antarctic blue whales. Feeding behaviour was observed off the South Island's west coast in January 2013 and strong evidence of feeding off the east coast in March 2013, the first this has been reported for these locations. Feeding behaviour was also observed in the Hauraki Gulf in November 2010. The population identity, taxonomic status, habitat use and ecology of blue whales off New Zealand are uncertain and more research is warranted.

SC/65a/SH19 described acoustic and visual observations of blue whales around New Zealand. Low frequency calls attributed to blue whales were detected all around the South Island of New Zealand during the voyage transits. Following acoustic bearings from directional sonobuoys, blue whales were seen and photographed confirming they were the source of these sounds. Previous underwater sound recordings made in New Zealand in 1964 and 1997 identified a complex sequence of low frequency sounds that were attributed to blue whales based on similarity to blue whale songs in other areas. The sounds recorded during this voyage with a consistent series of pulsed and tonal elements that are repeated at regular intervals also had these characteristics and confirm that these earlier recordings also came from blue whales. Acoustic detections (with no visual confirmation) also indicated the presence of whales east of Cook Strait. These recordings, together with the historical recordings made northeast of New Zealand suggest song types that: (1) persist over several decades; (2) remain distinct from the Antarctic blue whales; and (3) are indicative of the year-round presence of a population of blue whales that inhabits the waters around New Zealand. However, current calls are characterised by longer durations, lower frequencies and lower pulse rates than previous recordings and suggest that blue whale song in this region has changed slowly, but consistently over the past 50 years. The most intense units of these calls were detected as far south as 52°S, which represents a considerable range extension compared to the limited prior data on the spatial distribution of this population.

The sub-committee discussed the taxonomic status of blue whales in New Zealand waters. Based on available data on morphology, timing, distribution and acoustics, these whales are most likely to represent a form of pygmy blue whales. This finding is consistent with a growing body of evidence that populations of pygmy blue whales show considerable variation across the Southern Hemisphere. However, the sub-committee reiterated that the relationship among pygmy blue whales in different areas is unclear and merits further discussion.

SC/65a/SH19 noted a change in the frequency of blue whale calls over time. The reason for this change is unknown but one hypothesis is that it is due to an increase in noise in the ocean. However the direction of the observed change is not consistent with what would be expected in that case. SC/65a/SH19 also noted that seismic survey noise was detected at the same time and at the same frequency of blue whale calls, at a distance from over 400km away from the seismic survey source.

Childerhouse presented Torres (2013) on behalf of the author. Blue whale distribution in the Southern Hemisphere is poorly understood and this paper reported a new blue whale feeding ground in New Zealand. Various data sources were compiled to support the hypothesis that the South Taranaki Bight, between the north and south islands of New Zealand, is used as a foraging ground by blue whales for a common euphausiid prey that aggregate as a function of a nearby coastal upwelling system. The distribution of blue whales was compared with ship traffic density and the distribution of seabed mining activities in the region, and revealed close proximity between whales and these potential threats. This paper presented evidence that the South Taranaki Bight is a blue whale foraging habitat and called for a greater understanding of their habitat use patterns to manage anthropogenic activities effectively.

Childerhouse relayed an update from the author that the total number of sightings is now up to 80 reported blue whale sightings in the South Taranaki Bight including 33 sightings by marine mammal observers during a seismic survey over 10 days in early 2013.

5.1.3 Chilean blue whales

SC/65a/SH17 reported results from the Alfaguara Project on blues whale off Chile. During ten marine surveys conducted off north-western Isla de Chiloe from February to April 2013, 98 groups of blue whales comprising 138 individuals were encountered. Biopsy samples of skin and blubber were collected from 31 blue whales and one fin whale on four days. Four sightings totalling six humpback whales and one sighting of one fin whale were recorded. A probable mother-calf pair was observed on 13 March off northwestern Isla de Chiloé. SST ranged from 13 to 16°C, the lowest since 2005. Two aerial surveys were conducted on board a Chilean navy helicopter, and found 12 groups of 18 blue whales, eight groups of 11 probable blue whales, and one humpback whale. Blue whale sightings primarily occurred around 20 n.miles offshore which is the furthest distance from land since the project started in 2004. In addition, a few opportunistic sightings were reported in the inlets by members of the National Marine Mammal Sighting Network. Comparisons of individuals from inlets with those catalogued off northwestern Isla de Chiloe found two matches of five individuals. This new information further substantiates that they are part of the same population and, although with lower sighting rates, also use the inlets to feed, primarily in the fall. Finally, a dead 21.5m male blue whale stranded on 26 April in Puerto Godoy, north of Chacao Channel. No apparent cause of death was found based on our external observations, but ship strikes can not necessarily be detected from external evidence.

The high frequency of large vessels in the mouth of the Chacao Channel (along the north side of Isla de Chiloé) and the high number of blue whales in the area raises the possibility of vessel collisions. For the second consecutive year, Isla de Chañaral, located in northern Chile some 1,400km apart from Isla de Chiloe southern feeding area, has been monitored. During four marine surveys conducted between 14-17 February, 23 groups of blue whales containing 30 animals were encountered. Five sightings of seven humpback whales, seven sightings of 27 fin whales and two sightings of 18 bottlenose dolphins also were made. SST temperature ranged from 16 to 19°C. Sightings records in this northern feeding aggregation highlight the importance of continued monitoring and increased photo-identification efforts to better understand the dynamics of the blue whales that feed off Chile.

The taxonomic status of Chilean blue whales was discussed. It was noted that these whales were previously considered to be pygmy blue whales but recent analysis by Branch (2007) suggested that these are intermediate in size between Antarctic and pygmy blue whales. It was further noted that blue whales off Chile and Australia are more different genetically from each other than each is from Antarctic blue whales. Ongoing genetic analyses using additional samples from the Southern Hemisphere, Eastern Tropical Pacific and North pacific will be undertaken to try to resolve their taxonomic status (see SC/65a/SH25).

5.1.4 Photo-id catalogues

SC/65a/SH23 presented progress on the Southern Hemisphere Blue Whale Catalogue (SHBWC). Catalogues from South America, Eastern Tropical Pacific (ETP) and Antarctica have been fully uploaded. The Indonesia/ Australia/New Zealand area is in the process of uploading catalogues. A total of 884 blue whales are catalogued, including, 649 photo-identified from the right side, 654 from the left and 23 from flukes. Comparisons between the eastern South Pacific and ETP have been completed and no matches have been found. Comparisons between the ETP and the Southern Ocean, as well as those from eastern South Pacific and the Southern Ocean are approximately 50% complete (all left side photographs of individual blue whales have been finalised; right side comparisons still are underway) and no matches have been found. It is possible that either Southern Ocean or eastern South Pacific blue whales could use the region near the Equator or the ETP as breeding grounds. Although Antarctic blue whale type calls have been detected in the ETP, no recaptures have been found to date between the ETP catalogue and those from the eastern South Pacific and the Southern Ocean. Although preliminary, the authors concluded that their data did not provide evidence of exchange between ETP and the eastern South Pacific or the Southern Ocean. This is consistent with the other data (satellite tracking acoustic, and photo-identification) linking the ETP blue whales to blue whales off Baja California, Mexico and California. On the other hand, genetic analyses of blue whales off Antarctica and Australia, has found dispersal of individuals from Australia to Antarctica and the first record of hybridisation. Therefore, it is expected that photo-identification matching between Australia and Antarctica, when finalised, may reveal some connectivity between those two areas.

In discussion, it was noted that the main catalogues in the Southern Hemisphere have now joined the SHBWC (see Appendix 4) and that others have expressed their intention to join. It was **recommended** that all data holders submit their photos to the SHBWC. In response to a question, Galletti clarified that fluke photos are also catalogued because they are used by some groups as an auxiliary identification feature.

The sub-committee **recommended** continued support for the SHBWC. Financial implications are described in Item 9.2, below.

SC/65a/SH16 reported on the comparison of Antarctic blue whale photographs from JARPA to the Antarctic Blue Whale Catalogue. Thirty-one individual Antarctic blue whales were identified from photos collected during JARPA cruises in the Antarctic during 12 austral summer seasons between 1992/93 and 2004/05, in IWC Management Areas III, IV, V and VI. The contribution of 31 individuals to the Antarctic catalogue brings the number of photo-identified Antarctic blue whales up to 305 and notably increases the number of whales photo- identified in Area III to 165 and in Area V to 93. Comparisons of identification photographs were made within the JARPA collection and to the Antarctic Blue Whale Catalogue. No matches were found. The sighting histories of individual Antarctic blue whales from photo-id provide data for mark-recapture analysis as well as information on the movement of individual blue whales within the Antarctic region.

In discussion, it was noted that that there are 380 additional blue whale identification photographs and associated data from JARPA II cruises should be compared to the Antarctic Blue Whale Catalogue. The sub-committee **recommended** that this work be undertaken and this is an item of financial implication (Item 9.2, below).

5.1.5 New genetic information

Double presented Attard *et al.* (2012) on behalf of the author. This paper reported on the analysis of blue whale biopsy samples collected off Antarctica during IDCR/SOWER cruises and biopsy samples collected off Australia. They reported several cases of hybridisation between the two recognised blue whale Southern Hemisphere sub-species in a previously unconfirmed sympatric area off Antarctica. The results suggest that pygmy blue whales using waters off Antarctica may migrate and then breed during the austral winter with the Antarctic subspecies. Alternatively, the author hypothesised that these sub-species may interbreed off Antarctica outside the expected austral winter breeding season. The genetically estimated recent (i.e. ecological) proportion of blue whales off Antarctica consisting of pygmy blue whales were greater than the genetically estimated historical (i.e. evolutionary) proportion and greater than previously published estimates that were based on female body length and ovarian corpora data from whaling catches. This discrepancy may be due to differences in the methods or an increase in the proportion of pygmy blue whales off Antarctica within the last four decades. Potential causes for the latter are whaling, anthropogenic climate change or a combination of these and may have led to hybridisation between the subspecies.

In discussion, it was noted that although individuals do mix on the feeding grounds they are not breeding at that time for hybridisation to occur. However, the breeding areas of Antarctic blues are unknown and so they may overlap with pygmy blue breeding areas, or at least the extremes of the ranges of these two sub-species may overlap. Hybridisation has also been observed in the North Atlantic between blue and fin whales (Bérubé and Aguilar, 1998) and it has probably been occurring since prior to whaling. The sub-committee noted that it would be worthwhile repeating this analysis on other populations such as Chilean blue whales to see if the pattern reported by Attard *et al.* (2012) is evident in groups other than Australian pygmy blue whales. This result is more pronounced than other similar analyses conducted for the south eastern Pacific population of blue whales (including those off Chile) but more microsatellite loci were used in the Australian study. The sub-committee highlighted the importance of this study in the context of being able to genetically differentiate between blue whale sub-species.

6. REVIEW NEW INFORMATION ON OTHER SPECIES

6.1 Sperm whales

SC/65a/SH14 investigated the potential recovery of sperm whale bulls off Albany, Western Australia, a segment of the population reduced by 74% between 1955 and 1978 by commercial whaling. In 2009, an aerial survey was undertaken to assess whether there was any evidence of recovery. As far as possible, the survey was designed to replicate the behaviour of the 'spotter' planes employed by the Albany whaling fleet from 1968-78; the analysis thus used the number of sperm whale bulls seen on each morning flight as a comparative index between bulls seen historically and those seen in 2009. The mean number of sperm whale bulls seen on transect per day (morning) in 2009 was 2.43±1.08; this increased to 3.38±0.95 when off-effort sightings were also included. These 2009 estimates were substantially lower than the mean number seen in any of the years between 1968 and 1978, which ranged from 6.30±1.18 (1976) to 12.45±1.83 (1968). Whilst at this stage, the authors emphasised the preliminary nature of the results, they believed that they were indicative of no increase in the number of sperm whales frequenting this area compared to when the whaling operations were taking place.

In discussion of this paper, the sub-committee noted that oceanographic changes can affect the movement patterns of whales and it would be useful to determine what the oceanographic conditions were in the past and where comparable conditions now occur. Historically, the whales were known to feed at submarine canyons and it was unlikely, but possible, that the upwelling systems in the region had changed significantly. An investigation of squid and/or other fisheries in the region might yield insight into temporal changes in prey availability.

There was discussion about the methods used in the present survey and how comparable they were to the original surveys. There were some issues related to a lack of survey effort in September which was previously a period of the high abundance, but the authors had investigated this effect and considered it an unlikely explanation of the observed results. It was recognised that the early surveys were not ideal for comparative purposes and that caution should be taken in interpreting these results. The sub-committee discussed that future work in the region should consider alternative techniques, including acoustic surveys, to better understand this population.

In light of the potential concern raised by SC/65a/SH14, the sub-committee discussed the feasibility of undertaking an assessment of sperm whales. There was general agreement that such an assessment should concentrate on sperm whales in the Southern Hemisphere, but include equatorial nursery groups and the Arabian Sea. It would also be informed by information on populations in other areas, such as the Gulf of Mexico and the Gulf of California. The sub-committee reviewed the availability of data on population structure within ocean basins, population size within ocean basins (and abundance in smaller areas) and catch history. Discussion also focussed on the development of a new assessment model.

On the topic of population structure within ocean basins, sub-committee discussion focussed on the availability of genetic information. It was agreed that there are several sources of data, including frozen samples and teeth from various sources. It was noted in discussion that teeth would be useful for obtaining mitochondrial DNA, but not for nuclear markers.

A second issue discussed was information on population size. There are a few recent density estimates, and acoustics data are available from several sources. IWC/SOWER sightings data are available for large bulls, but dive time information is required. Tags such as those used in the Gulf of Mexico can provide information for deriving $g(0)$ in such instances. With regard to historic catches, the recent work by Smith and colleagues was noted. For the 20th century, Soviet catches may need to be allocated in detail. It was noted that Allison should be consulted on the current status of sperm whale catches in the IWC database.

Finally there was discussion of the development of a new length-structured model, but there is a need to be able to model spatial behaviour and the implications of hunting social species need to be considered.

In conclusion, it was **agreed** that work be undertaken intersessionally to further ascertain the availability of data for a future sperm whale assessment. Brownell would coordinate these activities by means of an intersessional correspondence group and report back to the sub-committee in SC/65b, as described in Item 9.3. The sub-committee also **recommended** that sperm whales be addressed under their own agenda item in SC/65b.

6.2 Other species

Several papers reported new information on other large whale species in the Southern Hemisphere, as summarised below.

SC/65a/SH17 reported one sighting of a fin whale during ten surveys off north-western Isla de Chiloe, Chile from February to April 2013. One biopsy sample was obtained. Seven groups (27 animals) were observed during four marine surveys conducted between 14 to 17 February off Isla de Chañaral.

SC/65a/IA13 reported on cetacean sighting survey results in Gabon coastal waters from 4-10 September 2011 and in the Gulf of Guinea (Côte d'Ivoire, Ghana, Togo and Benin) from 23 March-06 April 2013 (see details under Item 3.2). In the Gabon survey, two sperm whales (two groups), six sei whales (one group) and two Bryde's whales (one group) were observed. In the Gulf of Guinea survey, one Bryde's whale was observed.

SC/65a/SH10 summarised the occurrence of cetaceans in the Scotia Sea during a February-March 2013 survey on board of the oceanographic vessel ARA *Puerto Deseado* (see details under Item 3.3). Species relevant to this item included sightings of fin whales and sei whales.

SC/65a/SH20 described an aerial survey for cetaceans in the western Weddell Sea, Bransfield Strait and along the north coast of the South Shetland Islands in the Drake Passage from 25 January-11 March 2013 (see details under Item 3.3). There were 123 sightings of 351 fin whales. Large numbers of fin whales were encountered over the shelf break north of the South Shetland Islands in feeding aggregations of up to 60 animals. Further analysis will include density estimation and habitat modelling, taking into account oceanographic and krill data obtained during the cruise.

7. CONSERVATION MANAGEMENT PLANS

A list of priority populations for Conservation Management Plans was prepared in response to a request from the Conveners. These are presented with further explanation in Appendix 5.

8. UPDATED LIST OF ACCEPTED ABUNDANCE ESTIMATES

An updated list of accepted abundance estimates was compiled for Southern Hemisphere whale stocks in response to a request from the Conveners. These are presented with further explanation in Appendix 6.

9. WORK PLAN AND BUDGET CONSIDERATIONS

9.1 Humpback whales

The sub-committee strongly **agreed** that it would complete its assessment of Breeding Stocks D/E/F in SC/65b, and that this would complete the Comprehensive Assessment of Southern Hemisphere Humpback Whales.

The following tasks were **recommended** as a high priority in order to complete the assessment:

(1) Continued development of a single-stock model for BSD and two-stock models for BSE1/Oceania. More complex models may also be explored. Butterworth, Holloway and Ross-Gillespie will undertake this work for a cost of £3,000 (Appendix 7).
(2) Completion of a series of two-stock models to assess the recovery of breeding stocks E1, E2, E3 and F2. This work will be undertaken by Jackson with no associated costs.
(3) An intersessional correspondence group to coordinate and facilitate the assessment modelling efforts. This group would be led by Ross-Gillespie.
(4) An analysis to produce a minimum abundance estimate of Breeding Stock D humpback whales from Western Australian aerial surveys. This work is described in Appendix 8 and some will be undertaken by Hedley, with a total budget request of £4,000. It will be facilitated by an intersessional e-mail correspondence group including Butterworth, Double, Hedley, Ross-Gillespie, Hammond, Holloway, Palka, Salgado-Kent and Zerbini (Convenor).
(5) A two-day pre-meeting Workshop before SC/65b to ensure that there is sufficient time to complete the assessment. A Workshop steering committee will be led by Robbins and a preliminary budget is provided in Appendix 9.

The sub-committee also **recommended** that work continue on the Antarctic Humpback Whale Catalogue (AHWC). This work will be undertaken by Carlson and colleagues with a budget request of £15,000 (Appendix 10).

Intersessional email groups are detailed in Table 1.

Table 1

Intersessional groups.

Group	Terms of Reference	Membership
Assessment of Southern Hemisphere Humpback Whale Breeding stocks D/E/F	To coordinate and facilitate the completion of assessment modelling recommended in Item 3.1.2.	Ross-Gillespie (Convenor), Butterworth, Double, Holloway, Jackson, Holloway, Kitakado, Pastene, Robbins, Zerbini.
Obtain a minimum abundance estimate of Breeding Stock D humpback whales	To obtain a minimum abundance estimate of BSD, possibly through strip-transect methodology, and investigate the sensitivity of data selection.	Zerbini (Convenor), Butterworth, Double, Hedley, Ross-Gillespie, Hammond, Holloway, Palka, Salgado-Kent.
Steering committee of the pre-meeting to complete the assessment of hump-back whale breeding stocks D/E/F	To plan a pre-meeting Workshop to facilitate the completion of the assessment of breeding stocks D/E/F at SC/65b.	Robbins (Convenor), Butterworth, Double, Jackson, Zerbini.
Investigate the feasibility of a future sperm whale assessment	Identify data availability and needs to undertake a future assess-ment of sperm whales. Information would be sought in the following categories: (1) population structure within ocean basins; (2) population size within ocean basins and abundance in smaller areas; (3) catch history; and (4) consideration of the development of a new assessment model.	Brownell (Convenor), Baker, Bannister, Bell, De La Mare, Hoelzel, Kasuya, Kato, Leaper, Mate, Matsuoka, Mesnick, Miyashita, Palacios, Perrin, Reeves, Smith, Whitehead.

9.2 Blue whales

The sub-committee **recommended** that work continue on the Southern Hemisphere Blue Whale Catalogue (SHBWC) and that this work will be conducted by Galletti and associated researchers with a total budget request of £15,000. Details of this proposed work are provided in Appendix 4.

The sub-committee **recommended** that the JARPA II blue whale photo-identification catalogue be compared to the Antarctic blue whale catalogue. This work will be conducted by Olson with a total budget request of $11,500 USD (Appendix 11).

9.3 Sperm whales

An intersessional e-mail group was **recommended** to consider the feasibility of undertaking a future assessment of sperm whales. The terms of reference of this group would be to evaluate data availability and work required in the following areas: (1) population structure within ocean basins (Baker, Mesnick and Hoelzel): (2) population size within ocean basins and abundance in smaller areas (Leaper); (3) catch history (Brownell, Reeves and Smith); and (4) consideration of the development of a new assessment model (de la Mare, Whitehead and others). Groups will report back to Brownell on these items by 1 January 2014 to allow information to be synthesised for SC/65b.

10. ADOPTION OF THE REPORT

The report was adopted on 18:19 on 11 June 2013. The sub-committee thanked the chair and the rapporteurs for their efforts.

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Appendix 1

AGENDA

1. Introductory items
   - 1.1 Opening remarks
   - 1.2 Election of Chair
   - 1.3 Appointment of rapporteurs
   - 1.4 Adoption of the Agenda
   - 1.5 Review of documents
2. Southern Ocean Research Partnership (SORP)
3. Assessment of Southern Hemisphere humpback whales
   - 3.1 Assessment of Breeding Stocks D, E and F
     - 3.1.1 Review new information
     - 3.1.2 Assessment models
     - 3.1.3 Future work
   - 3.2 Review new information on other breeding stocks
   - 3.3 Review new information on feeding grounds
   - 3.4 Antarctic Humpback Whale Catalogue
   - 3.5 Other
4. Review new information on the Arabian Sea humpback population
5. Assessment of Southern Hemisphere blue whales
   - 5.1 Review new information
     - 5.1.1 Antarctic blue whales
     - 5.1.2 New Zealand blue whales
     - 5.1.3 Chilean blue whales
     - 5.1.4 Photo-identification catalogues
     - 5.1.5 New genetic information
6. Review new information on other species
7. Conservation Management Plans
8. Updated list of accepted abundance estimates
   - 8.1 Humpback whales
   - 8.2 Blue whales
9. Work plan and budget considerations
   - 9.1 Humpback whales
   - 9.2 Blue whales
10. Adoption of the Report

Appendix 2

ESTIMATED MIXING PROPORTIONS OF BSD, BSE1 AND OCEANIA (BSE2, BSE3 AND BSF) IN FOUR DIFFERENT REGIONS OF THE ANTARCTIC FEEDING GROUNDS

Pastene, L. and Kitakado, T.

Estimated mixing proportions of breeding stocks D, E1 and Oceania (BSE2, BSE3, BSF) in the Antarctic were prepared at the request of the sub-committee to reflect alternate Antarctic area boundaries. The underlying data, assumptions and methods of calculation are presented in SC/65a/SH13.

Table 1

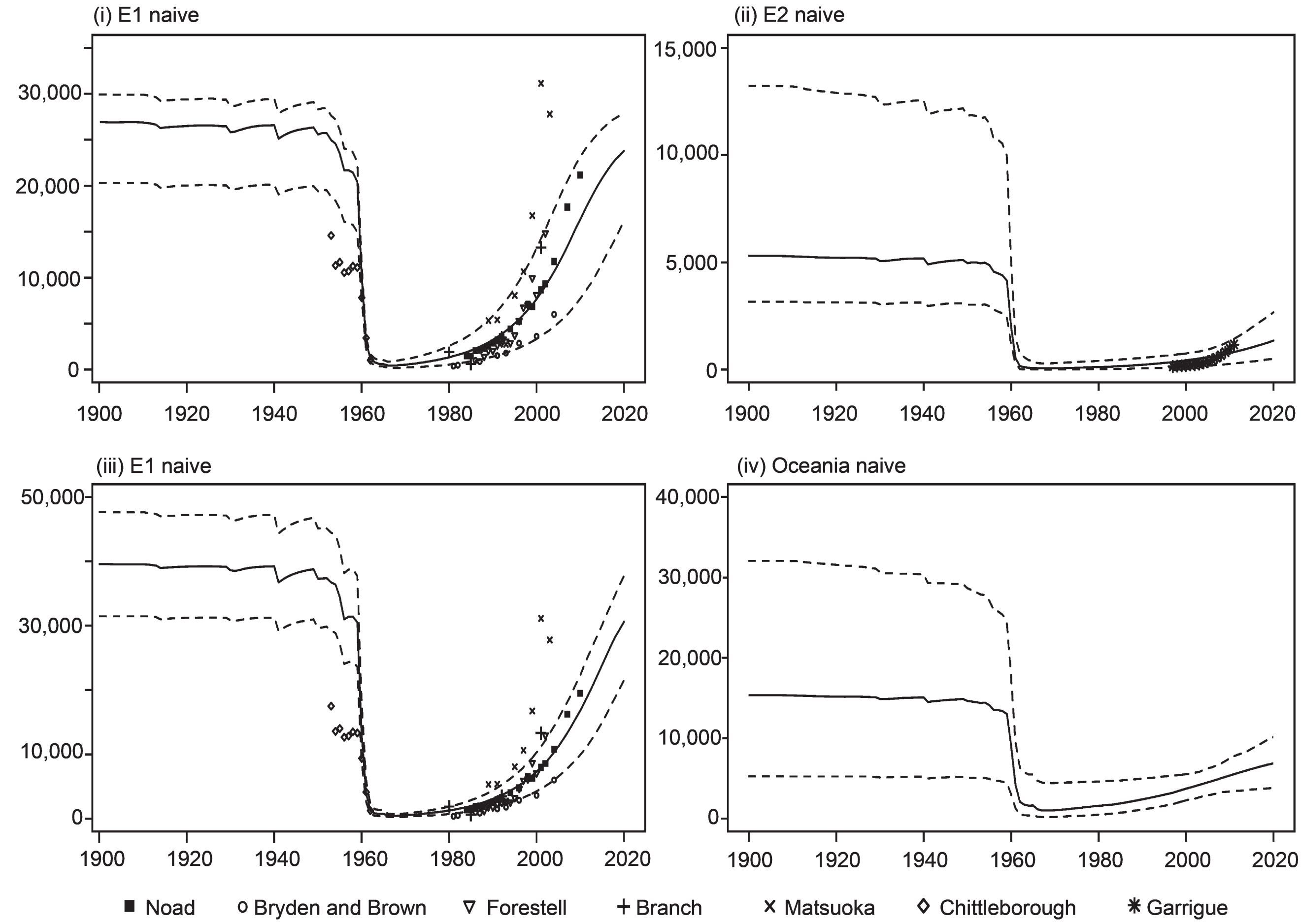
Estimated mixing proportions of Breeding Stocks D, E1 and Oceania.

Antarctic area boundaries	BSD	BSE1	Oceania
70°E-140°E	0.855	0.145	0
140°E-160°E	0.083	0.917	0
160°E-150°W	0	0.324	0.677
150°W-110°W	0	0	1.00

Appendix 3

PLOTS OF AVAILABLE RELATIVE AND ABSOLUTE ABUNDANCE INDICES FOR EAST AUSTRALIA (BSE1) AND OCEANIA (BSE2, BSE3, BSF2)

J.A. Jackson



The naïve population trajectories presented in SC/65a/SH07 were co-plotted with available abundance indices from East Australia and Oceania. The naïve population model for East Australia (BSE1) and New Caledonia (BSE2), shown in plots (i) and (ii) above, co-allocated feeding ground catches between 130°E -180° to both breeding stocks. The naïve population model for East Australia (BSE1) and Oceania (BSE2+BSE3+BSF2), shown in plots (iii) and (iv) below, co-allocated feeding ground catches between 130°E-120°W to the breeding stock and Oceania (a group of breeding stocks).

Abundance indices

Noad *et al.* (2011): absolute abundance data from shore counts in East Australia.

Brown *et al.* (2003): relative abundance indices from shore counts in East Australia.

Forestell *et al.* (2011): relative abundance obtained from mark-recapture resights.

Branch (2011): absolute abundance of feeding ground Area V from SOWER surveys.

Matsuoka *et al.* (2011): absolute abundance of feeding ground Area V from JARPA surveys.

Chittleborough (1965): catch per unit effort data from whaling stations in East Australia.

Garrigue *et al.* (2012): relative abundance obtained from mark-recapture resights.

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Appendix 4

SOUTHERN HEMISPHERE BLUE WHALE CATALOGUE 2013/14

RELEVANT AGENDA ITEM (NO. AND TITLE)

Item 5. Assessment of Southern Hemisphere Blue Whales

BRIEF DESCRIPTION OF PROJECT AND WHY IT IS NECESSARY TO YOUR SUB-COMMITTEE

The Southern Hemisphere Blue Whale Catalogue (SHBWC) is an international collaborative effort to facilitate cross-regional comparison of blue whale photo-identifications catalogues. In 2006 the Scientific Committee of the International Whaling Commission (IWC) agreed to initiate an in-depth assessment of Southern Hemisphere blue whales and in 2008, the Committee endorsed a proposal to establish a central web-based catalogue of blue whale identification photographs, known as the SHBWC.

Currently the SHBWC holds photo-identification catalogues of researchers from major areas off Antarctica, Australia, Eastern South Pacific and the Eastern Tropical Pacific. A total of 884 blue whales are catalogued, including, 649 photo-identified from the right side, 654 from the left and 23 from flukes (see Table 1).

Results of comparisons among different regions in Southern Hemisphere will improve the understanding of basic questions relating to blue whale populations in the southern hemisphere such as defining population boundaries, migratory routes and model abundance estimates.

In addition, assessment of blue whales and estimates abundance of populations will require improving software capabilities to access encounter histories of individuals.

TIMETABLE

2013/14: Software improvements and maintenance.
2013: Comparisons among catalogues from Australia/New Zealand/Indonesia regions.
2013/14: Comparisons between catalogues from ETP, Southern Ocean and eastern South Pacific versus Australia.
June 2014: Final report to IWC.

RESEARCHERS' NAMES

Bárbara Galletti (catalogue curator, regional coordinator and contributor).
Paula Olson (regional coordinator and contributor).
Chandra Salgado (regional coordinator).
Contributors: Chris Burton, Asha de Vos, Paul Ensor, Tim Gerrodette, Peter Gill, Curt Jenner, Luciana Moller, Margie Morrice, Daniel Palacios, Michael Double.

ESTIMATED TOTAL COST WITH BREAKDOWN AS NEEDED (E.G. SALARY, EQUIPMENT)

Personnel
Photo comparisons (2013-14): £10,000
Project and database management: £2,000
Software improvements: £2,000
Supplies and web hosting: £1,000
Total: £15,000.

Table 1

Summary of photographic collection of blue whale catalogues under the SHBWC.

Region	Group	Quantity			Area
		Fluke	Left side	Right side	
South America	IWC SOWER CHILE[1]	0	14	9	Chile
	CCC[1]	0	288	299	Chile
	Sub-total	**0**	**302**	**308**	
ETP	NOAA[1]	0	60	53	Peru, Ecuador, ETP
Indonesia-Australian-NewZealand	Asha de Vos[2]	0	0	0	Sri Lanka
	BWS[2]	23	84	86	Southeastern Australia
	WWR[2]	0	30	23	Timor Leste - Australia
	CWR[2]	0	20	22	Western Australia
	AAD[2]	0	0	0	Australia sub-Antarctic
	Sub-total	**23**	**134**	**131**	
Southern Ocean	IWC SOWER[1]	0	158	157	Antarctica
	Total	**23**	**654**	**649**	

[1]Catalogues fully contributed until 2009. [2]Catalogues still in process of uploading.

Appendix 5

PRIORITY POPULATIONS FOR CONSERVATION MANAGEMENT PLANS

The sub-committee discussed potential candidates for a Conservation Management Plan (CMP), in light of the guidance provided in SC/65a/SCP01. It noted that three large whale populations have already been proposed and/or have CMPs initiated: the Arabian Sea humpback whales, south east Pacific southern right whales and southwest Atlantic southern right whales. A CMP for the Arabian Sea humpback whale population is still under development (see Item 4), while the latter two populations already have approved CMPs underway. Other populations that were identified as potentially benefit from a CMP in the future included:

(1) humpback whales off Indonesia;
(2) Antarctic blue whales;
(3) southeast pacific (Isla de Chiloe) blue whales; and
(4) southeast Pacific fin whales.

However, the current information on status and/or threats in these cases was not adequate to support a recommendation at this time. The sub-committee **agreed** that the Arabian Sea population remains a high priority for a CMP (Table 1, below), as do those populations that already have draft CMPs in place. It was **agreed** that other populations would be re-evaluated for priority listing as additional information becomes available.

Table 1

Priority list of populations for future Conservation Management Plans.

Population	Abundance	% unexploited	Trend	Range states	Known/likely threats	Information gaps
Arabian Sea humpback whales	82 (95% CI: 60-111) in 2004	Unknown	Unknown	Oman, India, Pakistan, Sri Lanka (occasional sightings in Iran, Iraq)	Entanglement, ship strike, pollution	Current abundance and trends; human impacts, geographic range

Appendix 6

INITIAL LIST OF ACCEPTED ABUNDANCE ESTIMATES

Table 1

Initial list of accepted abundance estimates.

Population/type*	Area	Use category[1]	Evaluation extent[2]	Year	Method[3]	Estimate	95%CI	Original reference	Comments
Humpback whale									
BS A	Brazil	1	1	2005	DS	6,300	4,300-8,600	Andriolo *et al.* (2006)	
BS B1	Gabon	1	1	2005	MR	6,800	4,350-10,400	Collins *et al.* (2010)	
BS B2	W South Africa	1	1	2001	MR	300	200-400	Barendse (2011)	This small area estimate is thought to represent an unknown fraction of sub-stock BSB2.
BS C1	Mozam-bique	1	1	2003	DS	6,000	4,400-8,400	Findlay *et al.* (2011)	
BS C3	Madagascar	1	1	2004	MR	7,500	2,100-12,700	IWC (2009); Cerchio *et al.* (2009)	
BS D	W Australia	3	1	2008	DS	28,800	23,700-40,100	Hedley *et al.* (2011)	This estimate was previously accepted for use in the assessment of BSD, but under re-evaluation in SC/65a.
BS E1	E Australia	1	1	2010	DS	14,500	12,700-16,500	Noad *et al.* 2011	
BS E2+E3+F	Oceania	1	1	2005	MR	4,300	3,300-5,300	Constantine *et al.* (2012)	
BS G	Ecuador	1	1	2006	MR	6,500	4,300-9,900	Felix *et al.* (2011)	
Arabian Sea	Arabian Sea	1	1	2007	MR	80	60-110	Minton *et al.* (2011)	
Blue whale									
Antarctic type	Antarctic, S of 60°S	1	1	1997	DS	2,300	1,100-4,500	Branch (2007)	
Pygmy type	Perth Canyon	3	1	2005	MR	1,000	560-1,150	IWC (2009); Jenner *et al.* (2008)	Information is needed to understand how this area estimate relates to the greater stock to which it belongs.
Pygmy type	Madagascar Plateau	3	1	1996	DS	420	200-900	Best *et al.* (2003)	As above.

*BS=Breeding Stock. [1]Use categories: (1) acceptable for use in in-depth assessments or for providing management advice; (2) adequate to provide a general indication of abundance; or (3) use to be determined. [2]Evaluation extent: (1) examined in detail; (2) partially examined but method standard; (3) unclear but method standard; (4) partially examined and new method; and (5) unclear and new method. [3]Method of calculation: DS=distance sampling, MR=mark-recapture.

The sub-committee prepared an initial list of abundance estimates used in in-depth assessments, or useful for providing a general indication of abundance. Due to time constraints in SC/65a, this work focused on annotating a list that was previously prepared (Zerbini and Robbins, 2012). That previous list had been limited to the most recent acceptable estimate for a given area or stock, noting that breeding stock estimates were preferentially selected because of the potential for stock mixing on feeding grounds. Here, that list was further limited to the estimates that were examined in detail by the sub-committee. For the future, the sub-committee **agreed** that use category and evaluation extent should be explicitly noted each time an estimate is reviewed.

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Appendix 7

MODELING OF SOUTHERN HEMISPHERE HUMPBACK WHALE POPULATIONS

RELEVANT AGENDA ITEM (NO. AND TITLE)

Item 3.1 Assessment of Breeding stocks D, E and F

BRIEF DESCRIPTION OF PROJECT

The project will focus on a combined assessment of humpback breeding stocks D, E1 and Oceania using a three-stock model which allows for mixing on the feeding grounds. Methods used will be based upon the Bayesian methodology as developed and presented for BSC and BSB comprehensive assessments recently completed. Exploration of alternative models which may be able to explain the observed data will be explored. These will include models that address anomalies identified during the 2013 Scientific Committee meeting regarding the population model fit to data for breeding stock D, and approaches suggested there to account for them, such as use of Cooke's environmental variation model and changes in carrying capacity over time.

TIMETABLE

Report on results at 2014 Scientific Committee meeting.

RESEARCHERS' NAMES

Butterworth, Johnston, Ross-Gillespie.

ESTIMATED COST WITH BREAKDOWN AS NEEDED

Salary contribution for period up to and including 2014 Scientific Committee meeting: £3,000.

Appendix 8

OBTAINING MINIMUM ABUNDANCE ESTIMATES OF BREEDING STOCK D HUMPBACK WHALES FROM WESTERN AUSTRALIAN AERIAL SURVEYS, 1999, 2005, 2008

RELEVANT AGENDA ITEM (NO. AND TITLE)

Item 3.1 Assessment of Breeding stocks D, E and F.

BRIEF DESCRIPTION OF PROJECT AND WHY IT IS NECESSARY TO YOUR SUB-COMMITTEE

During the course of SC/65a, it became apparent that the observers' search pattern during these aerial surveys had not followed conventional protocols for conducting aerial surveys. In particular, the observers searched in an elliptical fashion, looking outwards from bubble windows, forward, aft and down (close to the trackline of the aircraft). The effect of such search patterns on the estimates is unknown, but sufficient concerns about their effect were expressed that the sub-committee now cannot confidently rely on the resulting abundance estimates to inform the modeling exercise being undertaken.

The sub-committee recommended that minimum estimates be produced (by October) using strip-transect methodology; an investigation into the sensitivity of data selection when conducting such analyses would also be useful. This project will undertake these analyses and as needed (within reason!) will undertake further analyses on request to assist the modeling exercise (in correspondence with a small group comprising Butterworth, Double, Ross-Gillespie, Hammond and Holloway).

TIMETABLE

The task will be completed by October, since the inputs are needed for the modeling exercise.

RESEARCHER'S NAME

Sharon Hedley.

ESTIMATED TOTAL COST WITH BREAKDOWN AS NEEDED (E.G. SALARY, EQUIPMENT)

Salary costs: £4,000.

Appendix 9

INTERSESSIONAL WORKSHOP TO COMPLETE THE ASSESSMENT OF HUMPBACK WHALE BREEDING STOCKS D, E AND F

A two-day 'invitation only' Workshop is proposed immediately preceding SC/65b to facilitate the timely completion of the assessment of humpback whales breeding stocks D, E and F (see Item 3.1.2). These are the last stocks remaining in the Comprehensive Assessment of Southern Hemisphere humpback whales. The sub-committee has **agreed** that this assessment should be completed during SC/65b, as a matter of high priority.

The Terms of Reference of the Workshop are to finalise this work for consideration by the Scientific Committee in SC/65b. The Workshop will evaluate the results of intersessional modelling efforts as determined in Item 3.1.2:

(1) evaluate the single-stock model for BSD and two-stock models for BSE1/Oceania, in light of agreed data, including a minimum abundance estimate for BSD developed intersessionally for this purpose; and
(2) evaluate a series of two-stock models to assess the recovery of breeding stocks E1, E2, E3 and F2.

The Workshop will also undertake additional work as needed to ensure that the assessment can be concluded in SC/65b.

The Steering Committee for this Workshop will include Butterworth, Double, Jackson and Zerbini, provisionally led by Robbins. The Steering Committee will prepare an agenda and select participants intersessionally based on the progress and results of intersessional work. Priority will be placed on scientists able to contribute to the analytical issues to be addressed, but will also include those familiar with data used in the assessment.

Essential prerequisites for the Workshop are the intersessional modelling results and input data recommended in Item 3.1.2. The outcome of this Workshop will include a final suite of assessment models and conclusions of Workshop members for consideration by the sub-committee in SC/65b.

Budget

A preliminary budget of £7,000 was estimated for lodging, subsistence, travel and meeting room fees. Lodging and subsistence is estimated for two days for 10 invited participants. Most invitees would also be attending SC/65b and so would not require travel costs, but air travel is also budgeted for one participant. The final budget will depend on the final participant list and the venue selected for the SC/65b meeting.

Appendix 10

IWC RESEARCH CONTRACT 16, ANTARCTIC HUMPBACK WHALE CATALOGUE (AHWC)

RELEVANT AGENDA ITEM (NO. AND TITLE)

Item 3.4 Antarctic Humpback Whale Catalogue

BRIEF DESCRIPTION OF PROJECT AND WHY IT IS NECESSARY TO YOUR SUB-COMMITTEE

Continue the cataloguing of submitted photographs and further develop and enhance the system for online access.

We have made tremendous progress in the catalogue with funding support from the IWC. Increasing awareness of the project among research organisations, tour operators and other potential contributors has widened the scope of the collection; research efforts in areas that had not previously been sampled have extended the geographic coverage. The AHWC has grown by 25% in the last two years, adding 1,066 new individuals. There continues to be strong interest in the catalogue, and photographs catalogued during the contract period included substantial additions from areas that were previously under-represented in the collection.

The project has a hemispheric scope and the database spans more than two-and-a-half decades. As a result the AHWC is in an excellent position to make a substantial contribution to the Southern Ocean Research Partnership and other research and management initiatives.

TIMETABLE

July 2013-June 2014.

RESEARCHERS' NAMES

Judith M. Allen, Carole Carlson and Peter Stevick, College of the Atlantic, 105 Eden Street, Bar Harbor, ME 04609 USA.

ESTIMATED TOTAL COST WITH BREAKDOWN AS NEEDED (E.G. SALARY, EQUIPMENT)

Project and database management £3,350
Photo comparison £10,000
Fringe @ 16.5% £1,650
Total budget: £15,000.

Appendix 11

COMPARISON OF ANTARCTIC BLUE WHALE IDENTIFICATION PHOTOGRAPHS FROM JARPA II TO THE ANTARCTIC BLUE WHALE CATALOGUE

RELEVANT AGENDA ITEM (NO. AND TITLE)

Item 5. Assessment of Southern Hemisphere Blue Whales.

BRIEF DESCRIPTION OF PROJECT AND WHY IT IS NECESSARY TO YOUR SUB-COMMITTEE

The population status of the endangered Antarctic blue whale (*Balaenoptera musculus intermedia)* is a concern of the IWC Scientific Committee (IWC, 2006, p.40). The Antarctic Blue Whale Catalogue contains the sighting histories of 305 individual blue whales from the circumpolar Antarctic (all six IWC *Management Areas*). The sighting histories of individual Antarctic blue whales from photo-id provide data for a mark-recapture estimate of abundance as well as information on the movement of individual blue whales within the Antarctic region. The addition of more samples to the collection of Antarctic blue whale identification photographs would be extremely useful for these analyses. Three hundred and eighty blue whale identification photographs were collected during JARPA II cruises but need to be compared to the Antarctic Blue Whale Catalogue and the associated sighting data added to the sighting history database.

TIMETABLE

Photographic analysis and report of results by June 2014 (SC/65b).

RESEARCHER'S NAME

Paula A. Olson, Southwest Fisheries Science Center NMFS/NOAA, La Jolla, CA USA.

ESTIMATED TOTAL COST WITH BREAKDOWN AS NEEDED (E.G. SALARY, EQUIPMENT)

$11,500 USD total, including $11,400 for researcher salary and $100 for photo printer ink, photo paper, photo notebook and photo sleeves.

REFERENCE

International Whaling Commission. 2006. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 8:1-65.

Annex I

Report of the Working Group on Stock Definition

Members: Jackson (Convenor), Baker, Bickham, Bravington, Broker, Collins, Double, Cipriano, Elvarsson, Gaggiotti, Hoelzel, Kanda, Kasuya, Lang, Palsbøll, Pampoulie, Park, Pastene, Perkins, Perrin, Rosenbaum, Scordino, Skaug, Solvang, Tiedemann, Urbán, Víkingsson, Wade, Waples, Weller.

1. INTRODUCTORY ITEMS

1.1 Opening remarks
Jackson welcomed participants.

1.2 Election of Chair and appointment of rapporteur
Jackson was elected as Chair and Lang acted as rapporteur.

1.3 Adoption of Agenda
The adopted agenda is given in Appendix 1.

1.4 Review of documents
The documents identified as containing information relevant to the Working Group were: SC/65a/SD02, SC/65a/RMP01, SC/65a/RMP03, SC/65a/IA06, SC/65a/SH13, SC/65a/BRG16, Anderwald *et al.* (2011), SC/65a/Rep03 (Item 5.2) and Weller *et al.* (2013).

2. GUIDELINES FOR GENETIC STUDIES AND DNA DATA QUALITY

This agenda item relates to two sets of guidelines that the Scientific Committee has requested the Working Group (hereafter SDWG) to develop for reference in the Committee's discussions of stock structure. The DNA Data Quality guidelines are already available as a 'living document' on the IWC website, and the Genetic Data Analysis guidelines will be available in this form by SC/65b. Both are subject to ongoing update as appropriate.

2.1 Genetic data analysis guidelines document
The document provides guidelines for some of the more common types of statistical analysis of genetic data that are employed in IWC management contexts. The main section is intended as guidance for managers and also contains examples of management problems that are regularly faced by the Committee. There is also an extensive Appendix of genetic analysis techniques for specialist readers. During SC/65a some additional Appendix sections were completed and SDWG members reviewed the guidance section and made progress on the management problems sections. This work is anticipated to complete intersessionally (see the work plan in Item 7.1).

2.2 Genetic data quality review
During SC/65a, additional sections were added to the guidelines on marker validation and systematic quality control. These sections provide guidance on: quality control and development of single nucleotide polymorphism data, quality control and development of other marker types not discussed in the original document (e.g. major histocompatibility complex genes), the quality of next generation sequencing data and guidelines regarding acceptable levels and types of errors occurring in DNA data.

3. STATISTICAL AND GENETIC ISSUES RELATING TO STOCK DEFINITION

The Stock Definition Working Group has the task of discussing high-priority stock related papers from other sub-committees and Working Groups, and then providing stock structure related feedback and recommendations to those sub-committees and Working Groups (IWC, 2013b). These discussions often refer to the genetic analysis guidelines and genetic data quality documents, the latter of which can be found at *http://iwc.int/scientific-committee-handbook#ten.*

Some general comments were made which are relevant to many papers submitted to the Scientific Committee.

The SDWG discussed the fact that with new next generation sequencing tools it is now relatively inexpensive to increase the number of loci analysed (e.g. by developing single nucleotide polymorphisms, SNPs and using Double Digest Restriction Associated DNA sequencing, ddRADseq, approaches) so that more information could be gained from each sample in a population study. More genetic markers are often called for in circumstances where the existing marker set cannot detect differentiation due to lack of discriminatory power or lack of subdivision. Increasing the number of loci increases the power to detect subtle population structure using both traditional and clustering analyses and can facilitate future studies of relatedness patterns among sampled animals. Whilst the addition of more markers to a study is generally valuable, it was also cautioned that the value of this is truly in the context of the questions being addressed - for example, do the existing markers already have sufficient power to exclude the possibility of demographically independent sub-stocks within the sample? Simulation analysis of the power of data to measure departures from panmixia and to reject demographically significant (i.e. sufficiently high) migration rates between putative differentiated clusters are useful in this regard. Increased numbers of loci can increase power to detect subtle population structure and also allow for improved inference of the population history underlying the substructure. However, they can increase resolution to the point where even individuals can be discriminated and can also amplify spurious signals from genotype errors and small departures from random sampling. Therefore it is important to consider the level at which structure needs to be detected in order for it to be of management concern.

A general caution was issued regarding removal of relatives from genetic datasets when analysing population differentiation. A major characteristic of small populations is that they are inbred and therefore contain close relatives. Removal of relatives can therefore bias the population sample. However, this can be justified if there is reason to believe that the population sample is not random. For example when mother-calf pairs are sampled together, sampling is not independent, so calves can be removed from such datasets.

3.1 Population structuring and migration rates

3.1.1 Revised Management Procedure

SC/65a/RMP03 summarises the genetic stock structure studies performed on North Atlantic fin whale. It presented a summary table including allozyme, microsatellite loci and mitochondrial DNA (mtDNA) and gave information on levels of structure observed. SC/65a/RMP03 emphasised the generally low levels of differentiation observed except at some allozyme loci. The allozyme results are then discussed in relation to a new manuscript (Olsen *et al.*, In press) suggesting that allozyme patterns at the two most informative loci (*MPI* and *MDH-1*) were not detected by DNA results. These new results suggested that the observed pattern at these loci may therefore not reflect genetic drift, migration or even selection at those loci. The results of the allozyme studies should consequently be interpreted with caution. SC/65a/RMP03 also presents additional work which has been done on estimates of numbers of migrants (gene flow) and relatedness analysis (logarithm of odds, or LOD score) and emphasised the need to develop these methods further in the absence of strong genetic differentiation. SC/65a/RMP03 noted that the development of new genetic markers, such as SNPs, might provide greater power to detect structure than do the existing markers. SC/65a/RMP03 also emphasises the need for more cooperative work and more effort to combine all data/samples available to get a better picture of the stock structure of North Atlantic fin whale.

In discussion, it was questioned whether there was any evidence in the results to suggest that animals were travelling in stable groups as they moved from area to area. The author noted that a pair of animals identified as a mother/son pair were sampled in close temporal and spatial proximity; however, the female of this pair was also identified as being related to another animal that was sampled further away (SC/65a/RMP01). Concordant with this, Daníelsdóttir (2006b) found allozyme differences between years; one plausible explanation for this finding was that animals were traveling together in groups. However it was also noted that Olsen *et al.* (In press) recently sequenced two of these allozyme loci and found no non-synonymous DNA substitutions (see IWC, 2013a, pp.238-39), suggesting that these allozymes are not informative about population structure in the way previously interpreted in Daníelsdóttir (2006b). If allozymes are not considered, the mitochondrial DNA and microsatellites are consistent in showing low genetic differentiation between management areas. In this regard it was observed that the use of recently developed methods such as ddRADseq (Peterson *et al.*, 2012) would allow sequencing of thousands of genetic loci, including both neutral loci and those under selection. Additional loci increase the potential for identifying diagnostic markers and would enable a broader range of questions to be addressed, particularly enabling better estimation of migration rates.

SC/65a/RMP03 emphasised the value of integrating available data and samples from North Atlantic fin whales, particularly in light of future efforts to develop new markers. In discussion, it was noted that data from different sources had been integrated for some previous papers (Daníelsdóttir, 2006a; Pampoulie *et al.*, 2008), and that efforts to collaborate were ongoing.

3.1.2 In-depth assessment

SC/65a/IA05 presented the results of microsatellite DNA analysis conducted on the North Pacific sei whale samples obtained from 2010-12 IWC-POWER. The samples came from the IWC-POWER cruises that surveyed 173°E-172°W area of the central North Pacific in 2010 (*n*=13), 170°W-150°W area of the central North Pacific in 2011 (*n*=29), and 150°W-135°W area of the eastern North Pacific in 2012 (*n*=35). All of the areas were north of 40°N. The POWER genetic data from 14 microsatellite loci was then analysed with previously reported genetic data from the JARPN II samples (*n*=489) collected from the western North Pacific between 143°E and 170°E in 2002-07 and the commercial whaling samples collected from the central North Pacific between 180° and 150°W in 1972-73 (*n*=57) and from the eastern North Pacific between 150°W and 139°W in 1973 (*n*=64). Analyses of these samples allowed the authors to detect temporal (40 years apart) and spatial (143°E to 135°W area divided into western, central, and eastern) genetic differences among the North Pacific sei whales. The results showed:

(1) very similar levels of genetic diversity among the POWER, JARPNII and commercial whaling samples;
(2) no evidence of genetic differences among the three POWER samples;
(3) no evidence of the temporal genetic differences between the recent POWER and past commercial whaling samples collected from the same area; and
(4) no evidence of spatial genetic differences among the western, central, and eastern samples.

This study supports authors' previous view that the open waters of the North Pacific were occupied by the individuals from a single stock of sei whales.

The SDWG thanked the authors for presenting this work, noting that the number of samples analysed was large and covered not only a large fraction of the North Pacific but also a large temporal scale (~40 years). This time span represents at least 2-3 generations and the fact that no differentiation over time or space was identified is important. On the other hand, a couple of potential limitations of the datasets and analyses were identified. First, it was pointed out that the microsatellite markers used in this study were developed for species other than sei whales, and that in some cases this can result in reduced data quality. Others, however, pointed out that use of non-species specific markers is widespread within the IWC, and that the Japanese laboratory has a strong record of producing high quality data. The second limitation is one that arises often in interpreting genetic data for cetaceans - the absence of information about breeding grounds, which means that samples are taken from potentially mixed aggregations of individuals from different stocks. This latter scenario complicates interpretation of results of statistical tests comparing samples from different spatial and temporal strata.

In response to a question, it was explained that this study did not include analysis of mtDNA data, although previous analyses (which did not include POWER samples) did not detect evidence of differentiation among North Pacific sei whales using mtDNA (Kanda *et al.*, 2009). The Working Group also asked whether differentiation between the JARPNII and 2012 POWER samples had been measured, as such a comparison was not reported in this paper. It was noted that while it is unlikely that differences would be identified given the results in SC/65a/IA05, these samples represent the most spatially segregated sample sets available from recent surveys and as such it might be of interest to conduct this comparison.

Discussion of these issues led to a more general discussion of the potential advantages of considerably boosting the number of genetic markers (e.g. by identification of large numbers of SNPs) to provide greater resolution in situations when levels of genetic differentiation, if any, are likely to be low and samples from putative breeding populations are not available (see Item 3).

The authors noted that no power analysis of the current dataset has been conducted. However, simulations have been used to test the power of a subset of this dataset to detect stock differentiation (Pastene *et al.*, 2009). These simulations indicated that if the magnitude of differentiation was similar to or even smaller than that observed between the J and O stocks of North Pacific minke whales, population structure could be detected using the current set of the microsatellite markers and sample sizes. It was noted however that since North Pacific sei whales inhabit the open ocean, the level of differentiation between any existing breeding stocks might still be lower than their simulations. The Working Group **recommended** that the power of the current dataset to detect subtle population structure be analysed. However they observed that without knowing how the analysed samples correspond to breeding populations, the results of such a power analysis must be interpreted with caution. For example, it is possible to have a situation in which two breeding stocks appear in the same proportions in all areas and all time periods over which the feeding ground has been sampled. In this case, no differentiation would be detected in any of the comparisons of samples collected on feeding grounds. Although this scenario is unlikely given the spatial and temporal coverage of the samples analysed in SC/65a/IA05, it illustrates the difficulty of assessing power given the sampling design.

The Working Group discussed the value of clustering analyses (e.g. STRUCTURE, which does not require *a priori* stratification of samples) to detect population structure within North Pacific sei whales. STRUCTURE was used in a previous study utilising the JARPNII samples; no structure was detected (Kanda *et al.*, 2009). The magnitude of the F_{ST} value reported in Kanda *et al.* (2009) was similar to that identified in SC/65a/IA05. It was noted that STRUCTURE has little power to detect clusters when F_{ST} values are low and structure is weak, but can at least be informative as to whether or not strong population structure exists. It was **recommended** that clustering analysis, using STRUCTURE or a similar approach, should be conducted with the current data set.

Relatedness analyses can provide insight into population structure in scenarios where low but meaningful levels of differentiation exist (reviewed in Palsbøll *et al.*, 2010) . These analyses can be informative even when only a small number of relatives are detected, and the number of available samples is expected to increase if the POWER surveys continue. The Working Group **recommended** that relatedness analysis be conducted in the future to provide insight into whether subtle structure exists among North Pacific sei whales.

3.1.3 Bowhead, right and gray whales

SC/65a/BRG16 and Appendix 2 both discuss genetic evidence for stock structuring of gray whales, so were presented together. Appendix 3 summarises the hypotheses laid out in both documents.

SC/65a/BRG16 reviews the issue of stock structure of North Pacific gray whales and the status of the western gray whale population. The authors present five stock structure hypotheses, which are not intended to be exhaustive of possible hypotheses but sufficient to frame a discussion of the issue. Because telemetry played such a key role in changing the previous view about seasonal migration habits and possible stock structure, additional tagging would have value in further evaluating these hypotheses. It was recommended that historic or ancient samples of the pre-depletion western gray whale be investigated to help determine if all or any of the animals that summer in the Sea of Okhotsk are descendants of the pre-depletion stock. It was also recommended that a more exhaustive survey of genetic variation to cover the extensive range of the eastern gray whales is necessary for an adequate understanding of the status of the Sea of Okhotsk population. Recommendations were also made to increase the number of mitochondrial genes studied and to change from microsatellites to SNPs for nuclear DNA studies. In this way, inter-laboratory comparisons are possible for nuclear loci and the methods could be applied to both historical and current samples. Finally it was recommended that a gray whale genome project be undertaken to provide the development of better analytical methods and a deeper understanding of gray whale biology.

Appendix 2 presented the results of nuclear microsatellite genetic comparisons between whales sampled off Sakhalin Island and Eastern North Pacific (ENP) whales sampled north of the Aleutians. Three stock structure hypotheses were put forward, and the results were evaluated in light of recently discovered movements of gray whales between Sakhalin Island and the ENP.

In discussion, it was observed that at least two major factors are at play when considering the population genetics and dynamics of the western gray whale. From a historical perspective, it is important to understand the evolutionary history and biogeography of the western gray whale, for the purpose of understanding population identity, and through this whether the feeding ground members are a historical ‘relict’ population (i.e. ancestors of the current feeding group used this feeding ground prior to exploitation), or are a result of recent immigration from the Eastern North Pacific. Ancient DNA analyses of western gray whale material could potentially resolve this question. It was noted that ancient DNA analyses of gray and bowhead whales from the Eastern North Pacific and North Atlantic suggest large scale changes in distribution possibly related to environmental changes in the past, indicating that feeding and breeding ground locations can be quite fluid (Alter *et al.*, 2012; Foote *et al.*, 2013). From a management perspective, genetics is applied to understand the current level of genetic and therefore demographic distinctiveness of the western gray whale from the Eastern North Pacific population in order to determine management decisions, regardless of the age or historical distinctiveness of the feeding aggregation in question. This is the principal objective of work carried out by the SDWG.

In discussion of Appendix 2, it was observed that even with the various stratifications of the dataset, significant differentiation continued to be observed when Sakhalin Island whales were compared with gray whales sampled north of the Aleutian Islands. It was further observed that the estimates of nuclear DNA diversity in each subsample were difficult to compare because they were not corrected for sample size. It would therefore be useful to see allelic richness values as well as confidence intervals for the point estimates of differentiation presented.

It was commented that nuclear DNA diversity in the Sakhalin Island whales is high, which would not necessarily be expected if the Sakhalin island whales were a true ‘relict’ population. However if the Sakhalin sample contains some animals that are migrating from the ENP, then those animals could increase the diversity identified in the Sakhalin stratum. It was further observed that many sub-structured baleen whale populations have high genetic diversity despite clear evidence of recent population bottlenecks (e.g. humpback whales, bowhead whales) and that current levels of bowhead diversity are similar to the levels reported here (Givens *et al.*, 2010; Morin *et al.*, 2012). In this regard, the high diversity may be because the Sakhalin animals are a mixture of whales from eastern and western wintering grounds. There is no direct evidence from tagging that Sakhalin animals travel south towards China (a putative wintering ground). However indirect evidence is available, as one of the animals observed off Japan was first identified as a calf off Sakhalin (Weller *et al.*, 2008).

Some suggestions were made for intersessional analyses of the data presented in Appendix 2. It was **recommended** that these analyses be repeated for each sex to see whether there were any sex-specific differences in F_{ST} values. It would be useful as previous analyses by sex (Lang, 2010) for a subset of these data suggested mainly male mediated gene flow between Sakhalin Island and the Eastern North Pacific. It was also **recommended** to measure F_{IS} for each locus. It was also noted that if a good demographic model can be obtained for this species, it would be possible to use the number of pairs of related individuals to infer migration rates (Peery *et al.*, 2008). A further analysis of interest would be to derive the genotypes of the 'missing fathers' from the genotypes of the mother-calf pairs. This would allow calculation of allele frequencies of the missing fathers, which could then be compared to the other gray whale strata (Sakhalin and Eastern North Pacific) to determine paternal similarity. It was also observed that kinship reconstruction would be possible if more markers were generated.

Given that there is weak evidence for departures from Hardy-Weinberg and linkage equilibrium in Appendix 2, Table 4, the approach outlined in Waples (2011) was also **recommended** for measuring the degree of population sub-structuring at Sakhalin Island. Waples (2011) observed that the magnitude of the Wahlund effect in population mixtures is expected to be highest at loci which differ the most between the two (or more) contributing populations. Specifically, F_{IS} at individual gene loci in the mixture should be proportional to F_{ST} between the contributing populations, and r^2 (an index of linkage disequilibrium) for a pair of loci in the mixture should be proportional to the product of F_{ST} at the two loci. This implies an expected linear correlation between F_{IS} and F_{ST} at single loci and between r^2 and $F_{ST}(1) * F_{ST}(2)$ at pairs of loci. It was noted that among the tests for Hardy-Weinberg equilibrium, the significant *p*-values were only marginally significant, so the current evidence for a Wahlund effect appears to be weak. It was also observed that for any analysis that requires the *a priori* determination of allele frequencies per population, this would be difficult or impossible in the case of the 'western Pacific population' since the relevant individuals cannot be independently identified, i.e. the identity of the population is unknown. However, in order to better understand the structuring of the Sakhalin feeding ground relative to the Eastern North Pacific gray whales the SDWG **agreed** that it would be useful to conduct this test using the stratifications described in Appendix 2. The authors agreed to conduct an update of this analysis considering the suggestions above and to present this new information to IWC SC/65b.

It was noted that if the whales utilising the Sakhalin feeding ground include a mixture of whales that breed in the WNP and in the ENP, then evidence for the Wahlund effect should be detected. However, the Wahlund effect disappears in a single generation of random mating, and so no signature would be detected if only offspring of ENP and WNP whales were sampled. Single locus tests of Hardy Weinberg equilibrium would however be expected to detect admixture if the sample set included parent ENP and WNP whales and their offspring. Given this scenario, the approach outlined in Waples (2011) would be expected to detect residual admixture disequilibrium for two to four generations. In addition, if new ENP animals are immigrating to the Sakhalin feeding ground over multiple years and generations, the Wahlund effect could be observed in each generation. By comparing the one-locus test and two-locus test it might be possible to discriminate between a scenario involving mixing of ENP and WNP whales on the feeding ground but no interbreeding and a scenario in which interbreeding of ENP and WNP whales occurs by comparing the results of these two methods.

It was also suggested that it would be useful to consider whether a type of Allendorf-Phelps effect (Waples, 1998) could be contributing to the observed levels of differentiation between ENP and WNP samples. The Allendorf-Phelps effect is related to the better-recognised founder effect, but it does not require any permanent population subdivision; it arises when progeny of a local breeding event involving a small number of parents are sampled before they become mixed with the larger population. Examples of how a combination of AP and founder effects could generate levels of differentiation consistent with those seen among whales in the ENP and WNP are provided in Appendix 4. While the examples discussed utilised nuclear DNA, it was noted that the same process could be measured in mitochondrial DNA with some modifications to the formulas used. While the examples shown in Appendix 4 suggest that it is plausible that this effect could be generating the levels of divergence seen between whales in the ENP and WNP, this is not the only scenario in which the observed differentiation could arise. Therefore a positive result may not necessarily mean this process is the underlying mechanism, but consideration of the potential role of AP/founder events could provide a useful context for interpreting empirical data. It was noted that these examples do not incorporate overlapping generations or age structure in the population, and more detailed hypothesis testing could be complicated. The main take-home message from the simple examples in the Appendix is that it is relatively easy to generate the levels of divergence observed between WNP and ENP samples, using various combinations of small numbers of individuals and one or a few generations of recent isolation. It was noted that it might be easier to prove that this effect was not the primary process creating the observed differentiation using information on movements of animals or parent-offspring relationships between individuals.

It was noted that this method is not informative with respect to evaluating the plausibility of hypotheses that assume that some of the whales sampled off Sakhalin are a remnant of the pre-exploitation population of western North Pacific gray whales. However, it could be informative with respect to evaluating the demographic processes currently influencing stock structure in gray whales.

A novel approach was also proposed for distinguishing between gray whales that feed near Sakhalin Island or the ENP, using biopsy samples to identify the micro flora living on whale skin, using meta-genomic sequencing of the *16S* locus (Caporasoa *et al.*, 2011).

It was noted that the synthetic likelihood approach described in Wood (2010) could be useful in discriminating between stock structure hypotheses. This approach proposes a method to estimate parameters in scenarios where it is difficult or impossible to calculate the true likelihood. This approach uses simulations from which a large number of statistics of interest can be calculated. Observed values of these statistics can then be compared to the distribution generated from the simulations to evaluate the likelihood, given the specific parameters and hypothesis used. It was noted that this type of approach might be valuable when complicated overlapping hypotheses exist and where the effects on any one statistic are difficult to tease out. As such, this approach might be of general interest to the Scientific Committee, where there are often many hypotheses to discriminate between. Lang and Gaggiotti offered to investigate this approach further and report back to the SDWG at SC/65b.

Weller *et al.* (2013) reports on a workshop held by the US National Marine Fisheries Service (NMFS) to assess gray whale stock structure. Currently a single stock of gray whales, the eastern North Pacific stock, is recognised in US waters. More recently, however, new information has suggested the possibility of recognising two additional stocks in US waters:

(1) the Pacific Coast Feeding Group (PCFG); and
(2) the western North Pacific (WNP) stock.

To assess this possibility, NMFS established a scientific Task Force comprised of eight NMFS scientists with expertise in fields relevant to stock structure assessment. The objective of the Task Force was to provide an objective scientific evaluation of gray whale stock structure as defined under the US Marine Mammal Protection Act (MMPA) and implemented through the NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS, 2005). The Task Force reviewed new information relevant to gray whale stock structure, including the results of genetic, photo-identification, tagging, and other studies. The Task Force agreed on a series of questions relevant to evaluating if the PCFG and/or the WNP gray whales qualify as stocks under the MMPA and the GAMMS guidelines. A structure decision-making process was used whereby Task Force members allocated likelihood points to categories reflecting their certainty as to how well each question could be answered given the currently available scientific evidence. The Task Force concluded that there was substantial uncertainty regarding whether the PCFG represents a separate stock under the MMPA and GAMMS guidelines and was unable to provide definitive advice as to whether the PCFG is a population stock under the MMPA and the GAMMS guidelines. The Task Force did, however, provide unambiguous advice that the WNP stock should be recognised as a population stock under the MMPA and the GAMMS guidelines. The Task Force provided recommendations for future work, including the continuation of field studies as well as additional analysis of the existing photo-identification and genetic data.

In discussion, it was noted that the use of likelihood point allocation to measure support for stock structure hypotheses could be biased by strong certainty on the part of a minority of Task Force members, and that there could be future value in including scientists with no prior involvement in the research findings that were being assessed. It would also be valuable to explore other methods of compiling the scores of expert panels, such as that used for Olympic diving, where the highest and lowest score are removed before averaging the score of the rest of the panel. This would help alleviate concerns that the scores of potentially biased or invested individuals could dictate the interpretation of a collective group opinion.

3.1.4 Icelandic Special Permit Research Program

The following two papers were presented to the SDWG following discussions at the Expert Workshop to Review the Icelandic Special Permit Research Program (Marine Research Institute, Reykjavik, 18-22 February 2013, see SC/65a/Rep03).

SC/65a/SD02 is a paper requested by the Expert Workshop, and is an integrated paper incorporating information from genetics, morphometry, telemetry, biological parameters, stable isotopes, fatty acids and pollutants (recommendation 12.1.2 (1) of the report of the Expert Workshop: Produce a fully integrated paper incorporating the information from genetics, morphometrics, telemetry, biological parameters, stable isotopes, fatty acids and pollutants). This multidisciplinary approach is based on Annex D of the Report of the Expert Workshop to Review the Icelandic Special Permit Research Programme, presenting the summary of potential indicators of structure developed by proponents during the workshop. While the genetic studies performed during the Icelandic Scientific Permit did not reveal any genetic pattern, which should be of concern for the IWC (evident lack of genetic differentiation), other biological information suggested that stock structure might exist among the IWC stock boundaries, and that, in addition, some subtle structure might exist on breeding grounds.

The SDWG thanked the authors for presenting this commendable compilation of data, which addresses a specific recommendation of the Expert Workshop. In particular, the value of Annex 1 (a summary of potential indicators of structure, with priority rankings) was highlighted as it is a useful summary of the various datasets available and represents an important first step. The next step is to use these data to decide what information should be given more importance or is most relevant to stock structure questions. It was noted that the compilation suggests that there is biological heterogeneity within the feeding ground, but the underlying processes creating these differences are currently unknown. Interpretation of indicators is also complicated by limited knowledge of the timescale over which most are informative, and therefore how they relate to migration and unidentified seasonal wintering grounds. Caution is therefore advised in interpreting these data in the context of those processes.

Some specific comments were raised during discussion of the various indicators. The SDWG noted that it is hard to interpret information from diet composition, isotopes and fatty acids in a stock structure context. The turnover time for both isotopes and fatty acids is variable and can be of short duration (e.g. Caut *et al.*, 2010). While the available evidence suggests that minke whales eat little if anything during winter, it is not known for sure if they fast. There are indications, however, that minke whales may accumulate less fat reserves during summer than do other baleen whales (SC/65a/SP01, SC/65a/Rep03), raising the possibility that they may not be as extreme in fasting as some baleen whales are. If this is the case, then some of the indicators which pertain to diet (i.e. diet composition, isotopes, fatty acids) may be useful for discerning wintering ground differences if collected just after arrival on feeding grounds.

The SDWG noted that it is hard to interpret information from isotopes and fatty acids in a stock structure context, since the turnover time for both of these indicators is unknown. While the available evidence suggests that minke whales eat little if anything during winter, it is not known for sure if they fast. There are indications, however, that minke whales may accumulate less fat reserves during summer than do other baleen whales (SC/65a/SP01, SC/65a/Rep03), raising the possibility that they may not be as extreme in fasting as some baleen whales are. If this is the case, then some of the indicators which pertain to diet (i.e. diet composition, isotopes, fatty acids) may be useful for discerning wintering ground differences if collected just after arrival on feeding grounds.

Telemetry data seems to suggest autumn movements south towards a wintering ground, with signals received from one whale off the west coast of Africa in early December. Efforts were made to collect biopsy samples from tagged animals but they were unsuccessful. It was noted that the analysis of organic contaminants (e.g. Auðunsson and Víkingsson, 2013-rev) used several different markers and different tissue types to compare different areas, resulting in a large number of pairwise comparisons. In such circumstances the likelihood of a significant result occurring by chance is moderate, so it was suggested that a correction for multiple tests be applied. The authors noted that this had been discussed during the Expert Workshop, and that a revised analysis was planned. It was also questioned whether any sex differences in the organic pollutant levels and trace element signatures were observed in the study. It was noted that differences between the sexes are known to exist for other baleen whales, for example some females have lower contaminant levels due to the offloading of pollutants in their milk during nursing (e.g. Aguilar *et al.*, 1999). No further differences were identified, although it was noted that samples sizes were small after subdividing by sex.

A question was raised as to whether it would be possible to look at the genetic patterns among parasites to provide more information on stock structure. Given that the life cycle of parasites is so much shorter than of whales, patterns could be amplified among the parasites. This approach has been successfully used in baleen whales before (e.g. right whales, Kaliszewska *et al.*, 2005). It was noted that this approach usually requires dead whales, but that this was a possibility worth looking into.

Anderwald *et al*. (2011) is a published paper that was made available for the Icelandic Special Permit Expert Review Workshop as SC/F13/SP16 because it discusses stock structuring of minke whales in the North Atlantic.

Anderwald *et al*. (2011) investigated minke whale stock structuring using nuclear microsatellites and 300 samples from 8 locations in the North Atlantic (NA) and 1 from the Sea of Japan. No clear signal was found in the NA using the clustering program STRUCTURE (K=1), however analysis of the NA dataset together with Japan identified K=3, indicating two clusters in the NA. Although the authors acknowledge that K=1 in the NA is the best supported result from STRUCTURE, the features of these two clusters ('putative breeding stocks'; PBS1 and PBS2) were nevertheless thoroughly assessed to test the null hypothesis that K=1 (not to confirm the apparent differentiation indicated in STRUCTURE when K=3). These tests concerned independent data on the shape of ordination clusters, the possibility that previous (published) indications of structure instead reflected differential mixing of two stocks in different locations, and consistency with mtDNA (for structure, diversity and population history). For example, both microsatellite and mtDNA data showed lower diversity in PBS1 and population splitting and expansion just after the last glacial maximum (LGM). None of the tests were fully consistent with K=1. The authors concluded that although STRUCTURE finds no clear signal for multiple stocks in the NA, their further analyses suggest that more research is needed to investigate possible cryptic structure, and at present cannot support a hypothesis of panmixia. Anderwald *et al*. (2011) suggested the need for a study with greater power (using e.g. 4,000-5,000 SNP loci), preferably in combination with satellite telemetry.

Anderwald *et al*. (2011) is a published paper but was discussed in SC/65a/Rep03 because it was included in the material available to the Review on Stock Structure. Comments on this paper are given in SC/65a/Rep03. The Panel noted that the analyses of nuclear genetic data that followed the partitioning of the samples based on results from STRUCTURE suffered from problems of circularity because the same data were used to both partition the samples and then test the resulting groups for differences. It was noted that there needs to be evidence that analyses based on data from a panmictic population do not produce comparable results when analysed similarly.

The corresponding author does not agree that the same data were used to both partition the samples and then test the resulting groups for differences, and offered the following comments:

The report raises three issues: (1) the way STRUCTURE was used; (2) the need for simulation tests; and (3) problems associated with circularity. The report is of course accurate about the use of STRUCTURE, but this was fully acknowledged in the paper and the strategy clearly described. As reported in the paper, the best estimate from STRUCTURE for the North Atlantic (NA) is for K=1. The authors explored the putative partitioning in the NA from STRUCTURE when K=3 to further test the hypothesis that K=1. With respect to simulation studies, Palsbøll had undertaken preliminary simulations that showed that STRUCTURE could generate subsamples from a single panmictic population that were differentiated when compared by F_{ST}. It would in any case be circular to simply use the same genetic data for differentiation from STRUCTURE to test for differentiation by some other test, and this was never the intention. The authors therefore devised tests to test predictions associated with K=1. For example, if K=1 they expected a single factorial component analysis (FCA) cluster, with the two putative populations representing different overlapping portions of that cluster ('2 halves of a ball'). If K=1 there should be no useful inference from comparing the relative proportions of the two putative stocks in different geographic regions, in the context of earlier indications of stock structure. Since the mtDNA genome is not expected to hitchhike on the nuclear genome in this species, if K=1 there should be no correlation between apparent differentiation based on microsatellite loci and differentiation at mtDNA loci. The process by which STRUCTURE separated these groups, where F_{ST} was significant, could in theory affect the analysis in IMa. While this should be small compared to what was observed (since any subsamples from a single panmictic population will share the same coalescent history), the key inference from this analysis was again related to the comparison with mtDNA results. From the microsatellite data PBS1 was less diverse and the apparent splitting time between PBS1 and PBS2 was around the time of the LGM. From mtDNA the inference was the same, with PBS1 less diverse and an expansion signal for just after the LGM. Since none of these tests were consistent with the null hypothesis of K=1, the authors suggest the possibility of cryptic structure. The degree to which these tests are robust varies, and none were individually very strong (the strength of inference related more to the congruence among them), but the author disagreed that they represent a circular analysis of the genetic data. Each depends on independent data (mtDNA, previous publications on stock structure, an assessment of the shape of ordination clusters, etc.), not the original genetic data to test predictions about what would be expected if the STRUCTURE result was an artefact. Since all showed some indication that the structure may be real, the authors felt the implication was strong enough to require further investigation, and this was their specific recommendation.

In discussion, the SDWG **recommended** some further analyses of the North Atlantic minke whale data to help resolve the uncertainty:

- conduct clustering analysis with a set of new, independently segregating markers to see whether the same groups of individuals are identified with the new dataset;
- complete simulations (already in progress) of panmictic populations using STRUCTURE, setting K=2; and
- try discriminant analysis of principal components as an alternative way of identifying structure within the dataset (Jombart *et al.*, 2010).

The authors **agreed** to try the above intersessionally and further noted that they were planning a SNP analysis of these samples, which would increase the number of available markers and thereby increase the resolution for identifying populations within a mixed assemblage. It was also noted that more regional samples are now available to add further geographical resolution to this dataset.

3.2 Population assignment and mixing

3.2.1 Other Southern Hemisphere whale stocks

SC/65a/SH13 presented the results of a mtDNA analysis of 575 humpback whales obtained in the Antarctic during surveys of the JARPA/JARPA II and IDCR/SOWER, and 1,057 whales from low latitude localities of the South Pacific and eastern Indian Ocean. The analysis was carried out in response to a recommendation from the IWC Scientific Committee in 2012 to calculate mixing proportion of breeding stocks D, E and F in the Antarctic feeding grounds of Areas IIIE, IV, V and VI. Genetic samples from breeding grounds were obtained mainly by biopsy sampling but also from sloughed skin and beachcast whales: Western Australia (WA, n=167, 1990-2002; n=185, 2007), Eastern Australia (Eden, Tasmania) (EA, n=104), New Caledonia (NC, n=243), Tonga (TG, n=240), Cook Islands (CI, n=56) and French Polynesia (FP, n=62). In the Antarctic feeding grounds, samples were obtained by biopsy sampling: Areas IIIE (n=106), IV (n=231), V (n=171) and VI (n=67). Genetic samples of both data sets were examined for approximately the first half of the mtDNA control region. Duplicated samples were excluded from the analysis. In the case of mother/calf pairs only one sequence was used. Sequences from both data sets were aligned to produce a single data set comprising 137 haplotypes. Two kinds of analyses were conducted: mixing proportion and F_{ST} under two stock structure hypotheses (six stocks and four stocks as baseline samples for the stocks proportion analysis). In general results were consistent with the geography. Under the six-stock hypothesis, the largest proportion in Area IIIE was of the WA stock. The largest proportion in Areas IVW and IVE was of the WA stock. The largest proportion in Area VW was of the EA stock. The largest proportion in Area VE was of the NC stock. The stock with the largest proportion in Area VI was the TG stock. None of the Antarctic Areas investigated was represented by whales of the FP and CI stocks, or just with a limited representation in Area VI (case of the CI stock). In general results of the mixing proportion analysis were consistent with the results of the F_{ST}, with a few exceptions.

In SC/65a/SH13, breeding ground samples are grouped into strata for analysis based on two stock structure hypotheses chosen from fig. 6 of IWC (2011): one medium plausibility and one high plausibility. This work is an update of Pastene *et al.* (2011), last discussed in IWC (2013a, p.236).

In discussion, the Working Group suggested that additional stock structure hypotheses would be worth exploring. These stock structure hypotheses will be discussed further in the sub-committee on other Southern Hemisphere whale stocks (Annex H of this volume). It was also observed that in the mixture proportion analysis, the French Polynesia breeding ground was not estimated to contribute substantially to any of the Antarctic feeding areas analysed. The SDWG **agreed** that additional biopsy sampling in Area I and eastern Area VI would provide more insight into where the whales that breed off French Polynesia are feeding.

3.2.2 Revised Management Procedure

3.2.2.1 NORTH ATLANTIC FIN WHALES

SC/65a/RMP01 presents a new method for genetic relatedness analysis based on a three-step procedure. First LOD scores were computed for three kinds of relationships (Half-siblings, Parent-offspring, and First cousin), then p-values were estimated and finally a False Discovery Rate (FDR) procedure was applied. Using this relatedness analysis based on the likelihood odds score (LOD) and false discovery rate (FDR) methods, SC/65a/RMP01 found relationships among 15 individuals caught in 2009 and 2010 in Icelandic waters (out of the 34,959 pairs comparisons), exhibiting different types of relationship, from grandparent to grandchild, to parent and offspring and half-sibling. One female was found to be related to two other animals. This female was the mother of a male and half-sibling with another female. SC/65a/RMP01 also suggested that this new three-step procedure supported by p-values should be applicable to stock structure issues raised by the IWC, in terms of different levels of relationships observed among IWC 'stock boundaries'.

In response to a query about possible genotyping errors, the authors noted that they had amplified all genotypes three times. All loci that showed mismatches were excluded, and only individuals with complete genotypes were used in the analysis. Because of this, the analysis was assumed to contain no genotyping errors. It was noted that the resolving power to detect relationships is limited by the number of loci used in the study (15 microsatellites), giving a false discovery rate of 10%. Therefore age was used as an additional consistency check, to evaluate whether the relationships most strongly supported by LOD scores are biologically feasible. Increasing the number of loci utilised in the study would allow errors to be more easily detected and would provide greater resolution to discriminate between relationships. It was commented that it is possible to distinguish between half-siblings and other relations using genetic evidence (Epstein *et al.*, 2000), although this would require many additional loci.

SC/65a/RMP01 utilised simulations to estimate p-values associated with each LOD score. This process involved simulating individuals by drawing alleles independently with replacement from a gene pool with the same allele frequencies as the empirical dataset. It was noted that this process is equivalent to simulating a population with an infinite effective population size, while in real populations the finite effective size creates linkage disequilibrium and random departures from Hardy Weinberg equilibrium. It seems possible that this might lead to high LOD scores as a consequence of finite effective size rather than relatedness. The potential effects of this assumption on the estimation of *p*-values for each LOD score should be explored. In the context of this study, the authors noted that another implementation based on the work of Skaug *et al.* (2010) has been performed on these data and supported the same sets of pairs as those identified in this study, suggesting that assumptions about effective size have not influenced the current results.

4. TOSSM (TESTING OF SPATIAL STRUCTURE MODELS)

No new items were presented on this topic during SC/65a. The SDWG noted that last year some long-term TOSSM work was suggested for the Pacific Coast Feeding Group (PCFG) of gray whales (IWC, 2013a, p.239). Some of this work is in progress. Weller *et al.* (2013) also made a recommendation for additional TOSSM simulations to be conducted to further explore plausible levels of immigration into the PCFG. The SDWG looks forward to seeing further progress on these TOSSM recommendations at SC/65b.

5. TERMINOLOGY AND THE UNIT-TO-CONSERVE

The SDWG discussed a series of tentative definitions of stock related terms, which are intended to be a useful reference point for the Scientific Committee (see Appendix 5). This document has been developed with the aim of encouraging consistent use of stock related terms within Scientific Committee reports and in papers submitted to the Scientific Committee. Once these definitions have been agreed by the Scientific Committee, the SDWG would like to make this set of definitions available by web-link both on the IWC website and to have them referred to in future calls for papers made by the IWC Scientific Committee.

It was noted that in reality, biological structure often exists along a continuum and it is challenging to identify distinct breakpoints along that continuum to define what units are important to conservation and management, both in terms of temporal and spatial breakpoints. Some members suggested that one way of better representing this problem spatially may be to use the term 'deme', a commonly used identifier in population biology. A definition of this, and how it relates to other stock related terms, is provided in Appendix 5. This concept is unlikely to rapidly spread outside the SDWG to the rest of the Scientific Committee, but in our discussions it may provide a useful language bridge between IWC work (as discussed by the SDWG) and the field of population biology. Additional work was identified to better develop the scope of the definitions laid out in Appendix 5 (see work plan Item 7.3).

6. OTHER ISSUES

The SDWG noted that with the rapid recent developments in NGS technology and analysis, there are a number of emerging issues of relevance to the Scientific Committee, in terms of: (1) assessment of NGS data quality, and how best to curate such data; and (2) new methods for measuring stock structuring and measurement of other statistical quantities of interest to the SDWG (such as inbreeding) using NGS data. New and published papers were therefore solicited on these topics for discussion at SC/65b, where they will be discussed and considered in the context of the existing guideline documents on DNA analysis and quality.

7. WORK PLAN

7.1 Genetic analysis guidelines

The genetic analysis guidelines are anticipated to be completed intersessionally (convened under Waples) and will be ready to circulate within the Scientific Committee by the end of 2013.

7.2 Gray whale stock structure

An intersessional email group was formed with the sub-committee on bowhead, right and gray whales to develop hypotheses of western gray whale stock structure, convened under Lang. Members are Bickham, Scordino, Hoelzel, Rosenbaum, Mate, Jackson, Baker, Broker, Urbán, Dupont, Brownell, Litovka, Reeves, Tyurneva and Waples.

The terms of reference are:

(1) to agree a series of hypotheses of gray whale stock structure, with a focus on evaluating the stock identity of the whales feeding off Sakhalin;
(2) to decide on the plausibility of hypotheses based on available data; and
(3) to discuss tests and methods to discriminate between the agreed hypotheses.

Results from this exercise will be reported at an intersessional Workshop (see Annex F) to assess the population structure and status of North Pacific gray whales.

Additionally, Lang and Gaggiotti have agreed to investigate the utility of synthetic likelihood methods as a means of better discriminating competing stock structure hypotheses and will report back to the SDWG in 2014.

7.3 Stock definition terminology

An intersessional email group was formed to decide appropriate stock definitions (using the terms laid out in Appendix 5), with reference to available data, for an example set of cetacean populations that have been the focus of Scientific Committee discussions over the last five years. Results from this exercise will be presented in SC/65b. The group was convened under Jackson and included Lang, Scordino, Pampoulie, Kanda, Double, Hoelzel, Cipriano, Waples, Palsbøll, Tiedemann, Bickham and Baker.

8. ADOPTION OF REPORT

This report was adopted at 19:30 on 12 June 2013.

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Appendix 1

AGENDA

1. Introductory items
   - 1.1 Convenor's opening remarks
   - 1.2 Election of Chair and appointment of rapporteurs
   - 1.3 Adoption of Agenda
   - 1.4 Review of documents
2. Guidelines for genetic studies and DNA data quality
   - 2.1 Genetic data analysis guidelines document
   - 2.2 Genetic data quality review
3. Statistical and genetic issues relating to stock definition
   - 3.1 Population structuring and migration rates
     - 3.1.1 Revised Management Procedure
     - 3.1.2 In-depth assessment
     - 3.1.3 Bowhead, right and gray whales
     - 3.1.4 Icelandic Special Permit research programme
   - 3.2 Population assignment and mixing
     - 3.2.1 Other Southern Hemisphere whale stocks
     - 3.2.2 Revised Management Procedure
4. TOSSM
5. Terminology and unit-to-conserve
6. Other issues
7. Work plan

Appendix 2

ADDITIONAL ANALYSES ON THE POPULATION STRUCTURE OF GRAY WHALES, WITH A FOCUS ON THE GRAY WHALES MOVING BETWEEN SAKHALIN ISLAND, RUSSIA AND THE EASTERN NORTH PACIFIC

A.R. Lang

Genetic comparisons have identified significant differences in mtDNA haplotype and microsatellite allele frequencies between the Sakhalin whales and eastern North Pacific (ENP) whales that feed north of the Aleutians (Lang *et al.*, 2011). In light of recent information demonstrating the movements of some Sakhalin whales to the ENP, these genetic differences need further examination. Differences in mtDNA haplotype frequencies, in combination with reduced haplotype diversity identified among whales feeding off Sakhalin, indicate matrilineal fidelity to this feeding area. This is consistent with observations of the return of whales first identified as calves to the Sakhalin feeding ground. These mtDNA differences could develop whether the animals feeding off Sakhalin include only whales which overwinter in the ENP or if whales feeding off Sakhalin consist of a mix of whales which overwinter in the ENP and whales that overwinter in the western North Pacific (WNP). Irrespective of the wintering origin of these whales, mtDNA differences support the demographic distinctness of the Sakhalin feeding ground whales. These results are consistent with results of a recent population assessment indicating little or no immigration into Sakhalin in recent years SC/65a/BRG27.

However, the mechanism driving the observed nuclear DNA (nDNA) differences is less clear. Although other explanations exist, here three potential hypotheses that could create nDNA differences among the animals feeding off Sakhalin and those feeding in the ENP are discussed.

(1) The Sakhalin feeding ground is utilised by a mix of whales that overwinter in the ENP and whales that overwinter in the WNP. Whales that overwinter in the ENP are randomly mating with ENP whales feeding in other areas. The nDNA signal is generated by interbreeding among whales remaining in the WNP year-round.
(2) The Sakhalin feeding ground is utilised largely or exclusively by whales that overwinter in the ENP. Much of the breeding for this group of animals occurs early in the migration when the whales are still west of the bulk of the ENP population; this interbreeding is generating the nDNA signal.
(3) The Sakhalin feeding ground is utilised largely by whales that overwinter in the ENP and mate randomly with ENP whales feeding in other areas. The nDNA signal is created by the high levels of maternal relatedness among the animals feeding off Sakhalin.

Currently, genetic data (sex, mtDNA control region sequences, and genotypes for 12 microsatellite loci) are available for 142 gray whales sampled while feeding off Sakhalin between 1995 and 2007. These samples include 83% of all gray whales photographically identified off Sakhalin during this time period. Twenty-two of the Sakhalin gray whales that have been recorded in the ENP are included in this genetic dataset. Here we stratify the Sakhalin dataset with respect to the animals that have been recorded in the ENP and re-analyse the genetic data. Results are evaluated in light of the previously stated hypotheses.

Methods

All data was generated as part of earlier comparisons; sample collection methods, laboratory processing, and analytical methods are described in Lang *et al.* (2011). The strata utilised in the comparisons below include:

(1) Sakhalin (n=142): This stratum includes all whales sampled on the Sakhalin feeding ground (1995-2007).
(2) Sakhalin – no ENP migrants (n=108): This stratum is identical to the previously described stratum (#1) except that all of the Sakhalin whales that have been recorded in the ENP have been removed. In addition, whales that have been photographically identified (and genetically confirmed) as the mothers, calves, or maternal half-siblings of those whales recorded in the ENP have also been removed.

(3) Sakhalin-ENP migrants (*n*=22): This stratum includes Sakhalin whales that have been recorded in the ENP.
(4) Sakhalin – no relatives (*n*=84): This stratum is identical to the first stratum (no. 1) except that in cases where both individuals of a photographically identified (and genetically confirmed) cow-calf pair were sampled, the calf has been removed from the dataset.
(5) North (*n*=110): This stratum includes all whales sampled north of the Aleutians; the majority of these samples were collected as part of the aboriginal harvest off Chukotka, Russia.

Results and discussion

Limitations exist with respect to the analyses presented here. First, sample sizes representing the Sakhalin-ENP migrant group are small and likely do not represent all of the animals feeding off Sakhalin that travel to the ENP during winter. Similarly, although maternal relatives identified photographically (e.g. based on identified mother-calf pairs) were removed from either stratum prior to analyses, it is likely that additional maternal relatives of the Sakhalin-ENP migrants exist among the animals remaining in the Sakhalin dataset. These limitations need to be kept in mind when interpreting the results presented here.

Examination of the haplotypes carried by the Sakhalin-ENP migrants did not reveal a clear pattern. While some Sakhalin-ENP migrants carried haplotypes that are rare among Sakhalin whales, others carried the two very common haplotypes found off Sakhalin (Table 4). However, one of those two haplotypes is also common among ENP whales, and the other is found among a moderate number of ENP whales. Haplotypes carried by the Sakhalin-ENP migrants were dispersed throughout the median joining tree, and no pattern was evident (Fig. 1).

Mixing of whales that overwinter in the ENP and the WNP on the Sakhalin feeding ground would be supported by a finding of Hardy-Weinberg (HW) disequilibrium among whales sampled off Sakhalin. Although one locus was out of HW equilibrium in the Sakhalin stratum, this was similar to the results in the North stratum (Table 3). However, the power of HW tests to detect admixture is relatively low and thus these results are not necessarily informative with respect to discriminating between the first and second hypotheses.

Under hypothesis 1, the Sakhalin-ENP migrants would be expected to be more similar to ENP whales than to Sakhalin whales that remain in the WNP year-round. In contrast, the Sakhalin-ENP migrants were generally more similar to the remaining animals sampled off Sakhalin than they were to the animals in the North stratum (Tables 3 and 7). As aforementioned, however, it is plausible that some of the whales remaining in the Sakhalin stratum could be maternally related to the Sakhalin-ENP migrants, which would reduce differentiation between these groups. As such, the results of this comparison are difficult to interpret.

Table 1

MtDNA diversity summary statistics.

Strata	*n*	No. of haplotypes	Haplotype diversity	Nucleotide diversity (%)
Sakhalin	142	22	0.77	1.57
Sakhalin - no ENP migrants	108	18	0.77	1.62
Sakhalin - ENP migrants	22	8	0.81	1.11
Sakhalin - relatives removed	84	22	0.82	1.45
North	107	33	0.95	0.84

Table 2

Results of mtDNA comparisons.

Comparison	F_{ST}	*p*-value	χ^2 *p*-value
Sakhalin (*n*=142) *vs* North (*n*=107)	0.085	<0.001	<0.001
Sakhalin - no ENP migrants (*n*=108) *vs* North (*n*=107)	0.084	<0.001	<0.001
Sakhalin - ENP migrants (*n*=22) *vs* North (*n*=107)	0.065	<0.001	0.009
Sakhalin - no ENP migrants (*n*=108) *vs* Sakhalin - ENP migrants (*n*=22)	0.031	0.062	0.008
Sakhalin - no known relatives (*n*=84) *vs* North (*n*=107)	0.058	<0.001	<0.001

Table 3

Results of Hardy-Weinberg comparisons for heterozygote deficits.

	HWE *p*-value (prob test)	
Locus	Sakhalin	North
EV14t	0.1107	0.2395
EV37	0.9697	0.1608
EV94t	0.7404	0.0988
Gata028t	0.8035	0.6708
Gata098	0.4934	0.3994
GATA417t	0.823	0.5242
GT023t	0.3174	0.1864
RW31t	0.858	0.0186
RW48t	0.021	0.371
SW10t	0.7549	0.4233
SW13t	0.7294	0.6783
SW19t	0.9144	0.0877

Table 4

MtDNA haplotype frequencies.

HapID	North	Sakhalin	Sakhalin - no ENP migrants	Sakhalin - ENP migrants
1	**10**	**51**	**36**	**9**
2	**4**	**44**	**37**	**3**
3	15	9	9	
4	**5**	**5**	**2**	**3**
5	1	3	3	
6		1	1	
7	7	2	2	
8	**1**	**2**		**2**
9	**1**	**1**		**1**
10		**1**		**1**
11	3			
12	5	1	1	
13	6	2	2	
14	1	1	1	
15	2			
16	1			
17	1	1	1	
18	3			
20	6	1	1	
21	2			
22	1	1	1	
23	5			
24	2			
25	6	1	1	
26	**2**	**1**		**1**
28	2	3	3	
29	3			
31	1			
33	5	1	1	
35	**1**	**7**	**3**	**2**
36	1			
38	1	3	3	
40	1			
42	1			
43	1			
Total	107	142	108	22

Table 5

Number of significant (p<0.05) comparisons in the linkage disequilibrium test (total comparisons n=66).

Strata	Number of significant comparisons
North	3
Sakhalin	9
Sakhalin – no ENP migrants	5
Sakhalin – no known relatives	5

The number of pairs of loci in linkage disequilibrium (LD) was markedly higher among whales sampled off Sakhalin than it was among the North stratum (Table 5). When known relatives were removed from the comparisons, the number of pairs of loci in LD was reduced. The significant nDNA differences between Sakhalin and the North stratum remained after removal of known relatives, although the magnitude of differentiation was less (Table 7). While the lower magnitude of differentiation might suggest that the inclusion of related animals has inflated measures of genetic differentiation, the fact that the comparisons remain significant could also be interpreted as evidence that the nDNA signal is not entirely driven by maternal relatedness among the Sakhalin animals.

An additional consideration in the evaluation of the hypotheses laid out above is the results of paternity analyses of whales first identified as calves on the Sakhalin feeding grounds (Lang *et al.*, 2010). Analysis of 57 mother-calf pairs and 42 males sampled off Sakhalin identified putative fathers for 46-53% of the calves. These results supported interbreeding among the whales feeding off Sakhalin. Given that 83% of the animals photographically identified during the same time period had been genetically sampled, however, they also raised questions regarding the identity of the 'missing' fathers.

The paternity results are not consistent with hypothesis 3, in that they support interbreeding among whales sampled off Sakhalin. The paternity results could be consistent with hypothesis 1, in which case the calves that were not assigned fathers would be the calves of mothers that travel to the ENP and interbreed with ENP males. The results could also be consistent with hypothesis 2. Under this hypothesis, all or most of the Sakhalin whales are migrating to the ENP but interbreeding among them is occurring while relatively far west on the migratory route. However, it is likely that not all females would mate early in the migration, and thus the unassigned paternities would represent cases where some females interbred later in the migration when they were intermixed with ENP animals migrating from other feeding areas. It is unclear how much of this interbreeding (between Sakhalin and ENP whales) would have to occur before the nDNA signal would be erased. Of note, most mothers had at least one calf assigned to a putative Sakhalin father in the analysis, and some of the Sakhalin-ENP migrants

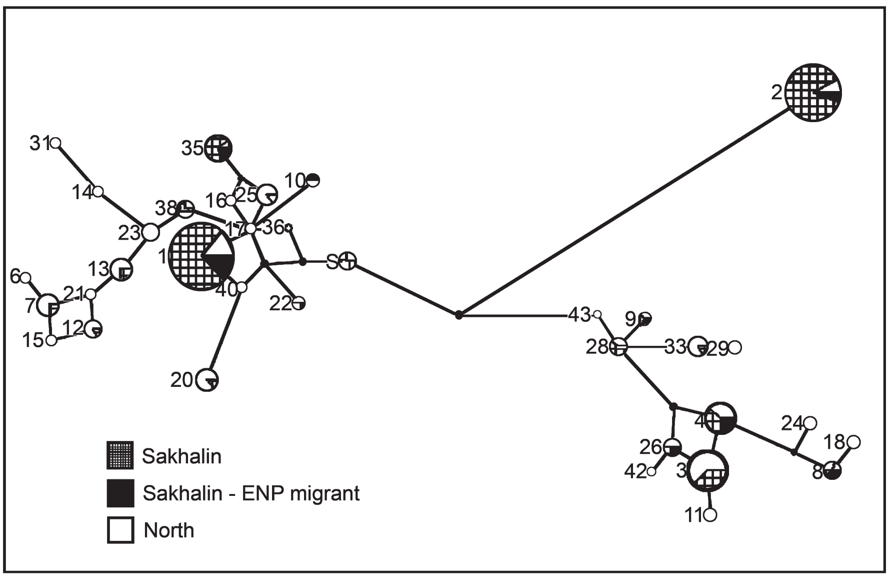

Fig. 1. Median-joining tree.

Table 6
Microsatellite diversity summary statistics.

Strata	*n*	Nb alleles	He	Ho
North	110	8.75	0.729	0.714
Sakhalin	142	8.33	0.690	0.702
Sakhalin - no ENP migrants	108	8.08	0.686	0.697
Sakhalin - ENP migrants	22	6.75	0.716	0.720
Sakhalin - known relatives removed	84	8.17	0.699	0.721

Table 7
Results of microsatellite comparisons.

Comparison	F_{ST}	F_{ST} *p*-value	G``$_{ST}$	G``$_{ST}$ *p*-value	χ^2 *p*-value
North (*n*=110) *vs* Sakhalin (*n*=142)	0.02	0.001	0.04	0.001	0.001
Sakhalin - no ENP migrants (*n*=108) *vs* Sakhalin - ENP migrants (*n*=22)	0.00	0.374	-0.04	0.441	0.258
North (*n*=110) *vs* Sakhalin - ENP migrants (*n*=22)	0.00	0.065	-0.03	0.057	0.015
North (*n*=110) *vs* Sakhalin - no known relatives removed (*n*=84)	0.01	0.001	0.02	0.001	0.001

were assigned as putative fathers. These results provide some support for hypothesis 2 over hypothesis 1; further evaluation of the paternity results is ongoing.

The results presented here suggest that analysis of the existing genetic data may not be able to discriminate between hypotheses 1 and 2. In the future, use of a simulations-based approach may be helpful in further evaluating the plausibility of hypothesis 3. In addition, future work will involve increasing the number of microsatellite loci genotyped on the Sakhalin whales to facilitate a study of relatedness patterns among these whales. The increased number of loci will also strengthen the paternity analysis and allow better evaluation of those results.

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Appendix 3

POSSIBLE STOCK STRUCTURE HYPOTHESES FOR NORTH PACIFIC GRAY WHALES

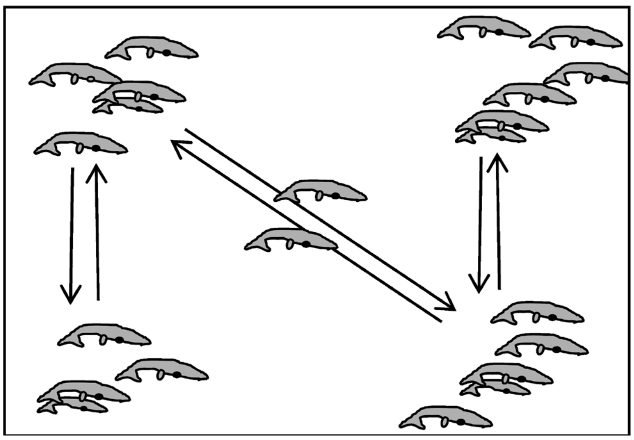
Aimee Lang, John Bickham, Jon Scordino, Jennifer Jackson

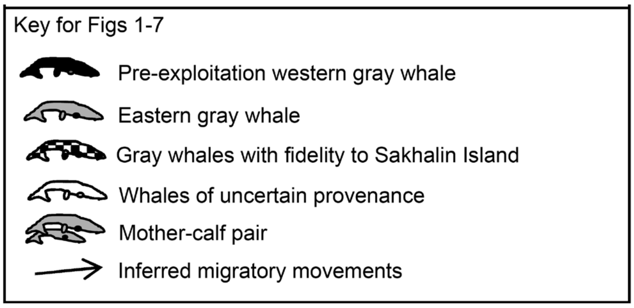
Here we present possible stock structure hypotheses for North Pacific (NP) gray whales, with the intent of facilitating discussion of methods to discriminate between hypotheses. Of note, discussion of these hypotheses is focused on evaluating the stock identity of the whales feeding off Sakhalin; no attempt is made to evaluate the Pacific Coast Feeding Group of whales.

Each hypothesis is accompanied by a description and a figure representing the scenario.

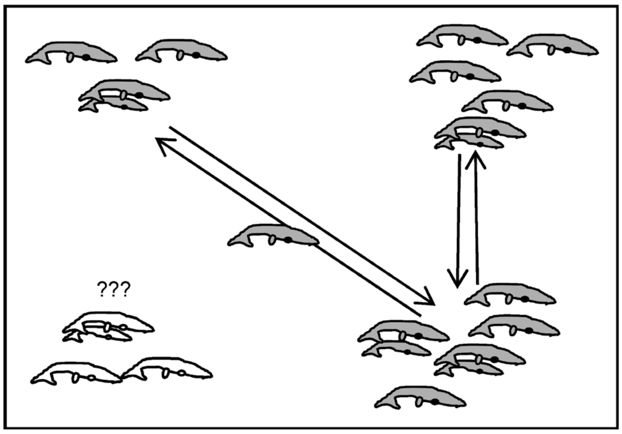
1. Panmixia – persistent

No population structure (e.g. panmixia) is present among feeding grounds used by NP gray whales; individuals move between feeding areas and exhibit random mating. Panmixia has been present over long time scales (prior to exploitation). Gray whales in the North Pacific use multiple migratory routes and wintering grounds with high levels of gene flow [animals randomly choose feeding grounds and randomly choose migratory routes and wintering grounds].



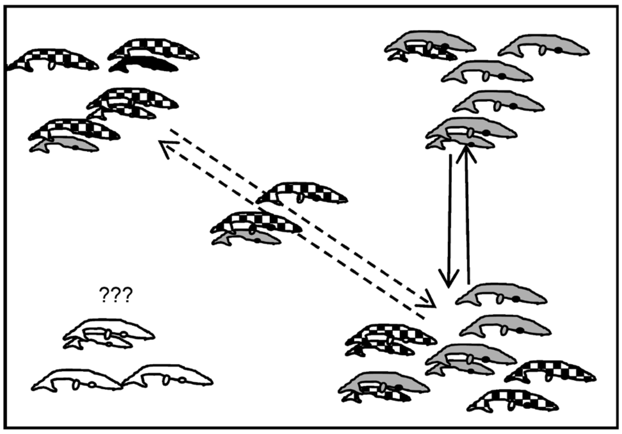


2. Panmixia – post-exploitation - [SC/65a/BRG16, Hypothesis 1]



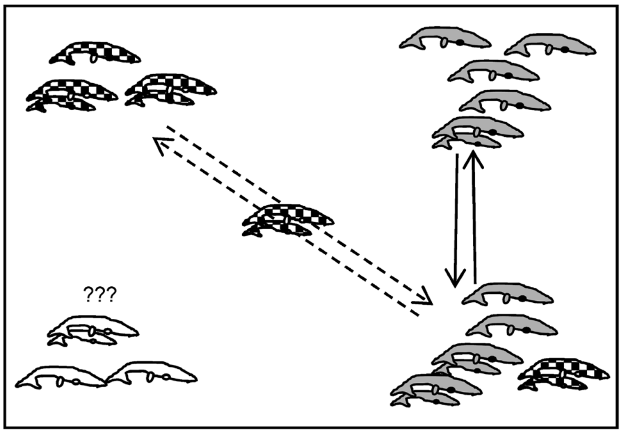
No population structure (e.g. panmixia) is present among feeding grounds used by NP gray whales; individuals move between feeding areas and exhibit random mating. Panmixia developed post-exploitation, and the pre-exploitation population of western gray whales (e.g. 'true' western gray whales) is extinct or utilises unidentified feeding areas in the western North Pacific (WNP). Whales off Sakhalin represent a random (e.g. different each year) subset of Eastern North Pacific (ENP) whales. All whales feeding off Sakhalin migrate to the ENP during winter months and breed randomly with other ENP whales.

3. Maternal feeding ground fidelity, one wintering ground, random mating - [SC/65a/BRG16, Hypothesis 2 and Appendix 2, Hypothesis 3]



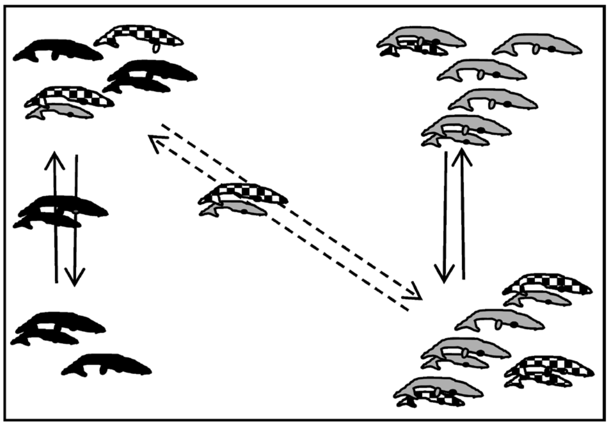
Utilisation of feeding areas is influenced by internal recruitment, with calves following their mothers to feeding grounds and returning in subsequent years. Mating is random with respect to feeding ground affiliation. The Sakhalin feeding ground is utilised by a subset of whales that show matrilineal fidelity to the feeding ground; these whales overwinter in the ENP and mate randomly with whales from other feeding grounds. The pre-exploitation population of western gray whales (e.g. 'true' western gray whales) is extinct or utilises unidentified feeding areas in the WNP.

4. Maternal feeding ground fidelity, one wintering ground, assortative mating with respect to feeding ground - [Appendix 2, Hypothesis 2]



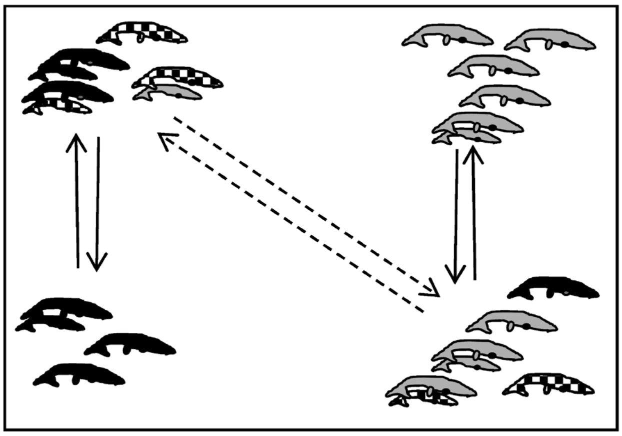
Utilisation of feeding areas is influenced by internal recruitment, with calves following their mothers to feeding grounds and returning in subsequent years. Mating is not random with respect to feeding ground affiliation. Whales using Sakhalin migrate to and overwinter in the ENP; however, some interbreeding occurs early in the migration when Sakhalin animals would be more likely to interbreed with each other than with animals feeding in other areas. The 'true'/pre-exploitation western gray whales are extinct or utilise unidentified feeding areas in the WNP.

5. Maternal feeding ground fidelity, two wintering grounds, random mating with respect to wintering grounds - [SC/65a/BRG16, Hypothesis 3 and Appendix 2, Hypothesis 1]



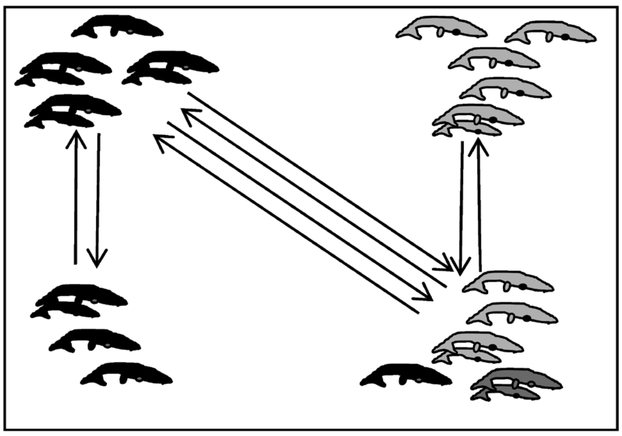
The Sakhalin feeding ground is utilised by whales that show matrilineal fidelity to this feeding ground. Some proportion of these whales migrate to the ENP and interbreed with other ENP whales, while the remainder represent 'true'/pre-exploitation western gray whales that migrate in the WNP and interbreed with each other.

6. Maternal feeding ground fidelity, two wintering grounds, random mating with respect to wintering grounds - [SC/65a/BRG16, Hypothesis 4]



The Sakhalin feeding ground is utilised by whales that show matrilineal fidelity to this feeding ground. These whales include 'true'/pre-exploitation western gray whales that migrate to and overwinter in both the ENP and WNP with some interbreeding with eastern gray whales (EGW) as well as EGW that have colonised this summer feeding ground (i.e. it is a mixture of eastern and western gray whales, and the latter migrate in either direction).

7. Maternal fidelity to feeding grounds, two wintering grounds, assortative mating with respect to feeding ground - [SC/65a/BRG16, Hypothesis 5]



The Sakhalin feeding ground is utilised solely by whales that are the descendants of the 'true'/pre-exploitation western gray whales. They overwinter in both the ENP and the WNP with no interbreeding with the eastern gray whales.

Appendix 4

POTENTIAL RELEVANCE OF THE ALLENDORF-PHELPS EFFECT TO UNDERSTANDING GENETIC DIFFERENCES BETWEEN EASTERN AND WESTERN NORTH PACIFIC GRAY WHALES

R.S. Waples

The purpose of this Appendix is to suggest that a type of 'Allendorf-Phelps' (AP) effect might be contributing to observed levels of differentiation between ENP and WNP samples of gray whales. The AP effect is related to the more widely known founder effect, but it does not require any permanent population subdivision; the AP effect arises when progeny of a local breeding event involving a small number of parents are sampled before they become mixed with the larger population. Here is how the authors (Allendorf and Phelps, 1981) originally described the scenario: A lake has a single population of fish, but each year they spawn at random in different source streams. Let's say in one year a small number of adults spawn in stream A and a different, also small, number of adults spawn in stream B. If the adults are sampled, their genetic profiles would be expected to differ significantly no more often than the nominal Type I error rate (say 5% of the time). But if juvenile progeny are sampled before they mix in the lake, their allele frequencies will differ based on the chance differences in the two sets of parents, plus an episode of genetic drift. Also, the sample size of juveniles could be fairly large, further increasing the likelihood that the differences would appear to be statistically significant. But there is no permanent population subdivision in the system, because when they mature the juveniles randomly pick a stream to spawn in. Therefore, the apparent genetic differences between samples of offspring from different streams is an artifact caused by sampling after an episode of local genetic drift but before the offspring become mixed back into the larger population.

Waples (1998) showed that the expected magnitude of inflation in F_{ST} due to this type of sampling is equal to $1/(2\tilde{N}_e)$, where $\tilde{N}_e$ is the harmonic mean effective number of breeders in the two (or more) locations. It seems to me that a type of Allendorf-Phelps effect might be contributing to the genetic signal in WNP gray whales, and it could involve a variation of Hypothesis 1 in SD/WP1. A possible scenario might be something like this: each generation, some small, random subset of ENP gray whales breed in the WNP, perhaps behaviourally enticed to follow others across the Pacific. Their progeny will differ in allelle frequencies from the larger ENP population by a type of Allendorf-Phelps effect, with magnitude determined primarily by the effective number of breeders that move to the WNP each generation. Some of those progeny remain and breed in the WNP, while others return to the ENP populations. Such a system might be quasi-stable for many generations, or it might be quite ephemeral. regular rcolonisation by new ENP 'founders' would keep the overall divergence modest.

A few simple examples illustrate how consideration of the AP effect might be useful, at least in providing context for interpreting the empirical data. According to Appendix 2, F_{ST} for the ENP (termed North in that paper) and WNP is about 0.02. I assume this is an unbiased F_{ST} that accounts for sample size effects. Using the AP effect, we can ask questions such as: What type(s) of simple, contemporary demographic processes could produce an F_{ST} of that magnitude? The examples below should be regarded as only rough approximations to that question, because the standard models used assume a single population and discrete generations, whereas gray whales have overlapping generations and (at least) two interacting groups of individuals.

Scenario 1: simple AP effect over one generation. In this scenario, a small number (N_1) of whales leave the ENP population, migrate to the WNP, and reproduce there. Their offspring are sampled and compared with samples from the much larger (N_2) ENP population. What is the expected F_{ST}? As noted above, $E(F_{ST})$ for this scenario is $1/(2\tilde{N}_e)$. If we assume that the census size to effective size ratio in both populations is 0.5, the $E(F_{ST})$ is $1/\tilde{N}$, where $\tilde{N}$ is the harmonic mean N. Since N_2 is much larger than N_1, the harmonic mean of N_1 and N_2 will be very close to $2N_1$. So, for this scenario we conclude that $E(F_{ST})\approx 1/(2N_1)$. This implies that the empirical F_{ST} of 0.02 could be produced by a simple AP effect over one generation involving about 25 individuals [1/2x25)=0.02].

Scenario 2: After the one-generation founding event described above, the WNP population breeds in isolation for t generations before samples are taken to compare with ENP. Each generation of isolation would increase F_{ST} by approximately $1/(2\tilde{N}_e)$, which again can be well approximated by $1/(2N_1)$. So, after t generations following the founding event, $E(F_{ST})$ would be approximately $1/(2N_1)+t/(2N_1)=(t+1)/(2N_1)$. If population size in the WNP changes during this time period, one would use the harmonic mean N_1 in the denominator. For example, if descendants of the original founders bred for more than 4 generations in isolation before sampling, then F_{ST} of 0.02 could be produced by a founding (and subsequently constant) population size of about 125 individuals [(1+4)/(2x125)=0.02].

The ratio N_e/N could be lower than 0.5, especially if N is taken to be all individuals in the population (not just adults). If actual N_e/N is lower than assumed above, the empirical F_{ST} of 0.02 could be produced with more individuals in the WNP population. More complicated scenarios could be developed that involve multiple generations of one- or two-way migration, but these scenarios are not so simple to evaluate. In general, reverse migration from WNP to ENP should not have much effect on F_{ST} (unless it appreciably changes N_1), but recurrent migration from ENP to WNP would tend to retard divergence.

None of the above is meant to imply that these simple scenarios are likely to accurately describe contemporary processes involving WNP gray whales. However, scenarios involving some combination of AP and founder events seem quite plausible, and the examples above show that levels of divergence equal to those currently found can be generated fairly rapidly when small numbers of individuals are involved.

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Appendix 5

KEY STOCK DEFINITION TERMS FOR THE IWC SCIENTIFIC COMMITTEE

Recognising there is considerable potential value in standardising use of terminology related to 'stocks' and 'populations' within the IWC, the SDWG has assembled the following list of definitions of commonly used terms. Initially, these are intended to guide usage of documents prepared within the SDWG; eventually, we hope they might lead to more consistent usage in the broader IWC community.

We separate key definitions into two sets: (1) aggregations (a group of whales that occur predictably in a particular location and are persistent for at least part of a year); and (2) defined aggregations (i.e. biological information is available to identify stock composition/demes within the aggregation). We propose that the Scientific Committee use whenever possible the most exclusive (i.e. stock delineating) term among the definitions presented here. So for example if further information is not known regarding stock composition, a regularly occurring group of whales will be called an aggregation, but if additional relevant information is available this may for example be described as a mixed-stock aggregation, or a breeding stock. We also try to relate these definitions to population biology, using the deme concept defined in Section (3).

(1) Aggregations

Aggregation - a group of whales delineated by an area where many individuals of a species are aggregated part of the year, or by a location used for some important function in their life history, or alternatively where some structural property or ecological process occurs with high density (Derous *et al.*, 2007; DFO, 2004). Aggregation relates to events that repeatedly occur at a specific time and location, and can be inferred for both 'mating/breeding' and 'feeding aggregation' if additional information regarding behaviour or ecology is known. These terms are currently used in management of other marine organisms exhibiting migration over large distances from one area to another, mainly from breeding to feeding locations. Other relevant aggregation terms where data on stock composition are not available are 'wintering ground', 'breeding ground' and 'feeding ground'.

(2) Defined aggregations

Biological Stock – *all the individuals in an area that are part of the same reproductive process, forming a self-contained unit, with emigration/immigration rates far lower than the intrinsic rate of population growth.* This is similar to the ecological definition of a biological population, where immigration (or emigration) rates are insufficient to influence population demographics[1]. In this definition, a 'reproductive process' is a group of individuals sharing a common breeding ground during the breeding season.

Relationship to population biology: a collection of one or more demes among which interbreeding takes place such that there is demographic dependency within a population. Examples: West Australia breeding ground (humpback whales), New Zealand calving ground (right whales).

[1]The transition between demographic dependence and independence occurs at a point where migration (*m*) between populations is still high; see Waples and Gaggiotti (2006) for consideration of how small *m* must be before two populations are demographically independent. Hastings (1993) suggests from simulation that $m \approx 10\%$.

Sub-stock - *a consistently identifiable subunit of a stock, distinguished on ecological, behavioural or genetic grounds.* While gene flow among sub-stocks can be high, i.e. they may share a breeding ground with individuals from other sub-stocks; removal of individuals from one sub-stock may result in depletion of individuals within their particular niche (i.e. feeding group) over management relevant time scales. Sub-stock 'boundaries' can be difficult to define.

Relationship to population biology: a sub-stock can be one or more entire demes, part of a single deme, or include parts of more than one deme. Tentative examples: Pacific Coast Feeding Group (gray whales), West Greenland Feeding Aggregation (humpback whales), Mauritius and La Réunion breeding ground (humpback whales).

Mixed-stock *(adj.)* The SDWG discourage the use of 'mixed stock' as a noun and recommend instead the more precise and less ambiguous 'mixture of stocks'. We recommend use of mixed-stock as: *a compound adjective used to indicate that the modified noun involves a mixture of individuals from different stocks (*e.g. *a mixed-stock fishery or a mixed-stock aggregation).* Therefore 'mixed-stock', can be used appropriately as a compound adjective, as in 'the mixed-stock harvest took individuals from several different stocks`. The preferred term to describe situations where individuals from different stocks or populations coexist is therefore a 'mixture of stocks'.

Relationship to population biology: a mixed-stock aggregation contains multiple partial or complete demes. Examples of mixed-stock aggregations: mixed-stock wintering grounds in Dominican Republic (humpback whales), Mexican lagoons (gray whales), mixed-stock feeding Areas in the Southern Ocean (humpback whales).

(3) Relationship with population biology

Deme - the largest group of conspecific individuals within which matings can be considered to occur largely at random. Given this definition, a *population* can be described as a collection of one or more demes, among which interbreeding takes place such that there is demographic dependency within a population. Populations within the species are isolated enough from one another that they are demographically independent and merit separate conservation status. Note that determining the threshold or tipping point level of population isolation for demographic independence still requires reference to management objectives. Note also that although a population can include more than one deme, a single deme or parts of a deme cannot occur in more than one population.

(4) Relationship with IWC Revised Management Procedure

The biological stock is generally used as fundamental unit in RMP/AWMP trials, and is often the first focus of trials to meet conservation requirements.

Management stock - (RMP working definition, see Donovan, 1991) is a deliberately vague term and is defined as an area of ocean to which a catch limit is applied. This is ideally equivalent to a biological stock (above) but may be a mixed-stock aggregation, a sub-stock, a group of sub-stocks, or partial and temporal components of any of these types of stocks. The combination is specific to each management stock. Historically, this term arose from the drawing of 'stock boundaries' when information defining those boundaries was scant or based on catch distributions or recovery of implanted tags. It must therefore be borne in mind that many 'management stocks' as defined by the IWC may contain only a part of a breeding stock, or mixed-stock feeding aggregation.

(5) Relationship to government management objectives and the 'Unit to Conserve'

The 'unit to conserve' depends partly on biology and partly on the level of political and economic interest in the species. The unit to conserve is often an amalgam of the unit that best matches societal ideals (a policy driven decision) and units that exist in nature, with a lot of iteration between both elements (Taylor, 2005). Taking the precautionary approach, the unit to conserve might be the smallest division of the population that can be determined as a semi-autonomous unit (here the 'sub-stock', for example). At the other end of the spectrum, the unit to conserve might be the species itself, regardless of range or population structure. In the IWC context the unit to conserve may be considered equivalent to a management stock. With respect to government management objectives, the unit to conserve tends to be the priority focus and the term 'stock' is often applied to this unit (which may be a sub-stock or deme, or part of a biological stock). Since the IWC receives documents from many different governments, some of which discuss stock structure, it is useful to acknowledge that in these documents the term stock is often therefore defined differently, but that this term can easily be reinterpreted using the core SDWG stock related concepts defined above.

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Annex J

Report of the Working Group on Non-deliberate Human-induced Mortality of Large Whales

Members: Leaper (Convenor), An, Baulch, Bell, Bjørge, Brownell, Childerhouse, Chilvers, Cipriano, Collins, Cooke, Currey, Double, Feindt-Herr, Fortuna, Funahashi, Gallego, Galletti, Holm, Hughes, Iñíguez, Kitakado, Kock, Lang, Legorreta-Jaramillo, Liebschner, Marzari, Mate, Mattila, Nelson, New, Palsbøll, Peres, Reeves, Ridoux, Ritter, Robbins, Roel, Rojas-Bracho, Rosa, Rosenbaum, Rowles, Scheidat, Siciliano, Simmonds, Stachowitsch, Tajima, Víkingsson, Wadley, Williams, Wilson.

1. CONVENOR'S OPENING REMARKS AND TERMS OF REFERENCE

Leaper welcomed participants noting that this Working Group would continue the work of the Working Group on Bycatch and Other Human Induced Mortality. The new name reflects the emphasis on both bycatch and ship strikes. In addition, the Committee's agenda identifies closer links with the Commission's working groups. New items on the agenda included collaboration with Commission initiatives on entanglement and the Commission's Ship Strikes Working Group, including consideration of mitigation measures.

2. ELECTION OF CHAIR

Leaper was elected as Chair.

3. ADOPTION OF AGENDA

The Agenda was adopted.

4. APPOINTMENT OF RAPPORTEURS

Mattila offered to serve as rapporteur.

5. AVAILABLE DOCUMENTS

SC/65a/HIM01-04, SC/65a/SCP01, Vaes and Druon (2013), Neilson *et al.* (2012), Moore and Barco (2013), Moore *et al.* (2013), and Tejedor *et al.* (2013).

6. CRITERIA FOR DETERMINING CAUSE OF DEATH

Criteria for determining cause of death were discussed in a joint session with the environmental standing working group. The objective of the presentations and discussions was to assist the IWC in assessing human caused mortality. In particular, the Committee is hoping to agree to specific criteria by which its ship strike data review group could assess ship strikes reported to the IWC ship strike database. If standardised criteria became internationally accepted, this would assist countries as they report ship strikes to the IWC through their national progress reports.

Moore presented the relevant aspects of Moore *et al.* (2013) through a remote connection from Woods Hole, MA (USA). This recently published paper defines criteria for degrees of confidence in the diagnosis of human derived trauma as cause of death in cetaceans (and pinnipeds). Moore focused on the aspects of the paper regarding the diagnosis of sharp and blunt vessel trauma, and peracute and chronic fishery trauma in cetaceans, after giving brief remarks about issues related to examining large whales for human interaction evidence.

The amount of data needed to make an adequate diagnosis depends on the scenario. A floating carcass with severe dorsal propeller cuts or major entanglement with emaciation could be diagnosed at sea, but an at sea exam and sampling should never be regarded as a necropsy. Blunt trauma is often cryptic without an in depth beach necropsy. Data available for a determination can range from a single image at sea to a 100pp case report of a beach necropsy and consequent analyses. Regardless of the amount of available information, the most parsimonious diagnosis given available information always has value. Other useful references for examining carcasses include a handbook for recognising human interactions (Moore and Barco, 2013) and necropsy protocols (McLellan *et al.*, 2004; Pugliares *et al.*, 2007).

Floating carcasses reported at sea can be relocated using a plane depending on suitable weather, distance from land and landing site options. If a suitable boat is available then the carcass may be towed ashore for a beach necropsy. Viable strategies for relocating carcasses at sea have been derived using a US Coast Guard Search and Rescue drift model assuming that the drift of the carcass is equivalent to that of a 70% submerged 40ft (12m long) shipping container. For carcasses that wash ashore, beach surf maceration can orally eject viscera, muscle and then bones in a matter of hours. So a fully deflated carcass on a surf beach, with skin still attached, may have died more recently than might be assumed. A fully examined case will have gross and histopathology reports. Other analyses such as drift, propeller geometry, biotoxins, and paint fragments, can all be integrated into a peer reviewed and signed case report.

Blunt vessel trauma criteria

Confirmed cases will exhibit a number of: frank hemorrhage with edematous fluid in the subcutaneous tissue; hematoma, laceration or rupture with hemorrhage; hemothorax; hemoperitoneum; visceral displacement, herniation or rupture; skeletal fractures, luxations or subluxations with associated hemorrhage; microscopic fat emboli, acute hemorrhage, edema, rhabdomyocytolysis, and subcapsular and medullary draining hemorrhage in regional lymph nodes; history and/or abrasive evidence of the animal having been on the bow of vessel.

Probable cases will show similar gross necropsy and histopathology findings as a 'Confirmed Case' but insufficient information to conclude that other interpretations of the cause of death are not as likely.

Suspect cases will show blunt-trauma sequelae and/or bony lesions consistent with blunt trauma but may or may not have other signs of pathology from entanglement or disease.

Table 1

Criteria for diagnosis of underwater entrapment in cetaceans (see Moore *et al.*, 2013).

Cetaceans	Confirmed				Probable			Suspect
Reported by fisheries observer	X	-	-	-	-	-	-	
Entangled in gear	-	-	X	X	-	-	-	
Code 2 or 3	-	-	X	-	-	-	-	
Froth in lungs	-	-	-	-	X	X	X	
Whole/partially digested prey in stomach	-	-	-	X	X	X	X	Most parsimonious conclusion based on observer experience
Bruising at appendages/neck	-	-	-	-	X	X	X	
No other significant gross pathology		-	-	-	X	X	X	
Good nutritional status	-	-	-	X	X	X	X	
Net marks	-	X	-	-	-	-	-	
Rope/line marks	-	-	-	-	X	-	-	
Amputation/body slit	-	-	-	-	-	X	-	
Rostal/mandibular fractures	-	-	-	-	-	-	X	

Sharp vessel trauma criteria

Confirmed cases will show open wounds with sharp (incising) or sharp- and blunt-trauma (chop wounds) with histopathology supportive of gross findings of ante-mortem sharp trauma, or a reported, well documented vessel collision and resultant mortality with carcass present, where a necropsy may not be practical.

Probable cases show advanced decomposition, open incised wounds with sharp or sharp- and blunt-trauma sequelae, limited or no histopathology findings of trauma with open wounds and/or bony lesions consistent with sharp trauma, and may or may not have other signs of pathology (e.g. entanglement or disease).

Suspect cases involve a report/documentation of a carcass, no carcass in hand or minimal examination with limited or no necropsy. Findings can include open wounds and/or bony lesions consistent with sharp trauma, and may or may not have other signs of pathology (e.g. entanglement or disease).

Fishing trauma

This may present as whales anchored in gear, swimming, drowned, floating dead (after having bloated if a sinker), or beached dead. They may be in rope and/or net with wounds and/or scars. They are often largely stripped of gear if dead. Gear may include gillnet, single and pair trawls, and anchored pot gear such as lobster, crab and hagfish.

Peracute underwater entrapment

Evidence may include contact with fishing gear, evidence of hypoxia and physical trauma. Degrees of confidence are as shown in Table 1.

Chronic entanglement

Confirmed cases show sufficient evidence to say entanglement was the proximate cause of death or leading to death from consequent factors such as: inanition from emaciation, metabolic exhaustion from increased drag, exertional myopathy, overwhelming infection, starvation, or amputation, secondary to the chronic effects of ischemic necrosis and loss of energy stores.

Probable cases are diagnosed if some or all of the above factors were present, but carcass quality could not allow confident linkage of entanglement evidence with observed condition of the mortality.

Suspect cases show evidence of current or past entanglement, without sufficient findings to link the entanglement to major consequent changes in the animal, but that still had a suggestion of linkage. Moore concluded that evidence of the value of this approach has been recently published (Van der Hoop *et al.*, 2012) for NW Atlantic large whale mortalities and analysed in the context of management strategies designed to mitigate these impacts.

The working group thanked Moore and commended the authors on this work. Moore also drew attention to data from Van der Hoop *et al.* (2012) which showed the geographic and temporal trends in reports of both entanglements and ship strikes along the Atlantic Coast of the USA and Maritime Canada. The coast from Cape Hatteras to New York harbour showed the greatest number of reported vessel strikes, while the Gulf of Maine had the greatest number of entanglement reports. The trend in numbers (and location) of reports of vessel strikes and entanglements did not differ significantly before or after 2003, when a number of management mitigation initiatives were begun along the Atlantic coast of the USA. With regard to sharp trauma from vessel strikes, Ritter noted that, besides skegs, rudders and propellers, the sharp bows of certain types of vessels might also produce sharp trauma.

Rowles presented Moore and Barco (2013) on behalf of the authors. As an introduction to the presentation and in subsequent discussion she noted that much of the work for this handbook, and the Workshop that produced Moore *et al.* (2013), was motivated by regulations in the USA that require the determination of when human activities are the cause of death (mortality) or are more likely than not (51%) to lead to the death (serious injury) of a marine mammal. It was noted that welfare concerns are not currently being considered in injury determinations (NOAA, 2012). The human interactions handbook was the result of several years of work by the authors. The goal of the handbook is to standardise the evidence or observations collected to determine human interactions with cetaceans. The handbook contains: explanation of the goals and objectives of the data collection, definitions of terms, with descriptions, and multiple examples. The handbook stresses a process of making objective observations first then, if any potential external evidence of human interaction is found, the handbook gives instructions on how to fully document this so that it can be used later in making a final determination, when all evidence is collected. If a full necropsy is possible, then the criteria in Moore *et al.* (2013) may be followed, but if this is not possible, the handbook attempts to maximise the possibility of determining human interaction in the absence of forensic necropsies. The data collection form, with the handbook as an 'instruction manual' is used routinely by many stranding network organisations in the US. For the purposes of examining for evidence of ship strike, the handbook has very good examples of both sharp and blunt trauma. Data collected in a consistent manner has assisted in making determinations of the likely outcomes of free-swimming cetaceans with wounds similar to those categorised on carcasses. The manual and associated training have assisted the stranding network in distinguishing between a 'no' for human interactions (meaning the animal was examined and there was no evidence of human interactions) and a 'cannot be determined' which means that no assessment was possible due to decomposition or other factors. Distinguishing between cases that cannot be determined and those that are negative is critical in determining prevalence of interactions and cause of death due to human activities.

The working group thanked Rowles and commended the authors for this work. It was noted that this handbook, and Moore *et al.* (2013), represented very important tools for stranding networks globally. In order to help disseminate both of these the Working Group **recommended** that the IWC Secretariat should notify the stranding contacts list it maintains from member nations of these documents. In addition, Moore noted that he and a co-author (Gulland) had developed a curriculum for a joint IWC-UNEP-SPAW training Workshop for Spanish-speaking nations of the Wider Caribbean, hosted by Mexico in November, 2012. This had been very well received by the 36 veterinarians, researchers and government representatives in attendance. He added that another IWC-UNEP-SPAW training was planned for the French and English speaking countries of the Wider Caribbean in November, 2013. In further discussion it was noted that the two papers describe complementary actions and criteria, as the handbook (Moore and Barco, 2013) provides examples and instructions for primarily visual assessments and Moore *et al.* (2013) primarily provides the most current forensic examples, instructions and criteria. While it was noted that a full forensic necropsy might be very difficult for developing countries, the ability to conduct full necropsies of large cetaceans is challenging under almost all conditions in all countries, and that this should be the goal to aim for. The two papers provided a progression of data collection options, and the visual options in the handbook should be feasible almost anywhere.

In response to a question about how the current budget cuts in the USA would impact this type of work in the future, it was noted that a primary source of grants for this work was proposed to be phased out. In response to several questions about particularly unusual wounds observed by members of the working group, Rowles noted that much of the data collected using these protocols was being archived with the ultimate intent of making some images available on the web, including the IWC website, for consultations and training and that there are several large whale veterinarians and biologists who regularly consult in this manner. It was noted that Woods Hole Oceanographic Institute houses a large and varied collection of wound images. In response to a description of a particularly severe wound, Moore noted that if a whale does not die quickly from blood loss, and if it is otherwise relatively healthy, it can over time heal from remarkably severe wounds leaving major scars. However, he also cautioned that apparently 'healed' wounds can reopen as a result of normal changes, such as the case of healed propeller wounds which reopened during a female right whale's pregnancy, ultimately killing her.

Neilson *et al.* (2012) presents criteria for categorising reports of ships strikes as well as summarising 108 ship strike reports in Alaskan waters between 1978-2011. In order to assess the reliability of these reports, which ranged from well documented with full necropsies to second hand reports with sparse documentation, the authors developed 'confidence criteria'. The authors had suggested that these confidence categories be adopted internationally.

There was some discussion about terminology used in all three papers, especially, whether 'vessel' is more appropriate than 'ship' in the context of these papers and the IWC database, as they all record contact from all types of 'vessels' including those as small as kayaks. There was also some discussion about whether a whale making contact with an anchored or drifting boat should be considered a 'strike'. The Working Group used the criteria explained in these three papers to develop the criteria and definitions in Appendix 2 and **recommended** that these be adopted for the IWC ship strike database.

7. ENTANGLEMENT

7.1 Collaboration with FAO on collation of relevant fisheries data and progress on joining the Fisheries Resource Monitoring System (FIRMS)

The IWC is currently an observer to the FIRMS partnership (Fisheries Resources Management System), a collaborative partnership organised by the FAO, which enables fishery management bodies to share information. It had been hoped that FIRMS may hold data on fishing effort that could be useful in estimating bycatch but FIRMS appears to have changed its focus somewhat since initial discussions with the IWC. This has been on the agenda for some years and last year it was agreed to wait for a database of IWC bycatch data to be developed.

After some discussion, it was decided that the Working Group should drop this agenda item, but that the chair should continue to monitor any new developments intersessionally, that might warrant its return to the agenda.

7.2 Progress on including information in National Progress Reports

The Working Group was reminded that the process for including known entanglements, ship strikes and other anthropogenic mortalities in national progress reports, is now accomplished through an electronic portal. There has been considerable discussion about data entry, extracting data and the level of detail that should be included in national progress reports. The Working Group was not in a position to review this year's data but noted that the Committee as a whole would be discussing Progress Reports in more detail.

7.3 Estimation of rates of entanglement, risks of entanglement and mortality

A recent incidental catch of a baleen whale in longline fisheries off the Brazilian coast was described (SC/65a/HIM02). The incidental capture of a small to medium sized baleen whale was documented on 29 April 2011, *ca.* 80 n.miles south of São Sebastião, off São Paulo State, Brazil. It resulted in severe mutilation of the whale fluke and as such probably caused its immediate death. The tail fluke was the only part of the carcass found entangled in the longline gear. Despite uncertainty in the identification of the whale, the episode documented here seems to be the very first in its nature resulting in the severe mutilation of the peduncle of a small whale entangled in a longline gear off Brazil. As so, it demonstrates the need for more investigation of the magnitude of such interactions in the southwest Atlantic Ocean.

In response to a question about the size of the longline fleet, the author noted that there are approximately 170, 12-16m boats operating out of São Sebastião, however this may be relatively small in relation to fleets operating out of other ports along Brazil's southern coast, which also fish in the path of migratory whales. The fleets are not monitored and they are not likely to report whales entangled in their gear since it is forbidden to entangle a whale, and there are regulations that entanglements are reported, but they are not effective.

Iñíguez noted that, just to the south of this area, the Argentine Department of Fisheries and Department of the Environment co-hosted a meeting, September 2012, consisting of researchers, government managers, and NGOs, in order to develop an action plan to mitigate bycatch and entanglement in similar Argentine fisheries. It is hoped that a report of the action plan developed will be available at next year's meeting.

7.4 Collaboration with Commission initiatives on entanglement, including consideration of mitigation measures

At IWC/63 the Commission endorsed a proposal by Australia, Norway and the USA for a technical advisor to be seconded to the Secretariat in order to assist the Commission's work on mitigating human impacts, especially entanglements and ship strikes (IWC, 2012b, Item 7). A technical advisor, loaned by the USA, has been seconded to the Secretariat since October 2011, and much of the work conducted has been devoted to capacity building on the issue of large whale entanglement.

Working formally through the appropriate Governments, Commissioners, partner IGOs and agencies, over 500 scientists, conservationists, government managers have been engaged, in over 20 countries, including: Argentina, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Korea, Mexico, Norway, Panama, Peru, the United Kingdom and many Pacific Island countries of the South Pacific. Following the capacity building strategy for large whale entanglements endorsed by the Commission at IWC/64 (IWC, 2012a), the first step is to provide an overview seminar for scientists and government managers, followed by detailed training and assistance with setting up entanglement response networks, if requested. Using the IWC endorsed curriculum developed by the IWC's expert advisory panel on entanglements (IWC, 2012a), these detailed trainings have been conducted for: Argentina, Brazil, Mexico and the UK. Over the remainder of 2013, more detailed trainings are scheduled for Ecuador, with participants from the other Commission for the South Pacific (CPPS) countries, as well as national training in Panama, and joint IWC-UNEP-SPAW training for the French and English Caribbean.

The Working Group commended this work, noting that, besides assisting countries to establish relatively safe entanglement response capabilities which had already released a number of individual whales, it has stimulated other local and national initiatives on the issue of entanglement, including actions intended to both understand and mitigate them. With regard to prevention, a member noted that this largely falls into either some form of effort reduction, or the design of low or risk free gear, and that expertise in these fields could be brought to the Committee by invited participants. The working group agreed that prevention was the ultimate solution, as has been noted by the Commission, and the chair encouraged members to actively bring the results of prevention studies to next year's meeting. In response to this call, it was noted that work is being done in New England (USA) by the New England Aquarium, through the Bycatch Consortium, and that a large whale pinger study was underway in Australia. These initiatives among others might produce relevant results for consideration by the Committee.

7.5 Time series of data relevant to RMP and AWMP

In previous years the Working Group has discussed time series of bycatch used in RMP *Implementations* and particularly for minke whales in the northwest Pacific. No specific requests had been made for time series of data for input into RMP or AWMP discussions this year.

8. SHIP STRIKES

8.1 Progress on the global database

Last year the Committee had recommended the appointment of a dedicated IWC ship strike data coordinator with the tasks described in IWC (2013). Ritter and Panigada had been contracted to jointly conduct this work.

Ritter presented the first progress report on IWC ship strike data coordination. The primary objective was to progress the conservation and management work of the IWC with respect to the issue of vessel collisions with cetaceans, to raise awareness about the ship strike data base and to stimulate its use. A number of the tasks assigned to the ship strikes coordinators were addressed during the first six months of work.

Outreach activities included messages to MARMAM and European Cetacean Society (ECS) email lists. Consultation with a representative from Parcs Canada who had not been aware of the data base resulted in another 50 new entries to the data base. Contact was also made with researchers and authorities in Sri Lanka. Moreover, IWC papers and other scientific publications as well as internet and press reports have been evaluated, and scientists, maritime institutes and organisations such as ASCOBANS were contacted. These efforts resulted in a number of new cases being entered into the data base. Several cases reported for Arabia are expected to be entered soon. Moreover, raw data on a large number (>100) of ship strikes in Alaska were received and are currently being entered into the data base. A total of 111 entries of collisions between sailing vessels and cetaceans are expected to be entered by the end of 2013. A new edition of the IWC ship strike leaflet, supported by Belgium, and available in six languages (English, French, Spanish, Arabian, Chinese, Russian) has been distributed. A self-standing banner display has been developed and two copies were produced, and one was displayed at the recent ECS conference in Portugal.

The technical maintenance and user friendliness of the data base are being developed on an on-going basis. Data from around 100 incidents were entered in the last year and the data from around a further 200 incidents are expected to be incorporated during 2013. From the new data, it became clear that ship strikes are an issue in areas previously not dealt with in greater detail, for example, the Gulf of St. Lawrence (Canada). Also, according to data recently published (raw data has been provided to IWC, see above), Alaskan waters appear to be another emerging high risk area.

The Working Group commended Ritter and Panigada on the work described, noting that a modest financial investment by the IWC seemed to produce good results, and **recommended** that funding at the same level requested for 2012/13 should continue.

The working group was informed that Australia has developed a database with a compatible schema, definitions and criteria to the IWC ship strike database in order to facilitate data exchange. It is ready to launch when the IWC criteria are confirmed, but until that time, unofficial reports from Australia need to be treated as unverified. In response to related questions about the USA ship strike database and reporting infrastructure, Rowles explained the review process that ship strikes reported in the USA go through at the regional and national level, and that there is inevitably a time lag before these data make it into the USA's National Progress Reports. The USA is also working to make sure that its ship strike database is compatible with the IWC database, and that data fields can be accurately mapped between the two. The objectives of the IWC ship strike database were previously identified as to:

(1) allow use of all available data to generate larger sample sizes in order to investigate how factors such as speed and vessel type relate to collision risk – this should lead to better ways to model risk and identify high risk areas;
(2) improve ability to identify areas where the impacts of ship strikes may be of particular conservation concern at the population level, based on the numbers of reported incidents and/or modelling of risk; and
(3) improve potential to develop the most effective mitigation measures.

It was suggested that populations identified as possible candidates for development of CMPs should be prioritised for proactive data gathering outreach efforts. The Working Group **recommended** this addition to the work plan for the ship strike database coordinators.

8.2 Estimating rates of ship strikes, risk of ship strikes and mortality

Ritter presented SC/65a/HIM01, dealing with underwater noise measured from vessels off the Canary Islands (Spain), where a large fleet of commercial ferries operates on a year-round basis, and at the same time, a high number of stranded cetacean carcasses in the area have shown injuries typically attributed to ship strikes. Recordings of underwater sound were made during September 2012 off the island of La Gomera after the recording vessel was positioned in the projected track of an approaching ferry. Distance to the recording vessel and speed were obtained from an automatic identification system (AIS) receiver. Three different ferry types characterised by propulsion type and cruising speed were recorded: a regular ferry (propeller driven, travel speed: 15kn), a fast ferry (propeller driven, travel speed: 20-25kn), and a jet driven high-speed ferry (travel speed: 30-35kn). Each ferry type showed a unique frequency- and distance-specific energy content signature. Based on assumptions about critical ratios between the received sound from the approaching ship and background noise, the authors concluded that whales may be capable of hearing approaching vessels at distances that enable them to react fast enough to avoid a collision, however there are numerous behavioural, physiological and other factors to be considered in evaluating the actual collision risk. The estimated times available from detection to avoid a potential collision were found to be heavily dependent on the (suspected) cetaceans' hearing thresholds. As such, the calculated values, ranging from 0.53 to 3.5min, probably represent overestimates. They concluded that jet-driven ferries travelling at high speed, combined with comparably low intensity bow-radiated noise, result in an especially high risk of collision. These results confirm that vessel speed is a crucial factor, and hence reinforce the need to reduce vessel speed so as to minimise the risk for the animals, vessel crews and ferry passengers alike.

In discussion it was noted that a key issue is whether whales are able to assess when and where to swim so as to avoid being hit.

Two pygmy blue whales were struck and killed in Sri Lankan waters within a 12-day period in early 2012. The southern coast of Sri Lanka is one of the busiest shipping routes in the world and overlaps with an area of high whale sightings. Because there is no abundance estimate for the local population of blue whales, we do not know what impact these deaths might have on the population. However, the reported deaths can only be considered minimum values. These deaths and the unknown population size highlight the urgent need for long-term monitoring of the blue whale population in Sri Lankan waters and elsewhere in the northern Indian Ocean (SC/65a/HIM03). The group thanked the authors for providing a paper describing information that had been presented informally last year.

Methodology to model the seasonal ship strike risk of fin whales in the Western Mediterranean Sea by making use of data on vessel traffic from AIS data and satellite-derived data on fin whale habitat (Vaes and Druon, 2013) was also discussed. Habitat was modelled by using data from earth observation satellites (surface temperature and chlorophyll-*a* content). This 'potential habitat' was then extrapolated to the entire western Mediterranean Sea and 'calibrated' against 1,732 fin whale sightings recorded since 1995. Derived favourable habitat covered about 10% of the western Mediterranean Sea. AIS data were used to estimate vessel distribution and density, vessel speed and vessel size on a basin wide scale. Both vessel traffic and habitat data were then integrated by accounting for relative risk according to vessel speed as well as daily variability of traffic density and habitat data. The mean risk per month was then estimated from daily risk estimates.

AIS data were available for May, July and October. July was the busiest month in terms of vessels transiting the Mediterranean with significantly less traffic in October. Two areas were identified to have an especially high collision risk for fin whales: (a) The Liguro-Provençal Basin north of Corsica (including the Pelagos cetacean sanctuary), which shows a potential risk higher in mid-summer than late spring or autumn due to a higher traffic of passenger ferries in July-August notably towards Corsica and Sardinia; and (b) the Alboran Sea shows an even higher potential risk but fin whales are rarely observed in this area. The authors suggest that noise disturbance from hundreds of vessels crossing this narrow area each day may be a reason for low whale density in an area of potential good habitat. The near real time maps of potential fin whale habitat have been computed on a daily basis since 2010 and provided to partner research groups.

In discussion it was noted that this type of approach had been previously encouraged by the Committee, but that the use of habitat indicators (e.g. surface temperature and chlorophyll-*a*) as a proxy for whale presence represented a different approach to actual data on whales. The Working Group **agreed** that it would be useful to see this approach further compared with contemporary whale sighting data.

Ritter presented Neilson *et al.* (2012) on behalf of the authors and reported that data from the incidents described in the paper had been made available to the IWC database. It analysed all reported whale-vessel collisions in Alaska between 1978 and 2011. Each record was assigned to one of four confidence categories using standardised criteria that were created for this study: definite ship strike (*n*=89), probable ship strike (*n*=9), possible ship strike (*n*=10), or rejected report (*n*=11). 108 reports were classified as definite, probable or possible ship strikes. Most reports (*n*=86, 80%) were based on collisions witnessed at sea, while the remaining 22 reports (20%) were based on dead whales where no collision was reported. Most strikes involved humpback whales (*n*=93, 86%). Twenty-five collisions are known to have resulted in the whale's death but in most cases (72%) the fate of the whale was unknown. All types and sizes of vessels collided with whales; however, small (<15m) recreational vessels as well as commercial recreational vessels were the most common. When vessel speed was known, 49% of the collisions (*n*=37) occurred at vessel speeds ≥12kn. Maximum speed reported was 35 knots. Among the 25 mortalities, vessel length was known in seven cases (190-294m) and vessel speed was known in three cases (12-19kn). In 36 cases, human injury or property damage resulted from the collision, and at least 15 people were thrown into the water (i.e. collisions are a human safety issue as well). In 15 cases humpback whales struck anchored or drifting vessels. This suggests that the whales did not detect the vessels and that being in a silent vessel may increase the risk of a collision. Collision hotspots were identified; these are areas that warrant special attention in the form of vessel speed limits, public service announcements, increased law enforcement presence or other measures.

The authors of Neilson *et al.* (2012) had also recommended the wide distribution of the IWC's leaflet on vessel strikes that had been funded and co-ordinated by Belgium. The Working Group noted the value of the leaflet to highlight the issue and create an ongoing dialog on whale avoidance in the maritime industry. It was also encouraging to see others recommending the use of the leaflet.

In discussion it was noted that even though this paper presented a large number of cases, there were still relatively few in which the circumstances of the collision and outcome could be related to the size, speed and type of the vessel involved. This highlights the need of a central global database such as the IWC ship strike database which will increase the likelihood of obtaining a sample size sufficiently robust for meaningful analyses of factors related to risk.

8.3 Collaboration with the Commission's ship strikes working group including consideration of mitigation measures and plans for future Workshops

Mattila summarised the report of a Commission endorsed ship strike mitigation Workshop (Tejedor *et al.*, 2013), held in Tenerife in October 2012. He noted that this was primarily a management and mitigation oriented Workshop to discuss how best to distribute the current ship strike avoidance information to professional mariners who receive training and information through the IMO. The specific goals summarising the approach are listed as item 1.2 of the report. In brief the objectives were to:

- determine what information needs to be delivered to mariners to effectively reduce the risk of ship-strike of cetaceans? How (by what systems/technologies) can such information be delivered?
- what actions need to be taken and what key stakeholders need to be engaged to initiate the development of an international mariner outreach and training program?

The Workshop included a broad cross section of participants representing the IMO, shipping associations, shipping managers, ship companies and scientists working on the issue. While the Workshop did spend some time reviewing current ship strike avoidance schemes and strategies, there was a recognition that there is currently no technological equipment or system which has been proven to effectively mitigate ship strikes with whales. There was broad recognition and acceptance that currently, the best way to avoid ship strikes with whales is for ships to avoid them, and if they can't avoid whale habitat, then they should maintain a vigilant watch and slow down as appropriate. Several participants from the industry agreed that they and their captains would rather know of a whale 'hot spot' well in advance, and be able to plan their routes accordingly to avoid them, rather than getting a message upon arrival at an area that they need to re-route around, effectively adding more distance and time to their transits. Finally, the Workshop did recognise the IWC as a significant resource and stakeholder in the process of developing and disseminating the best available information to shipping, and saw the IWC as an important partner in this process. It was stressed that contacts established through this Workshop can potentially be used by the ship strike data coordinators to strengthen the dialogue with the maritime industry.

In discussion, it was noted that the idea of mapping cetacean hotspots for the purposes of estimating risk and avoiding ship strikes, had previously been discussed by the Committee. The apparent willingness of a significant number of key stakeholders at this Workshop to investigate the feasibility and utility of voyage planning to avoid high density areas represents an opportunity for the Committee to play an important role in this effort. The working group agreed that this was a potentially productive way forward on this issue, and **recommended** that the topic of defining and identifying critical whale 'hot spots' and engaging the shipping industry in the process of communicating this information was a valuable agenda item for the Commission's next ship strike Workshop. Members noted that there were already some initiatives underway to identify cetacean 'hot spots' and that these might be useful to the work of the IWC and the upcoming Workshop. These include: modeling work conducted by NOAA, for the west coast of the USA, and the Eastern Tropical Pacific, the mapping of current Marine Mammal Protected Areas by the ICMMPA and the identification of 'important cetacean habitat' by its new partner group, the IUCN Task Force on Marine Mammal Protected Areas.

Finally, the Working Group recognised that the Tenerife Workshop was primarily concerned with management and mitigation, and as such, **recommended** that the Commission's next ship strike Workshop review the report in full, and consider endorsing it and seeking partnerships with stakeholders to carry out appropriate recommended actions.

A funding proposal from researchers at the University of Auckland, New Zealand for aerial surveys of Bryde's whales in the Hauraki Gulf was also discussed. The population is believed to be less than 200 individuals and there have been 16 confirmed ship strike mortalities between 1996 and 2013. A Bryde's whale ship strike group has been established including major stakeholders such as Maritime New Zealand, Department of Conservation and the Port of Auckland. The primary objective of the proposed research is to provide an abundance estimate for Bryde's whales throughout their primary range in New Zealand and to use this and data on distribution to inform mitigation measures to reduce ship-strike mortality. The Working Group **recommended** that this project should be funded.

8.4 Time series of data relevant to RMP and AWMP

The Working Group has not yet been in a position to provide estimates of ship strike mortality beyond confirmed reports that would be suitable for use in the RMP and AWMP. However, developing methods to quantify mortality remains an objective for the Working Group.

9. INPUT INTO CONSERVATION MANAGEMENT PLANS

Entanglement and ship strikes are the highest cause of non-deliberate anthropogenic mortalities for large whale populations. The Working Group is focused on ways of estimating the numbers of such mortalities for use in assessments and evaluating mitigation measures. Both of these aspects of the work are relevant to Conservation Management Plans (CMPs).

The Working Group discussed ways in which it could assist in responding to the request from the Commission to create a list of priority populations for CMPs. This process was guided by the criteria for populations to be considered as candidates for CMPs in SC/65a/SCP01. These include populations that have been assessed, in which case the Committee has already considered human induced mortalities, but also populations whose status has not been assessed where human impacts are believed to be substantial and thus of concern. It is these latter populations for which some of the estimation and risk modelling approaches considered in the Working Group may be particularly relevant.

The Working Group drew up a preliminary list of areas in which, or populations of, large whales believed to be subject to particularly high levels of ship strikes and entanglements.

Areas or populations where high levels of reported ship strikes occur that have been discussed by the Committee include:

- Arabian Sea humpback whales;
- blue whales in the northern Indian Ocean;
- Bryde's whales in the Hauraki Gulf, New Zealand;
- fin whales in the Mediterranean;
- North Atlantic right whales;
- sperm whales around the Canary Islands; and
- sperm whales in the Mediterranean.

In some cases this list includes areas of known high ship strikes rather than the geographical extent of populations. In addition, this list includes some populations (e.g. Bryde's whales in the Hauraki Gulf) whose distribution may only extend across a single range state. Hence not all the areas or populations listed may be suitable for CMPs. These are also not listed in any order of priority but the Working Group noted that the status of the Arabian Sea humpback whales would make this population a priority for addressing ship strikes.

With the exception of North Atlantic right whales and Arabian Sea humpback whales, these populations have not been subject to assessment but concerns over their status have been largely driven by levels of mortality, often in the absence of abundance estimates. The Working Group noted that any population which is known to spend significant time in areas of high density shipping should be considered, even with a low number of reports. This is especially true if there is no local stranding network or ship strike reporting infrastructure.

In 2010, the Commission sponsored a Workshop on the Welfare aspects of Large Whale Entanglement (IWC, 2012c). In order to understand the magnitude of the problem, the Workshop was asked to review the global scope (regions and species) and impacts of large whale entanglement, and they were asked to prioritise populations at risk. In addition to the list identified by participants at the Workshop which identified species or stocks that were considered to be of the highest concern from a population or conservation perspective with respect to entanglements the Working Group added Arabian Sea humpback whales and **agreed** that this population should also be a priority for measures to address entanglement. This resulted in the following list:

- Arabian Sea humpback whales;
- J stock of minke whales in the western Pacific;
- North Atlantic right whales;
- North Pacific right whales (*Eubalaena japonica*);
- western Pacific gray whales; and
- other small populations (e.g. bowhead whales (*Balaena glacialis*) in the northeast Atlantic).

The Workshop had cautioned against highlighting specific species and interactions of concern to the exclusion of others, as environmental changes such as climate change may alter distribution of whales or fishing effort, resulting in new areas and species at increased risk of entanglement. Also, the Workshop had expressed concern that information is incomplete for many regions and/or species.

The Working Group also noted that entanglement is a potential concern in any area in which whales and stationary or drifting gear in the water overlap. Thus, any population should be considered at potential risk where overlap exists, even in the absence of confirmed reports. Areas of known or potential overlap of whales with gear in the water should also be prioritised when formal reporting and response capability is known to be limited or absent.

The concerns over mortality levels have largely been driven by the number of reported incidents in these areas. As a more quantitative understanding of how to evaluate risks develops, it may also be appropriate to propose populations for consideration where the risks from entanglement or ship strikes appear high, even in cases where there is limited data on reported mortality. There are many areas of the world where systems for reporting mortality such as fisheries observer programmes or stranding schemes do not exist. The Working Group noted that it was not currently in a position to propose any populations based just on risk analysis where reporting is very limited, but further developing such methods so that this could be possible in the future could be an objective for the Group.

The Working Group also discussed scientific input once CMPs have been developed. Some key components of CMPs are listed in SC/65a/SCP01 and include that the focus should be on practical and achievable actions. In addition a key component is that IWC involvement can bring in the involvement of other IGOs and scientific/technical expertise. For ship strikes in particular, IWC has consultative status to the International Maritime Organization (IMO) and so can assist with IMO involvement. The IMO is responsible for all measures outside of national waters that affect shipping and so an effective dialogue with IMO is critical for all measures related to ship strikes. It was also noted that the IWC and ACCOBAMS had developed a joint work plan on ship strikes. The Working Group agreed to maintain close links with the ACCOBAMS ship strike group and Ritter agreed to act as a liaison with this group.

For entanglements the IWC has established a large whale entanglement expert advisory group, with members from Australia, Canada, New Zealand, South Africa and the US, to advise countries on the issue, and has initiated a program to build capacity in prioritised areas, when requested. In addition, the Working Group **recommended** that the Secretariat bring the IWC's most current scientific and mitigation information to the relevant bodies within the FAO.

The mitigation aspects of measures considered within CMPs will need to be evaluated to assess what risk reduction is expected or being achieved. The Committee has had discussions about evaluating mitigation measures, for example for ship strikes at the joint IWC/ACCOBAMS Workshop in 2010 (IWC, 2011) and in future this work will be directed to the Working Group. There is therefore a need to especially encourage studies that fill any data gaps regarding ways that entanglement or ships strikes may be reduced for input into CMPs. This may be in areas where CMPs have already been developed (western gray whales; southwestern Atlantic right whales; and southeast Pacific right whales); are currently under consideration as candidates (Arabian Sea humpback whales) or are high on the list of priority candidates. Recognising that CMPs continue to evolve, the Working Group noted that it would welcome requests to further evaluate non-deliberate human induced mortality in the context of existing CMPs.

With regard to CMPs and the ship strike issue, Iñíguez noted that as part of the CMP for the southwest Atlantic population of southern right whales, the range states have agreed to collect information on ship strikes with this species and report them to the IWC.

10. OTHER ISSUES, INCLUDING ASSESSING MORTALITY FROM ACOUSTIC SOURCES AND DEBRIS

The discussion of marine debris including direct mortality is under the report of the SWG on Environmental Concerns.

11. WORK PLAN AND BUDGET REQUESTS

The focus of the group will remain on estimating mortality of large whales due to entanglement and ship strikes. The Working Group agreed that it would be beneficial to identify issues for priority attention within a longer-term plan of work. An intersessional group was established to make suggestions for such a plan which would be considered next year. Double offered to convene the group; other members are Brockington, Leaper, Mattila, Ritter, Rowles, Schweitzer.

The Working Group **agreed** that the ship strike data review group should continue to work intersessionally. The group consists of Donovan, Double, Leaper (Chair), Mattila, Panigada, Ritter and Rowles. Previous members of the group who were not at the meeting would be contacted to ask if they would be willing to continue.

The Working Group made two budget requests. One for £10,000 to continue the work of the database coordinators (see Item 8.1) and one for £27,050 for Bryde's whale surveys related to ship strikes in the Hauraki Gulf. Noting the importance of the work of the database coordinators to the group it was **agreed** that the request for funding for this work should be prioritised. The recommended tasks for the database coordinators are listed in Appendix 3 however it was noted that this was a long list and that not all the tasks would be expected to be completed within the funding period.

The work plan will include the following.

(1) Reviewing progress in including information in National Progress Reports.
(2) Entanglement:
  (a) estimation of rates of entanglement, risks of entanglement and mortality;
  (b) collaboration with Commission initiatives on entanglement, including:
    (i) consideration of mitigation measures;
    (ii) assist with communication of key scientific issues related to entanglement;
    (iii) review entanglement issues related to Conservation Management Plans; and
  (c) involvement with other international organisations who have complementary or overlapping mandates with respect to entanglement.
(3) Ship strikes:
  (a) estimation of risks and mortality from ship strikes;
  (b) collaboration with the Commission's Ship Strikes Working Group including:
    (i) consideration of mitigation measures including review of Bryde's whale surveys in Hauraki Gulf, New Zealand and ways these can inform measures to address ship strikes for this population;
    (ii) assist with communication of key scientific issues related to ship strikes;
    (iii) review ship strike issues related to Conservation Management Plans;
  (c) continuing development and use of the international database of ship strikes:
    (i) review progress by database coordinators on work programme in Appendix 3;
    (ii) review progress with reviewing new reports and application of new criteria; and
  (d) review scientific information from forthcoming Workshop organised by the Commission.
(4) Review of information on other sources of non-deliberate human induced mortality.
(5) Developing a five year plan with suggestions for priority work by the Committee to estimate and address non-deliberate human induced mortality; review work of intersessional group.

12. ADOPTION OF THE REPORT

Leaper thanked the group and particularly David Mattila for doing an excellent job as rapporteur. The report was adopted at 18:50 on June 10, 2013.

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Appendix 1

AGENDA

1. Convenor's opening remarks and Terms of Reference
2. Election of Chair
3. Adoption of Agenda
4. Appointment of rapporteurs
5. Available documents
6. Criteria for determining cause of death
7. Entanglement
   - 7.1 Collaboration with FAO on collation of relevant fisheries data and progress on joining the Fisheries Resource Monitoring System (FIRMS)
   - 7.2 Progress on including information in National Progress Reports
   - 7.3 Estimation of rates of entanglement, risks of entanglement and mortality
   - 7.4 Collaboration with Commission initiatives on entanglement, including consideration of mitigation measures
   - 7.5 Time series of data relevant to RMP and AWMP
8. Ship strikes
   - 8.1 Progress on the global database
   - 8.2 Estimating rates of ship strikes, risk of ship strikes and mortality
   - 8.3 Collaboration with the Commission's ship strikes working group including consideration of mitigation measures and plans for future Workshops.
   - 8.4 Time series of data relevant to RMP and AWMP
9. Input into Conservation Management Plans
10. Other issues, including assessing mortality from acoustic sources and debris
11. Work plan and budget requests
12. Adoption of the Report

Appendix 2

CRITERIA FOR EVALUATING VESSEL STRIKE EVENTS

Table 1

Criteria for evaluating vessel strike events.

IWC category	Neilson *et al.* (2012) category	Neilson *et al.* (2012) description	IWC description
Confirmed based on report	Definite *There is evidence that a strike occurred beyond a reasonable doubt.*	Strike was witnessed by the vessel operator/crew or by the operator/crew of a nearby vessel	Strike of live whale was witnessed by the vessel operator/crew or witnessed with certainty by the operator/crew of a nearby vessel. Outcome in this case may be either: **Confirmed mortality** if witnesses observe floating carcass shortly following impact; *or i*mages or forensic documentation collected at the time of the impact, links the event to a floating or beach cast carcass found later. **Serious injury** if witnesses observe level of impact that is most likely to be fatal given the type, tonnage and speed of the vessel; *or* witnesses observe whale with injuries expected to be fatal; *or* significant amount of blood in the water associated with severed body parts. **Injury** if witnesses observe level of impact that is unlikely to be fatal given the type, tonnage and speed of the vessel; *or* witnesses observe whale with injuries unlikely to be fatal. **Undetermined** if insufficient additional information.
Definite Based on report	Definite *There is evidence that a strike occurred beyond a reasonable doubt.*	Strike was not witnessed but evidence of a collision was found on the vessel (e.g. whale skin or tissue); *or* whale was found on the bow of a ship.	Strike was not witnessed but evidence of a collision was found on the vessel (e.g., whale skin or tissue) location of collision evidence on the carcass suggested whale was alive when struck. Whale carcass [category 2 fresh dead] was found on the bow of a ship.
Whale initiated collision	Subcategory: whale struck stationary vessel.	Vessel was stationary at the time of the collision (i.e. anchored or drifting) or whale actively approached slow moving vessel	
Confirmed based on carcass	Definite	Strike was not witnessed but whale has massive blunt impact trauma (defined by disarticulated vertebrae or fractures of one or more heavy bones including skull, mandible, scapula, vertebra or adult rib, and a focal area of severe hemorrhaging); *or* strike was not witnessed but carcass has apparent propeller wounds (i.e. deep parallel slashes or cuts into the blubber) on the dorsal aspect; *or* strike was not witnessed but carcass has propeller wounds on the ventral and/or lateral aspect which a necropsy confirms were produced ante mortem; *or* strike was not witnessed but carcass has an amputated appendage (e.g. fluke or flipper) which a necropsy confirms occurred ante mortem due to a sudden and traumatic laceration (versus an entanglement injury causing a slow, ischemic loss of the appendage).	Confirmed according to criteria in Moore *et al.* (2013) for blunt or sharp trauma.
Definite Based on carcass			Strike was not witnessed but whale has massive blunt impact trauma (defined by disarticulated vertebrae or fractures of one or more heavy bones including skull, mandible, scapula, vertebra or adult rib, and a focal area of severe haemorrhaging); *or* strike was not witnessed but carcass has diagnostic propeller wounds (i.e. deep evenly spaced slashes or cuts into the blubber) on the dorsal aspect; *or* strike was not witnessed but carcass has diagnostic propeller wounds on the ventral and/or lateral aspect which a necropsy confirms were produced *ante mortem*; *or* strike was not witnessed but carcass has an amputated appendage (e.g. fluke or flipper) which a necropsy confirms occurred ante mortem due to a sudden and traumatic laceration (versus an entanglement injury causing a slow, ischemic loss of the appendage).
Probable based on report	Probable *The report is likely to be true; having more evidence for than against, but some evidence is lacking.*	Vessel operator/crew or operator/crew of a nearby vessel believes that a strike occurred but cannot confirm the strike with absolute certainty.	Vessel operator/crew or operator/crew of a nearby vessel believes that a strike occurred but cannot confirm the strike with absolute certainty; *or* whale was found on the bow of a ship in a more advanced state of decomposition than category 2 but there is other evidence that the whale was alive when struck (e.g. the time when the strike was thought to have occurred is consistent with decomposition).
Probable based on carcass		Strike was not witnessed, and the whale is a calf with smaller broken bones (e.g. ribs) that could have been fractured by another animal rather than by a vessel; *or* strike was not witnessed and the whale shows partial evidence of a collision other than as defined under definite strike: (i)whale has a focal area of severe haemorrhaging but no known broken bones; therefore, it is possible the trauma was caused by another animal rather than by a vessel; or (ii) carcass has propeller wounds on the ventral and/or lateral aspect; however, the necropsy is not able to determine if they were produced *ante mortem*.	Probable according to criteria in Moore *et al*. (2013) for blunt or sharp trauma.
Possible based on report	Possible *The report may be true; however, a majority of evidence is lacking.*	Vessel operator/crew or operator/crew of a nearby vessel believes that a strike may have occurred but there is significant uncertainty; *or* vessel operator/crew or operator/crew of a nearby vessel believes that a strike occurred, while the vessel operator/crew or operator/crew of a nearby vessel believes that a strike did not occur	Vessel operator/crew or operator/crew of a nearby vessel believes that a strike may have occurred but there is significant uncertainty; *or* vessel operator/crew or operator/crew of a nearby vessel believes that a strike occurred, while the vessel operator/crew or operator/crew of a nearby vessel believes that a strike did not occur; or whale found on bow but evidence is not clear whether strike was *ante*- or *post-mortem.*
Possible based on carcass		Strike was not witnessed, and the whale shows partial evidence of a collision other than as defined under definite or probable strike, such as damage to an appendage or skin, but the necropsy is incomplete or there is no close examination of the whale (e.g. whale is viewed from a distance only).	Suspect according to criteria in Moore *et al.* (2013) for blunt or sharp trauma.
Rejected report	Rejected report *The report is not credible.*	Third-hand report; *or* no credible eye-witnesses; *or* lacking sufficient detail or documentation to be credible; *or* necropsy determines an alternate cause of death.	Third-hand report; *or* no credible eyewitnesses; *or* lacking sufficient detail or documentation to be credible.
Not a strike			The incident was reported in the belief that it was a vessel strike, but the DRG concluded that based on the evidence there was unanimous agreement that the incident did not involve contact with a vessel.

Neilson *et al.* (2012) note that the credibility of the eyewitness(es) was assessed on a case-by-case basis. The most credible eyewitness is someone who had 'something to lose' in reporting the collision (e.g. the captain and/or the crew of the vessel that struck the whale) because it is presumed they would not risk reporting the collision if it had not occurred. The least credible eyewitness is a passenger on a commercial vessel (e.g. whale watch vessel, cruise ship, etc.) who reports a collision, but there is no supporting evidence (photos, observation of wound, blood, etc.) or other eyewitnesses. In these cases, the report was rejected unless the passenger was an experienced observer and/or additional eyewitnesses were available to corroborate the report (assessed on a case-by-case basis).

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Appendix 3

TASKS FOR THE SHIP STRIKE DATABASE COORDINATORS

DATA GATHERING

(1) Liaise with regional databases in order to facilitate their submission to the global database – this will involve addressing issues of data confidentiality and classification, as well as facilitating easy submission to the database.
(2) Identify national contact points, organisations and groups that hold data on ship strikes that have not been contributed to the global database and encourage them to submit their data to the global database – this will involve use of mail lists (e.g. Marmam, ECS-talk) and will involve addressing issues of data confidentiality and classification, as well as facilitating easy submission to the database. Telephone interviews with identified contributors should be investigated to facilitate submission of data.
(3) Disseminate new criteria for ship strikes developed at SC/65a.
(4) Regularly contact national co-ordinators or stranding networks (from IWC list) providing them with any new updates relevant to ship strikes and helping to facilitate data entry of any new records to IWC database.
(5) Regularly review scientific journals for ship strike information and contact authors to collate data for entry into the database.
(6) Use search engines and other internet news monitoring tools for reports of ship strikes and follow up on reports of new incidents in order to gather information as soon as possible after the incident took place and facilitate its incorporation into the database – this will include informing national coordinators promptly of reported incidents within their area.
(7) Prioritise populations identified in CMPs for data gathering outreach efforts.

OUTREACH AND COMMUNICATION

(1) Work with the Secretariat to ensure that the IWC ship strike web site pages are kept up to date including:
- updating publicly available summaries from the database;
- providing links to other sources of information material e.g. that produced by international organisations such as ACCOBAMS, ASCOBANS, CMS, IMO as well as national groups; and
- consider whether there is value in highlighting recent cases/reports on the web page in a positive manner to encourage further reporting.

(2) Monitor and respond to emails addressed to the *shipstrikes@iwc.int* email address, including reports of new incidents, giving feedback to data providers and dealing with requests for summary information from the database.
(3) Work with the Secretariat to develop a communications strategy. This may include:
- developing approaches to ensure that the current leaflet on ship strikes prepared by Belgium with assistance from inter alia IFAW is as widely distributed as possible within shipping industry (direct to vessels), shipping management companies, and maritime academies;
- exploring ways of raising the profile of the database by contacting other organisations (including ECS, ACS, SMM, ACCOBAMS, ASCOBANS), NGOs, recreational boating associations, maritime organisations; and
- considering the need to update the leaflet.

(4) Liaise with national Port Authorities and Coast Guards for gathering information on ship strikes, to distribute awareness material and eventually access AIS data.
(5) Assist the Secretariat with maintaining links with IMO, ASCOBANS, ACCOBAMS etc.
(6) Provide an annual update to the Scientific Committee.
(7) Consider developing PowerPoint presentations/posters for use at Workshops, symposia, conferences, etc.
(8) Consider presenting information at specific conferences (e.g. ECS, SMM etc).
(9) Explore funding options for future IWC ship strike work.

DATABASE MANAGEMENT

(1) Work with the Secretariat to improve the user friendliness of the database (requires technical assistance) including in response to user problems and suggestions.
(2) Data entry of new records including data presented in meeting papers and National Progress Reports at annual meetings of Scientific Committee, including sailing vessel cases from Ritter – priorities for entry to be established with the Steering Group.
(3) Further development of database handbook, ensuring that the database documentation remains up to date, is widely distributed and that any changes are notified to all actual/potential collaborators.
(4) Work with data review group to ensure that all new records are appropriately reviewed including identification of potential duplicate reports.

Annex K

Report of the Standing Working Group on Environmental Concerns

Members: Rowles (Convenor), Parsons (co-Convenor), Baulch, Bell, Bickham, Bjørge, Broker, Brownell, Chilvers, Collins, Cooke, Currey, Diallo, Double, Feindt-Herr, Fortuna, Funahashi, Gallego, Galletti, George, Hall, Holm, Iñíguez, Kaufman, Kim, Kitakado, Kock, Lang, Liebschner, Marzari, Murase, Nelson, New, Øien, Palacios, Palsbøll, Peres, Porter, Punt, Reeves, Ridoux, Ritter, Robbins, Roel, Rojas-Bracho, Rosa, Rose, Rosenbaum, Sakamoto, Santos, Scheidat, Scordino, Siciliano, Simmonds, Stachowitsch, Suydam, Tajima, Luna, Tamura, Víkingsson, Wade, Williams, Willson, Ylitalo.

1. INTRODUCTIONS

Rowles and Parsons welcomed the participants to the Standing Working Group on Environmental Concerns (SWG).

2. ELECTION OF CHAIR

Rowles and Parsons were elected as co-Chairs.

3. ADOPTION OF AGENDA

The adopted Agenda is given in Appendix 1.

4. APPOINTMENT OF RAPPORTEURS

Rosa, New and Ylitalo were appointed rapporteurs.

5. REVIEW OF AVAILABLE DOCUMENTS

SC/65a/E01-04, SC/65a/Rep06, SC/65a/BRG15, SC/65a/BRG23, SC/65a/0O3, SC/65a/O06-O07, SC/65a/O09, SC/65a/SCP01, SC/65a/SM27, SC/65a/HIM01, SC/F13/SP21-29, Hunt *et al.* (2013), Moore *et al.* (2013), Moore and Barco (2013), and Park *et al.* (2012).

6. SOCER: RECEIVE THE STATE OF THE CETACEAN ENVIRONMENT REPORT

The SOCER provides an annual update, requested by the Commission, on: (a) environmental matters that potentially affect cetaceans; and (b) developments in cetacean populations/species that reflect environmental issues. It is tailored for a non-scientific audience. The 2013 SOCER report, SC/65a/E01 (see Appendix 4) was restricted to the Mediterranean and Black Seas as the regional focus. This year the response to the request for papers was particularly strong and papers ranged widely in focus.

A number of publications were summarised, ranging from impacts of fisheries removals on cetacean prey to strategies aimed at reducing bycatch in the severely reduced population of common dolphin (*Delphinus delphis*). A second group of publications was focused on contaminants in Mediterranean cetaceans. The full range from mega- to microplastics was documented in two papers, one reporting on a sperm whale killed by ingesting large amounts of greenhouse cover material, a second indicating the presence of toxic compounds in the blubber of baleen whales, namely fin whales, that are known additives in plastics. Disease continued to be an important issue in the Mediterranean, with a first report of herpesvirus in Mediterranean cetaceans (striped dolphins; *Stenella coeruleoalba*), a first report of the simultaneous occurrence of *Morbillivirus* and *Toxoplasma gondii* in a baleen whale (fin whale), and unusual chronic *Morbillivirus* infections in the brains of striped dolphins. Finally, an overview published by ACCOBAMS identified the main threats to cetaceans in the Mediterranean and Black Seas as being fisheries interactions, shipping interactions, habitat loss, pollution and noise, direct killing and climate change and concluded that many of the problems preventing cetaceans from reaching a favourable conservation status would be adequately addressed if the range states simply fully implemented and enforced the multiple obligations to which they have already committed and that are already in force.

Globally, numerous studies on climate change suggested that previous predictions of the impacts of climate change were overly optimistic, as greater sea level rise and ice sheet melt have been observed than were predicted. Specifically for oceanic impacts, fish species are already showing climate-linked shifts in distribution; shifts that may have major impacts on communities of tropical cetaceans. Moreover, linked to climate change, ocean acidification is starting to show impacts on marine primary producers such as shelled pteropods and squid.

Data on the impacts of underwater noise are increasing, with a study linking common dolphin strandings to military exercise-associated noise, research showing stress hormone responses by North Atlantic right whales to shipping noise, and a study showing elevated heart and breathing rates in beluga whales exposed to noise, all possible indicators of physiological stress. Another morphometric modeling exercise indicated that minke whale hearing ranges have the potential to be impacted by anthropogenic sounds such as shipping and sonar systems (commercial and military). Thus, idata and predictions for models are becoming increasingly available on stress responses linked to underwater noise both in large whale species as well as smaller odontocetes.

During discussion, the SWG expressed concern about the impacts of ocean acidification on marine primary productivity, particularly in the Antarctic region. The discussion concluded with questions about how this report would be promoted, in light of the fact that this is not an IWC Commission meeting year. It was noted that the SOCER Report would be posted to the IWC website, and the Secretariat would circulate an email to appropriate parties to inform them of the posting and provide them with the web link to the report. The SWG thanked the SOCER editors for compiling this year's report and **encouraged** participation in the upcoming version. Next year the focus of the SOCER will be on the Atlantic Ocean region.

7. POLLUTION

7.1 Pollution 2000+

As a summary of the intersessional work that was completed on POLLUTION 2000+ Phase III initiative, the authors presented SC/65a/E04. The objective of this work was to develop a framework for assessing the health risks associated with contaminant exposure on cetacean *populations*. A large body of data now exists which demonstrates that persistent organic pollutants can impact immunity, thyroid homeostasis, skeletal integrity and reproductive hormones. At the population level it is important to know how these physiological effects ultimately reduce fecundity and survival. Descriptions of the first two phases of this work can be found in Hall *et al.* (2011; 2012). The framework is an individual-based model (IBM) in which the characteristics of each individual are tracked through time (see Fig. 1).

Using this stochastic model, the bioaccumulation of contaminants and their population level effects can be explored. The model integrates measured tissue concentrations with a dose-response relationship to estimate potential impact on population dynamics. The effects of PCB exposure on cetacean potential population growth rates (potential because density dependent effects are not included) are modelled. Thus, the model is first primed with an appropriate stable age structure and run for 100 years to estimate annual population growth rates (lambda). Using a dose-response curve from a large number of studies on a surrogate, sensitive model species, the mink, calf survival was modified in relation to maternal PCBs. Two scenarios and examples were demonstrated using this framework; bottlenose dolphin (*Tursiops truncatus*) and humpback whale (*Megaptera novaeangliae*). The model outputs were then compared with the empirical data. This approach assists in confirming the structural reality of the model. It also helps to ensure that models are general enough to be widely applicable, scientifically accurate and useful for allowing management decisions and priorities to be determined. One of the model outputs is the blubber PCBs concentrations in the females by age. Using a supporting dataset to test model assumptions for bottlenose dolphins, it was estimated that an annual accumulation of PCBs at 1.2mg/kg lipid would result in concentrations in the mature females at the level seen in the empirical dataset for the modelled Sarasota Bay, Florida population (Wells *et al.*, 2005). In addition similar data to test model assumptions for the example population of humpback whales in the Gulf of Maine were recently available. For this population an annual accumulation of 0.2mg/kg lipid would result in a mean concentration of 1.57mg/kg lipid which is similar to the level measured empirically (1.62mg/kg lipid). This exposure level would therefore produce no discernible effects on population growth. Indeed potential population growth rates did not decline until annual accumulation rates exceeded ~ >2mg/kg lipid.

Model parameter sensitivity and uncertainty analysis was also carried out to investigate the effect parameter uncertainty has on the results. How are the outputs related to the inputs, parameters and model assumptions? This is important for quite complex individual based models, especially where models are used in management decisions. As expected, uncertainty in vital rates showed that variation in adult survival had the largest effect on population growth rate estimates. In addition, the effect of uncertainty in the concentration-response functions showed that the estimated proportional reductions in population growth rate (lambda) varied between ~±1% for the bottlenose dolphin example and ~±4% for the humpback whale example. This suggests that the model is reasonably robust and would be acceptable for making population inferences and management decisions.

Finally, an approach that would allow concentrations of total blubber PCBs in cetaceans to be estimated from data on concentrations in their prey was explored. This would assist in situations where biopsy samples are not obtainable and would enable dose response data based on ingested concentrations to be used in the models in addition to those in which tissue concentrations were measured. In an example again using the bottlenose dolphins from the southeastern and southern US, data on energy requirements and consumption rates and on concentrations of total PCBs in prey were combined in a Physiologically Based Toxicokinetic Model (PBTK, Fig. 2). These compartmental PBTK models use ordinary differential equations to estimate the absorption, distribution, metabolism and excretion of the pollutants of interest. The 'IndustChemFate' model of Jongeneelen and ten Berge (2011) to investigate the applicability of this approach for the

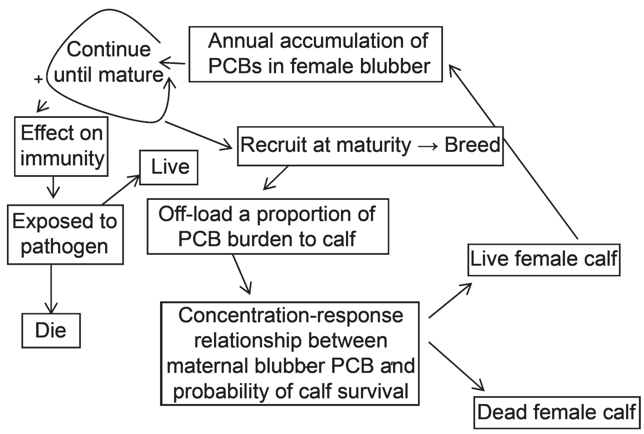

Fig. 1. Individual-based model (IBM) flow diagram incorporating calf survival and immune effects.

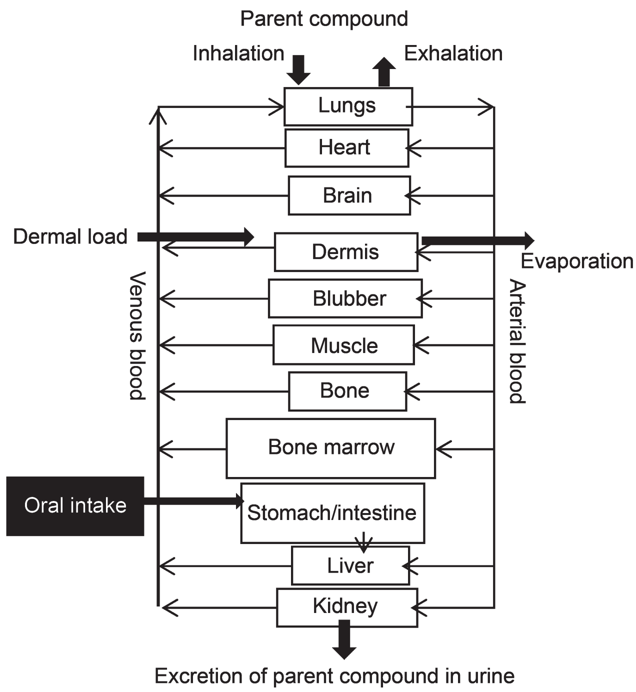

Fig. 2. The Physiologically Based Toxicokinetic Model (PBTK).

bottlenose dolphin example was used. Various physiological parameters for the dolphins and physico-chemical data for the PCBs were needed for the PBTK model. The model was run for one year and the estimated total blubber PCB concentrations reached a steady state after about 60 days. However, the increase in blubber concentration over time was not fully reflected in the model at this stage. Further information on the kinetic parameters of PCB metabolism in dolphins is needed to fully imitate the empirical data.

This joint IBM and PBTK modelling approach has provided a risk assessment tool that can be used to determine the population consequences of exposure to contaminants. The model framework has the potential for investigating the impact of a variety of stressors on cetaceans. In order to improve the reliability of the model there are a number of priority areas that have emerged. Obtaining reliable adult survival estimates for the underlying stable age structure is important. Further data on the relationship between the Concanavalin A (Con A) immune function assay and total blubber PCBs in bottlenose dolphins will be included in future as this will increase the precision in this relationship. Improved estimates of daily energetic requirements and fish consumption levels for wild animals would be helpful as would species-specific estimates of the kinetic constants for the metabolism of PCBs *in vitro*. The model framework, built using the open source program R, is currently being converted into a web-based program with a user-friendly interface that will be made available to the community and will be accessible from the IWC website.

The SWG inquired about the lack of control populations for comparisons and asked if any wild populations exist with 'zero' concentrations of PCBs. The author opined that is unlikely that PCB-free cetaceans exist anywhere in the wild. The SWG noted that exposures similar to those described in SC/65a/E04 can also cause population level genetic effects such as decreased diversity, direct gene mutation, etc. These impacts might also be modelled using similar data/models, as has been done in frogs and fish. The author expressed concerns about the level of uncertainty associated with impacts of parameter shifts in these areas on conservation biology and recommends modelling efforts be anchored in empirical data (i.e. knowledge of the genetic impacts of direct exposure to PCBs).

The SWG recognised the limitations related to the use of data derived from mink-based PCB exposure data as a surrogate for cetacean exposure. The author acknowledged the limitations of information from surrogate studies, but noted that the information that has been used (based on these models) is conservative and that it would be optimal to have a specific does-response relationship on cetaceans. However, the author suggests that results from mark-recapture and photo-ID studies in wild cetaceans, investigating contaminant concentrations in reproducing females to the subsequent survival of their calves, should enable the estimation of specific dose-response relationships for a number of cetacean species in future.

The SWG recognised that cetaceans are exposed to a mixture of environmental contaminants and that the issue of cumulative effects must be considered. The author noted that it is important that it is understood this paper presents a simplified approach. The SWG suggested that, if possible, mixtures of contaminants should be added to future modeling. The SWG **commended** the authors for the results presented on Pollution 2000+ Phase III objectives and **strongly supported** their continued work to develop the necessary tools to assess cetacean pollutant exposure risk. The SWG noted that the work would not have gone forward without the collaboration with researchers who collected and analysed samples of humpback whales and bottlenose dolphins. The Chair noted that the Pollution 2000+ Phase III risk assessment work plan is near completion and the effort has been an iterative process since its inception in in 1995.

The SWG discussed the next steps for IWC/SC pollution studies and developed a new work plan entitled Pollution 2020 (see Appendix 2).

The SWG **agreed** that Pollution 2020 would complete the web application for the risk assessment model and would focus on two new priority areas over the next few years: the toxicity of microplastics (see section on ingestion of marine debris in Item 11.2) and the impact of polycyclic aromatic hydrocarbons on cetaceans.

Based on information gained from the recent marine debris Workshop (see Workshop report summary in Item 11.2), the SWG identified the need to do a comprehensive review of the literature and write a background report on microplastics in collaboration with the international community studying marine debris. This would include the following sections:

(1) origin, fate and global distribution of microplastics to highlight potential high risk areas and therefore cetacean species, with particular emphasis on the importance of krill and copepods as vectors for transfer to cetaceans;
(2) an assessment of the toxic potential of the various chemical compounds associated with microplastics, summarising the current state of knowledge from laboratory animal models and human epidemiological studies;
(3) an assessment of the direct effects of microplastic ingestion and inhalation
(4) the utility of various matrices (e.g. skin, blubber, urine, faeces, blow etc.) for exposure determination;
(5) an assessment of the potential effect and/or biomarker measures;
(6) a list of the analytical techniques used to determine the direct ingestion of microplastics and the concentrations of their associated chemical compounds; and
(7) suggested research studies for prioritisation by the Pollution 2020 Steering Committee.

A second focus of Pollution 2020 will be polycyclic aromatic hydrocarbons and associated dispersants, given recent oil-spills, the potential impacts of oil exposure to cetacean habitats and populations, and the potential risk increasing as oil and gas exploration and shipping in the Arctic and possibly the sub-Antarctic expands. In discussion it was noted that, in the case of these oil-related compounds, their metabolism may be so rapid that it may not possible to detect exposure through tissue residue levels, either because the concentrations of the parent compound are so low; because they are exhaled rather than excreted in faeces and urine; or most probably because it would be more appropriate to monitor primary and secondary metabolites than parent compounds.

In order to move forward in the evaluation of PAH effects on cetaceans, the following work would be undertaken:

(1) Refine the PBTK model developed under phase III of Pollution 2000+ to allow researchers to determine which matrices would be most appropriate to look at (breath/blow, faeces or urine in live animals) and the likely time courses for excretion of the various metabolites given various exposure scenarios and depuration times; and

(2) Review the literature on dispersants with a view to recommendations for future research priorities.

The SWG thanked the Pollution 2020 steering group for their new work plan and **agreed** to the framework plan.

7.2 Oil-spill impacts and capacity building

Updates on the impacts of the Deepwater Horizon oil-spill to cetaceans were provided to the SWG. Following the Deepwater Horizon explosion and subsequent oil-spill on 20 April 2010, oil-spill response began followed immediately thereafter by a Natural Resource Damage Assessment (NRDA) to investigate the injuries and impacts to cetaceans (as one component of the overall assessment) in the Gulf of Mexico (GOM). As reported to SC/63 and SC/64 (IWC, 2011b; 2012a), the NRDA investigation has taken several paths over the last three years including:

(1) stranding response in the northern GOM;
(2) photo-id and biopsy surveys for bay, sound and estuarine dolphins in three sites across the northern GOM;
(3) aerial and boat-based surveys, including biopsy and tagging activities, for cetacean abundance and distribution in coastal and offshore habitats; and
(4) live capture release health assessments.

In addition, the investigation team has evaluated and used tools and techniques for assessing exposure and injury. Information about the NRDA process and restoration activities can be found online[1]. The following are updates on: (1) strandings; (2) health assessments; and (3) chemistry.

Strandings

As discussed at SC/63 (IWC, 2011a), an Unusual Mortality Event (UME) was declared in November 2010 for cetaceans in the northern Gulf of Mexico (Franklin County, Florida west through Louisiana) that started in February, 2010 and is still ongoing. The event includes over 1,000 cetaceans (86% bottlenose dolphins *Tursiops truncatus*) and has lasted more than 3 years. Statistical review of historically stranded dolphins in the Gulf of Mexico (1986-2011) was conducted. Large scale mortality years, years in which the number of stranded bottlenose dolphins by state exceeded the 90th percentile, included 2010 and 2011 for Louisiana; and 2011 for Alabama and Mississippi. Two distinct demographies within the UME include perinates (less than 115cm body length) in Alabama and Mississippi (early 2011) and non-perinates in Louisiana. Of 32 perinates investigated to date, 84% died in utero, 78% had fetal distress, and 63% had bacterial pneumonia, many of which were due to *Brucella*. Preliminary data suggest a diversity of genetic sequences of *Brucella* were present in this event. Among 28 fresh dead non-perinatal UME dolphins, 39% had death-associated bacterial pneumonia from a variety of pathogens, and 56% (5/9) of dolphins more than 190cm body length stranded near Barataria Bay, Louisiana had adrenal gland abnormalities (hypertrophy or cortical atrophy). Diagnostic tests to date do not support the UME cause to be morbillivirus or marine biotoxins, or *Brucella* among non-perinates. The Deepwater Horizon oil-spill has not been ruled out as a possible contributing factor to this UME, which is the longest lasting and largest dolphin mortality event in US recorded history. The undetermined etiology appears to have increased dolphins' susceptibilities to death-associated bacterial pneumonia, adrenal gland abnormalities, foetal distress and *Brucella*-associated abortions. Weekly updates continue to be posted on the website[2].

[1]*http://www.gulfspillrestoration.noaa.gov/oil-spill/.*
[2]*http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico2010.htm.*

Health assessments

In May 2011 (Sarasota Bay, Florida) and August 2011 (Barataria Bay, Louisiana), live-capture release health assessments were performed using standard capture techniques (Wells *et al.*, 2004) as part of the injury assessment activities. Long-term resident Sarasota Bay dolphins were used as a reference population for comparison with Barataria Bay dolphins, as Deepwater Horizon oil did not reach Sarasota Bay, but did enter Barataria Bay. Full physical examinations were performed, blood/faeces/swabs/urine/biopsy/tooth samples were collected for further analyses, and satellite and radio tags were placed on some animals captured in Barataria Bay. As reported previously, the animals in Barataria Bay showed significant health issues including pulmonary lesions and adrenal abnormalities as compared to animals in Sarasota Bay. Pulmonary ultrasonographic examinations were performed as previously described (Smith *et al.*, 2012), focusing on the left lung. Lung health was evaluated in 15 dolphins from Sarasota Bay, and characterised primarily as normal-mild lung disease (93%) with a low prevalence of moderate-severe lung disease (6.7%). This differed significantly from findings in the 28 dolphins evaluated in Barataria Bay, where dolphins were 4.8 times more likely to have moderate-severe lung disease (32%; p=0.054). Abnormalities detected in Sarasota Bay compared to Barataria Bay included: alveolar-interstitial syndrome (AIS; 60% vs. 61%), pulmonary nodules (33% vs. 32%), pleural effusion (6.7% vs. 11%), pulmonary consolidation (6.7% vs. 21%) and pulmonary masses (0% vs. 11%). When comparing severity of alveolar-interstitial syndrome (AIS) between the two populations, Barataria Bay dolphins were 3.5 times more likely to have moderate-severe AIS compared to Sarasota Bay dolphins (p=0.026). Pulmonary disease, particularly pneumonia, is the most common finding at death in both wild and managed dolphins (Baker, 1992; Bogomolni *et al.*, 2010; Cornaglia *et al.*, 2000; Di Guardo *et al.*, 1995; Venn-Watson *et al.*, 2012). Therefore, the high prevalence of lung disease detected in Barataria Bay should be considered cause for concern and warrants follow-up over time to determine the impact on overall population health.

The NRDA studies on cetaceans and their habitats continue along with other targeted species and ecosystem studies. In 2013, the stranding response efforts and investigations are continuing as both UME and NRDA investigations. In addition there are three live-capture release efforts underway for bay, sound and estuarine bottlenose dolphins: Sarasota Bay, FL (May 2013), Barataria Bay, LA (June 2013), and Mississippi Sound, MS (July 2013). Based on information gained from the previous work, additional blood, analytical and physical procedures will be conducted.

Chemistry

Chemical contaminant and biomarker analyses of various tissue and fluid samples collected from live capture bottlenose dolphins and stranded dolphins from the northern Gulf of Mexico have been completed. Polycyclic aromatic hydrocarbons (PAHs) were also determined in prey samples of marine mammals and sea turtles from the Gulf of Mexico to help determine PAH exposure via consumption of contaminated prey. Established analytical methods (Krahn *et al.*, 1984; Sloan *et al.*, 2005; Xu *et al.*, 2004) were used to measure PAHs, PAH metabolites and persistent organic pollutants in these samples, including a more recently developed liquid chromatography/tandem mass spectrometry method to determine levels of the dispersant component dioctyl sodium sulfosuccinate (Flurer *et al.*, 2011). These chemical data are currently being validated and will be reported in marine mammal reports and peer-reviewed manuscripts over the next year. In addition, as reported at the SC/64, the National Institute of Standards and Technology developed a vertebrate blood control material that was used in a 2011 inter-laboratory comparison exercise with the analytical laboratories performing vertebrate chemical contaminant blood analyses. The results of this inter-laboratory comparison exercise are available online[3].

During discussion, the SWG noted that, based on genetics data, the majority of stranded dolphins (87%) found in the Gulf of Mexico during the unusual mortality event are coastal animals. The SWG noted the difficulty in evaluating the population impacts of a spill when abundance and distribution information are not current or are completely lacking. The SWG expressed concern about underestimating the number of dolphins and whales from offshore populations that died as a result of the oil-spill due to the higher probability of recovering carcasses from coastal vs. offshore populations. Although the primary efforts in the Gulf are focused on coastal dolphin populations, a number of monitoring and assessment efforts have also been conducted in offshore areas, including photo-identification, acoustic and tagging studies, as well as aerial and boat based surveys. The SWG **expressed great concern** about the continued high dolphin strandings in 2013 and are encouraged that studies are continuing.

The SWG recognised the difficulty in attributing the GOM dolphin UME to the Deepwater Horizon oil-spill. In the US, the Natural Resource Damage Assessment (NRDA) process assesses the impacts or injuries to natural resources attributable to an oil-spill or to an oil-spill response activity but the entire process is focused on restoration. For the Deepwater Horizon oil-spill case, there are several websites that provide information on the NRDA investigations, restoration activities and proposals, and the RESTORE Act of 2012. For further information about restoring the Gulf of Mexico and restoration activities see online[4]. None of the proposed projects for early restoration thus far include restoration activities for marine mammals.

Mate provided comments to the SWG on baseline data for tagged sperm whales collected from 2002 to 2006 in the Gulf of Mexico. In addition, twelve whales were tagged in 2010 while the oil was still flowing during the Deepwater Horizon spill and, in summer 2011, another 24 animals were tagged. The study found that males have normally much larger home ranges than females, females tagged during the spill had larger home ranges than males, but their ranges were smaller than those recorded pre-spill. A similar trend was seen in 2011. Repeated sightings in 2011 and 2012 confirmed that the whales were in decent body condition and that calves were present in the local population. Mate indicated his concern that although the NRDA investigations are continuing and the case has not been settled, funds have not been available to all projects and restoration funds are only available for early restoration projects. Such funding gaps are problematic for studies that require multiple years to identify and evaluate the cumulative impacts or effects of toxicants.

The SWG **agreed** that funding gaps are problematic, recognising that three- to five-year funding cycles are not geared toward long-term monitoring projects, and will consider this issue in future discussions. The SWG thanked Mate for this update and recognised the value of having available pre-oil-spill baseline data, such as those collected for sperm whales in the Gulf of Mexico. There was much discussion on the findings of the study, including a question as to whether, although there may be a short-term increase positive effect to whales due to increased prey from the extra nutrient input, there might be a longer-term negative effect due to whales consuming oil-contaminated prey.

The SWG welcomed the new information on marine mammal studies in the GOM and **encouraged** scientists to provide restoration ideas to NOAA[5] related to cetaceans.

The SWG also received information related to Arctic oil-spill preparedness. It was noted that interest in oil and gas exploration and development in the Arctic is on the rise, as is marine shipping, thus, the likelihood of oil-spills is increasing. Prior exploration and limited development have occurred in Arctic regions, but recent spills in other areas, such as the Gulf of Mexico and the North Sea, have heightened awareness and concern regarding the adequacy of spill prevention and cleanup techniques in ice-infested waters, including those characterised by intact sea ice sheets, broken ice, and slushy conditions, especially during the spring and fall transitional periods. International development has occurred in Arctic regions, such as the Beaufort and Barents Sea, setting the stage for further exploration and development in the Arctic. Some believe these efforts to be examples of Arctic 'best practices'. However, the adequacy of oil-spill response is limited in the best of conditions irrespective of the complications of cleanup activities in sea ice. The true state of oil-spill preparedness in the Arctic is difficult to assess, as there are no global standards or adequate approaches for working in the Arctic that are adhered to by industry at this time.

Details were provided on the Arctic Council's efforts at bringing the Arctic States together to address oil-spill preparedness (and response), specifically, the legally binding instrument that was negotiated on oil-spill preparedness and response based on the 1990 International Convention on Oil Pollution Preparedness Response and Cooperation (OPRC), administered by the International Maritime Organization (IMO), to which all eight Arctic States are parties. The instrument, which is a regional multilateral agreement under the OPRC (Article 10), establishes a cooperative framework similar to the Arctic Search and Rescue Agreement[6].

Additionally, the SWG was given details on the US National Research Council's review of the capabilities, limitations, and needs for responding to an oil-spill in the Arctic[7], as well as the US Arctic Research Commission's recently published white paper examining the state of oil-spill preparedness, response and damage assessment in the Arctic[8].

The SWG also noted that, with an increased potential for oil-spills, coastal communities of the Bering and Anadyr straits are seeking ways to protect their health and safety, as well as their long-term cultural practices. This includes developing their own capacity to act as first responders in the event of an accident, either to keep oil away from key habitats and wildlife or to keep wildlife away from a spill. Large response gaps are inevitable in these remote communities before larger, specialised spill response entities arrive at an incident location in the maritime Arctic. Community leaders

[3]*http://nvlpubs.nist.gov/nistpubs/ir/2012/NIST.IR.7869.pdf.*
[4]*http://www.restorethegulf.gov* and *http://www.gulfspillrestoration.noaa.gov.*
[5]*http://www.restorethegulf.gov/.*
[6]*http://www.arctic-council.org/index.php/en/resources/news-and-press/press-room/733-press-release-15-May-Kirvna-z.*
[7]*http://dels.nas.edu/study-in-progress/responding-spills-arctic/DELS-OBS-09-02.*
[8]*http://www.arctic.gov/publicatiions/oil_spills.2012.html.*

in the Bering and Anadyr straits want to better understand what community members – including experienced hunters – can do if they are given the proper equipment and training to safely and effectively protect their coastal environment and the wildlife that they have always relied upon. A workshop organised by the Wildlife Conservation Society is being held in Anchorage in November 2013 to advance the understanding and establishment of strategic next steps in preparing local first responders[9].

The SWG noted that in the upcoming year, several Workshops focused on Arctic resource development and policy will be held. Developing recommendations related to cetacean conservation and management may provide the Convenors of these Workshops with information necessary for sound decision-making. The SWG reiterated its previous conclusion (IWC, 2011b) that a review of the capacity for oil-spill response in the Arctic was an urgent priority in the aftermath of the Deepwater Horizon oil-spill (IWC, 2012a) and that the Scientific Committee **concluded** that it would be useful to know more about the current capacities and mechanisms of oil-spill recovery. Given the amount of activity occurring related to oil-spill preparedness and the fact that oil-spill preparedness and response plans are being developed, the SWG **recommended** an increased exchange of information between the IWC Secretariat and the Arctic Council Emergency Prevention, Preparedness, and Response Working Group (EPPR WG). The SWG asks the Secretariat to communicate to the Arctic Council that the SWG would be pleased to offer guidance on cetacean conservation efforts related to oil-spill prevention, preparedness and response including best management practices.

7.3 Other pollution related issues

7.3.1 Resolution on IWC/WHO coordination

In response to the statement in Resolution 2012-1 (IWC, 2013a) encouraging the World Health Organization (WHO) to conduct reviews of recent scientific publications regarding contaminants in certain cetacean products and give updated advice for consumers the SWG **recommended** that the IWC Secretariat reinitiate discussions with the WHO as a preliminary step, to ensure that they are in need of this information and would be willing to receive it, prior to moving forward on this item.

7.3.2 New techniques for exposure and effects assessments

Following on from the SORP/IWC workshop on Living Whales in the Southern Ocean in 2012 in which recent advances in methods for non-lethal sampling were discussed (Baker *et al.*, 2012), the US National Marine Fisheries Service convened a workshop to further consider and discuss blow or breath sampling in cetaceans for monitoring their health and physiological status. The workshop then expanded into a paper by Hunt *et al*, published in *Conservation Physiology* (Hunt *et al.*, 2013).

Of relevance to studying the impact of pollutant exposure on cetaceans is the fact that many of these samples can be used to determine both the exposure of animals to pollutants and their response to that exposure. Due to recent advances in analytical techniques and sample collection methods, a variety of non-invasive (such as faeces and blow) or minimally invasive (such as blubber and skin biopsies) samples from large whales can be used to determine levels of pollutants or their metabolites indicative of exposure as well as applicable physiological response measures. The paper focuses on the methods that will produce information on parameters such as measures relevant to stress physiology, reproductive status, nutritional status, immune response, health, and disease. For example faecal samples are increasingly used for hormonal analyses, as well as for assessment of exposure to toxins, pollutants, and parasites. Blow samples contain many hormones as well as a diverse array of metabolites, and a variety of immune-related substances. Biopsy dart samples are now being used for endocrine studies along with proteomic and transcriptomic analyses. Field application of these techniques has the potential to improve our understanding of the physiology of large whales, better enabling assessment of the relative impacts of many anthropogenic as well as ecological pressures.

The Chair thanked the authors for their presentations. The SWG **commended** the compilation of recent advances in methods for non-lethal sample (see Table 1), noting that information on stress physiology, reproductive status, nutritional status, immune response, health, and disease are highly valuable to health assessment efforts. The SWG **endorsed** this work and **strongly recommended** further development and improvement of these methodologies.

As previously reported (IWC, 2011a), biopsy sampling is an integral element of tagging effort, for determining the sex of gray whales for which the sex is not already known and, for tagged females, to provide valuable information on reproductive status using hormone analyses as long as the sample is preserved frozen. In SC/65a/BRG23, progress of a program funded by Exxon Mobil to analyse biopsy samples of gray whales feeding off Sakhalin Island, Russia was reported. The biopsy analyses included: (1) pregnancy testing using a progesterone enzyme immunoassay; (2) determination of stable isotope ratios for carbon, nitrogen, and either mercury or sulfur; and (3) genetics, including molecular sexing and mitochondrial DNA (control region, CR, and cytochrome *b*, cyt *b*) analysis. Six western Gray whale biopsy samples (WGW 011, 019, 119, 129, 139, and 141) were collected off Sakhalin Island, Russia, in the fall of 2011. These included a single male (WGW139) and five females with four CR haplotypes and three cyt *b* haplotypes. The four CR haplotypes (A, AI, B, E) have all been previously reported in western gray whales. Optimisation of pregnancy testing in this species, using a progesterone enzyme immunoassay, is underway using eastern gray whale samples obtained from The Marine Mammal Center. Biopsy samples collected from the gray whales will be analysed upon completion of assay optimisation and validation. Stable isotope analyses are currently underway.

During discussion, the author was asked if stress hormones would be included as part of these analyses. There was also a question asked about the situation surrounding the four stranded animals mentioned in the study. It was noted that this information was possible to obtain by pulling the records related to these animals. The SWG thanked the authors and **commended** the application of such techniques to the gray whales feeding off Sakhalin Island, Russia.

7.3.3 Icelandic Special Permit Review

At the request of the Secretariat, the SWG received pollutant-related papers associated with the Icelandic Research Program and a summary of the findings of these studies was presented to the SWG.

In paper SC/F13/SP23rev, levels of 11 trace elements were determined in various tissues of common minke whales (*Balaenoptera acutorostrata*) from Icelandic waters. Trace element concentrations in muscle samples varied based on

[9]*http://www.wcsnorthamerica.org/WildPlaces/ArcticAlaska.aspx.*

Table 1

Comparison of techniques currently available for study of conservation physiology of large whales (adapted from Hunt *et al.* 2013).

Sample type	Typical collection methods	Typical sampling rate	Positive aspects	Potential limitations	Information relevant to conservation physiology
Faeces	Locate visually or with dog Surface collection with scoop or net; sub-surface collection with divers	Low without dog Medium with dog	Non-invasive Extremely high steroid content (easily detectable) Well-established steroid hormone techniques Long sampling time frame may enable study of chronic stress Repeated sampling possible	Low sampling rate Targeted sampling difficult Individual not always known (cannot always be genotyped due to DNA degradation) Cannot sample fasting seasons	Diet analysis Endoparasites Fatty acid and stable isotope analysis of diet Toxin exposure (e.g. domoic acid) Gut microbiome and relationships to stress, immunity and disease Some immunoglobins and other hormones may be detectable (?)
Respiratory vapour ('blow')	Pole-based samplers Remote-controlled devices possible (?) Different methods for droplets, exhaled breath condensate, and gases	Medium	Non-invasive Targeted biomarker sampling possible Repeated sampling possible Wide range of metabolites can be studied simultaneously	Novel technique, many validations remain to be done Target biomarkers at trace concentrations Advances detection strategies needed for quantitative analysis	Several hormones detectable May contain large variety of other detectable compounds (?) May be proxy for blood, as has been observed in human studies Respiratory microbiome Host immune response
Epithelium and blubber biopsies	Biopsy dart used with crossbow, pole or pneumatic rifle Sloughed skin may also be collected	Medium/high	Good sampling rate Many archived samples available Tissue sample	Invasive, causes small wound Permit restrictions Repeated sampling not possible	Lipophilic hormones in blubber Lipid/fatty acid analysis, contaminant load (POPs), diet, age, etc.

sampling sites on the whales. Mercury showed a significant linear increase with whale length for all tissues analysed. The authors reported that Icelandic whales had higher hepatic and renal levels of cadmium compared to those reported in other North Atlantic stocks but were lower than those found in Antarctic minke whales (*Balaenoptera bonarensis*). Mercury was the only element found to be linearly correlated among all the tissue types, with a 1:1 relationship observed between skin and muscle. The authors concluded that, for Icelandic minke whales, skin biopsies are generally not valid predictors of trace element concentrations in internal organs except for total mercury in muscle.

In another paper (SC/F13/SP22rev), legacy POPs, as well as the polybrominated diphenyl ether (PBDE) flame retardants, were measured in various tissues of Icelandic minke whales. Differences in the relative contribution of POP classes and POPs ratios based on tissue type were found. In general, POPs measured in the various tissue types were not affected by either sex or length, except certain POP classes determined in liver. Icelandic minke whales had lower POP concentrations (except for toxaphenes) compared to the other North Atlantic whales. The results of linear regression analyses of POPs in the various tissues indicated that for biopsies and blubber cores, there are strong 1:1 relationships for measured levels of HCB, b-HCH, p,p'-DDT, o,p'-DDT and toxaphene 26. For other POPs, biopsies provide good estimates of POP levels in blubber cores but not for the other tissues.

In SC/F13/SP21, the PBDE flame retardants were measured in minke whales and other marine mammal species by Rotander *et al.* (2012b). They reported that the highest PBDE levels were measured in toothed whale species from the North Atlantic, and the lowest levels were found in fin whales and ringed seals. In SC/F13/SP22rev, methoxylated polybrominated diphenyl ethers (MeO-PBDEs) were also measured in these marine mammals and, similar to the PBDE findings, toothed whales had the highest levels of these compounds (Rotander *et al.*, 2012a). The lowest levels of MeO-PBDEs were found in tissues of fin whales (*Balaenoptera physalus*) and ringed seals (*Phoca hispida*). In SC/F13/SP26, Dam *et al.* (2013) describe a Nordic study that reported on concentrations of 'new' contaminants measured in minke whales and five other marine mammal species from the North Atlantic and Arctic regions over a period of three decades. The temporal trend analysis of BFRs showed that the levels of Σ10 PBDEs increased from the 1980s to the late 1990s but thereafter declined during the first part of the 2000s. In SC/F13/SP30 the authors found the levels of Cesium-137 in muscle of Icelandic minke whales from 2003-04 to be significantly lower than those found off Greenland, Norway, and the North Sea, but similar to minke whales around Svalbard.

In discussion, the SWG noted the utility of measuring trace elements in various tissues of the same animal and commented on the unusually high levels of lipids determined in biopsy samples of minke whales. The SWG also remarked on the high levels of cadmium in minke whale tissues and wondered if it might be related to natural geophysical exposures. The SWG provided the following comments and suggestions on the Iceland Research Program papers: (1) discuss the potential of dietary differences or foraging areas contributing to differences in concentrations of trace metals (e.g. cadmium); (2) include both mean and standard errors values in contaminant and trace element concentration tables; (3) link body condition information with other health assessment data; and (4) examine differences in lipid content of minke whales based on sampling year.

However, concern was raised by the SWG about the large volume of papers, the lack of toxicology technical experts, and the short-time available to review Iceland's pollution papers. Some participants commented that they did not believe that the studies reported met any pressing need and baseline contamination levels in minke whales could have been achieved by non-lethal research. The SWG thanked the Icelandic delegation for summarising the papers for the SWG.

8. CETACEAN EMERGING AND RESURGING DISEASES (CERD) AND MORTALITY EVENTS

8.1 Update from the CERD Working Group

Rosa presented an update to the CERD work plan agreed to at SC/63 (IWC, 2012b), which included:

(1) identification of regional and national experts/points of contact via Steering Committee membership;
(2) creation of a listserve and a website;
(3) creation of a Framework Document; and
(4) identification of and contact with organisations synergistic with the goals of CERD.

Tasks (1) and (4) were largely completed during SC/64. Since SC/64, the CERD working group (WG) has made significant progress on the website but the final website has not yet been completed and it was noted that image resolution capabilities in the current software limit usefulness for image analyses of skin lesions. Task 3 is still outstanding.

8.2 CERD website and work plan

An update on website progress that focused mainly on the population of the website with disease-related data was provided to the SWG. Data on infectious and non-infectious diseases have been compiled and await entry onto the website. This includes information on general cetacean disease (e.g. viral, bacterial, fungal, parasitic, etc.), as well as nutritional disorders and biotoxins. Additional input is needed on skin diseases, visual health assessment and mortality events or unusual mortality events (UMEs). It is expected that the discussion board will be functional in the near future (1-2 months). The SWG thanked the CERD working group for their efforts on developing the website and **strongly encouraged** further development of this tool.

The SWG **agreed** that supporting the aggregation of website information and input was crucial to maintaining website momentum and completing the project. In discussion there were several ideas suggested related to this, including the possibility of an internship program with projects aimed at expanding specific sections of the website (skin diseases, mortality events and visual health assessment). The oversight of these interns would occur through the members of the CERD steering committee. The SWG **agreed** that supporting interns to assist with the content and organisation of the website and the ability to post and manipulate high resolution images and video are critical to website success and that an upgrade to the current software was essential for the CERD, entanglement and ship strike websites.

The SWG also **agreed** that there was value in linking to social websites in order to direct inquiries and information to the IWC CERD website (for appropriate material).

The Marine Debris Workshop report (SC/65a/Rep06) **recommended** that a marine debris component that focuses on the impacts related to ingestion and inhalation of microplastics and debris (with the other cases being cross referenced with the entanglement website) be added to the CERD website. The SWG proposed that the marine debris website progress and planning be taken up next year after CERD website is more fully functional and there is appropriate time to evaluate exactly what will be needed for that portion of the website. There was also discussion of developing a Pollution 2020 website which will host the web portal for the risk assessment model.

The SWG **commended** Rosa and the CERD working group members for their progress and their planning efforts at SC/65a and **strongly supported** their continued work to develop an interactive website.

8.3 Strandings and mortality events

Information on a number of mortality and mass stranding events (MSE) events was presented to the SWG.

SC/65a/SM27 reported on an MSE involving short-beaked common dolphins (*Delphinus delphis*) in Rio de Janeiro and speculated on the potential causes. In 2012, 20-30 animals stranded on a beach at Arraial do Cabo, Rio de Janeiro State, Brazil. In video footage collected by bystanders, the school of dolphins can be seen swimming straight onto the beach, but as soon as the dolphins stranded, tourists returned the animals back to the sea. It is assumed that all the dolphins were successfully returned to the water as no dead animals were found or reported from the area after the MSE, nor were any dead dolphins reported in the Cabo Frio region in the weeks following the MSE. Although there were no acoustic recordings at the time of this MSE to determine if any high intensity anthropogenic sounds were present in the general vicinity of this stranding, there were no predators seen in the area on that day and there were no geographical factors that could explain the stranding event. The authors, therefore, propose that these pelagic dolphins were likely acoustically trapped or restricted by some noise source at the mouth of Enseada da Prainha. This MSE was most probably induced by some additional acoustic event that caused them to panic/stampede and swim toward the beach and strand.

During the discussion that followed, Brownell noted the difficulty in figuring out potential anthropogenic causes after the fact and added that there is great value in gathering information as quickly as possible immediately following the event. A member noted that this event seemed similar to the published paper summarised in the SOCER (see Appendix 4). Jepson *et al.* (2013) reporting a mass stranding event of common dolphins in the UK in 2008. The authors noted that there was a potential for the involvement of military training exercises given the timing of sound-producing naval and helicopter activities and the fact that most other feasible causes have been ruled out.

Brownell then reported on an International Workshop for Capacity Building on Marine Mammal Stranding (NOAA-IMARPE; 18-22 March). The Government of Peru requested this workshop to assist them in building capacity for cetacean stranding response after a large die-off of common dolphins occurred in the early part of 2012, in northern Peru. This workshop generated a lot of interest and exceeded the expectations on both sides in terms of public participation of government agencies, universities and NGOs. The first day was spent discussing stranding network capacity. Fifty-four people from 28 different institutions participated in the workshop. On 20-21 March, 'hands-on' stranding response training took place.

Additional information on strandings and the detection of human-induced mortality was provided to a joint meeting of the Environmental Concerns SWG and the Human-Induced Mortality SWG. Two papers on categorisation of human induced trauma and interactions in cetaceans (Moore and Barco, 2013; Moore *et al.*, 2013) were presented by Moore (via 'webinar') and Rowles. Summaries of these papers can be found in Item 6 of the Human Induced Mortality report (Annex J).

SC/65a/BRG15 reported on a workshop dealing with the ongoing southern right whale (*Eubalaena australis*) die-off at Península Valdés, Argentina. The workshop was held during the Annual Conference of the International Association for Aquatic Animal Medicine on 23 April 2013. Details of the workshop discussion and recommendations can be found in SC/65a/BRG15. A previous IWC Workshop on the southern right whale die-off in 2010 (IWC, 2011c) developed three primary hypotheses to explain the high calf mortality: nutritional stress; biotoxins; or infectious disease; or a combination of these factors. That report drew attention to the increasing incidence of parasitic behaviour of kelp gulls (*Larus dominicanus*), which peck at the outer skin and then feed on the blubber of live whales at Península Valdés, and recommended that management measures be taken with respect to kelp gulls displaying this behaviour. The Workshop's review of findings since 2010 found no consistent gross or histological findings, or ancillary diagnostic results, from the stranding, necropsy and diagnostic investigations from 2003-11 within or between years to explain the recurrent annual deaths at Península Valdés. No clear temporal associations between plankton blooms and mortality patterns have been identified and significant biotoxin or contaminant levels have not been found. Further investigations of possible hormonal and metabolite evidence of malnutrition are ongoing. The most consistent pattern in the gross necropsy findings was the presence of gull attack lesions.

In light of the strong signal of gull attacks as a unique, increasing, and acute element of the life-cycle of young right whale calves at Península Valdés, workshop participants focused on the possible mechanisms by which gull attacks could lead to death of right whale calves. Participants considered that the physical injury of extensive gull lesions can compromise the integrity and impermeability of the whale's surface layers and lead to dehydration, loss of thermoregulatory capacity, and increased energy outlay to wound healing and metabolic stasis. Behavioural consequences include increased high-energy reaction or flight and reduced time resting and suckling. The workshop developed an additional hypothesis on the possible contribution of gull attacks to calf mortality at Península Valdés, preliminarily stated as: high levels of harassment by kelp gulls that peck on a calf's exposed skin and then feed on the underlying blubber; which in turn causes significant physical injuries energetically expensive avoidance behaviour, and reductions in suckling time. This syndrome may result in, *inter alia,* decreased food intake, increased energy expenditure, exhaustion, catabolism, dehydration, and thermoregulatory stress, with cumulative and cascading effects that can lead to calf death. Some participants suggested that an increasing factor of gull-attack mortality might be additive to the 'normal' increase in the number of calf deaths associated with the rate of population increase over the last several decades. Workshop participants committed to further development of the gull-attack hypothesis and exploration of the possible contribution of injury, behavioural, and nutritional elements of gull attacks to calf decline and death, to guide analyses of previous gull attack observations, and to assist in future research.

The SWG thanked the authors for this important workshop report and **commended** the investigative team in Argentina for their tremendous and very thorough investigation. The SWG expressed concern with the high mortalities and **encouraged** continued work to evaluate the cause(s) of these mortalities, the implications to this population, and the effectiveness of planned gull mitigation measures.

Park *et al.* (2012) provided information on a mass mortality of finless porpoises *Neophocaena asiaeorientalis* that occurred on 3 February 2011 at a dyke in the Saemangeum Sea, Korea. A total of 249 carcasses were collected from those that had been stranded adjacent to a sea dyke and had floated into the lagoon formed by the dyke. Eight bodies were measured, and four of these were dissected to analyse stomach contents. The blubber thicknesses of five bodies were compared with those of finless porpoises caught in the Yellow Sea from 2010. Finless porpoises at the Saemangeum Sea dyke exhibited better nutritive conditions than finless porpoises in the Yellow Sea. The air temperature in January 2011 was significantly lower than the prior five-year average ($p<0.05$). Water temperature when the mass mortality occurred was lower than values observed in 2009 and 2010: values below 0°C had been recorded, and the majority of the dyke lake had frozen over. The mass mortality event of finless porpoises may have been due to the unusually low temperatures freezing surface water in the enclosed area and the animals died of suffocation.

The SWG inquired as to the subsequent presence of finless porpoises in this area. The author stated that no animals were seen that winter, but that some were seen in 2012 (n=9) and more were seen in 2013 (n=12). When asked about ideas on how to prevent this sort of mortality, the author noted that testing pingers to keep porpoises from coming inside the dyke areas might be a useful research pursuit. When asked if the water would have frozen had there been no dykes, the author felt that the water would have frozen even if there had not been dykes, as many areas without dykes also froze in nearby areas. However, the author noted porpoises may have been able to escape more easily if there had been no dykes. It was noted that similar events have occurred in the USA in bottlenose dolphins when bays/estuaries have abrupt drops in temperatures or freeze over quickly or unexpectedly. The SWG **expressed concern** about this mass mortality event, especially with respect to the potential impact of dykes and **encouraged** the continued evaluation of animals in this area. The SWG thanked the authors for this paper and for the efforts made to investigate the stranding event.

The SWG also received an update on a highly unusual event involving the long-term displacement and mass stranding of approximately 100 melon-headed whales (*Peponocephala electra*) that occurred in May-June 2008 in the Loza Lagoon system in northwest Madagascar. A coordinated effort was organised for response to live animals, and to collect information through samples from stranded animals and a structured interview process. This mass stranding response involved local officials and citizens, conservation organisations, oil and gas exploration companies working in the area, and international marine mammal experts. Despite the remote location of the stranding event and the challenging logistics, field efforts were mounted within days and a significant amount of information about the stranding event was collected.

Following initial efforts to systematically analyse this information in 2008 and 2009, a formalised process for investigating the known facts associated with this event was established in 2012 through a partnership among many of the organisations involved in the mass stranding response effort, the IWC, and US federal agencies with relevant expertise and interest in the event; this process was undertaken in direct communication with the government of Madagascar. An Independent Scientific Review Panel (ISRP) reviewed all available information provided by responders and those analysing the events. Following a face-face meeting of the

ISRP with information providers, all potential primary or secondary factors potentially contributing to this atypical mass stranding were considered relative to all available information given to the ISRP. The intention was for the report to be finalised, translated into French, and ready for public release as a scientific paper at this IWC meeting. While nearing completion, these processes are not yet finalised. The report, along with supporting information on various aspects of the stranding and investigation, will be made available through the IWC website and an announcement of its availability will be posted on MARMAM listserve. It is expected that this will occur within a period of several months from today.

The SWG **commended** industry and response organisations for a tremendous and successful effort in responding to and investigating this event. A report of this event will be reviewed by the SWG at next year's meeting.

8.4 Other disease related issues

At the request of the Secretariat, the SWG received disease-related papers associated with the Icelandic Research Program and a summary of the findings of these studies was presented to the SWG. The contaminant related papers are in Item 7.3.2 (Icelandic Special Permit Review) of this report.

In SC/F13/SP27rev (Olafsdóttir and Shinn, 2013), the authors reported that a total of seven epibiotic species were found in Icelandic minke whales with prevalence varying 0.5 to 11.9%, with the most common one being the caligid copepod *Caligus elongatus*. The mean intensity of epibiotic macrofauna varied from one to 95.5, with the highest value being observed for the caligid copepod *Caligus elongatus*. No significant relationship was observed between parasite intensity and host body length for either *C. balaenopterae* or *C. elongatus*, while the proportion of infected hosts increased from early to late summer for *C. Balaenopterae*. Importantly, this study is the first known record of *C. elongatus* on a cetacean host.

SC/F13/SP28 reported the findings of Anisakids complex investigation in Icelandic minke whales. More than 90% of the whales were infected with Anisakids. Using a subsample of 16 whales, the prevalence was determined to be 87.5% and was not significantly different from that observed in 1977-78 collected samples. Most of the whales had less than 1 kg of nematode worms in the combined stomachs, but the maximum infestation rate was 112kg. Mean (±SD) abundance of anisakid nematodes in minke whales was 11.813±2.697 and calculated intensity of infection varied from 23 to over 1.3 million nematodes.

Results of gross pathology, histo- and haemological findings and bacterial examinations of Icelandic common minke whales were presented in SC/F13/SP29. The gross pathological and histopathological findings in the studied animals were sporadic, usually mild and mainly due to parasite infestations. No pathological lesions associated with infections with bacteria or viruses were found nor were pathogenic bacteria isolated from blood and major organs of these animals. The authors speculated that the parasite cysts found in the testes of the majority of the males animals dissected could have an impact on male fertility. Overall, all animals examined were found to be in normal condition and with a healthy appearance.

In discussion, the SWG noted the large number of parasites (up to 112kg) found in the stomachs of minke whales and expressed concern that such large parasite burdens may pose a health risk. In addition, the SWG recognised that cystic lesions noted in minke whale testes (likely parasite-related) could impact minke whale recruitment. The SWG noted the presence of microbes that did not appear to be coincident with clinical disease. The SWG noted that some seemingly harmless microbes may become pathogenic and cause clinical disease under certain stressful circumstances (e.g. viral disease, prey shifts due to climate change). The SWG appreciated the Icelandic delegation presenting their findings.

9. EFFECTS OF ANTHROPOGENIC SOUND ON CETACEANS AND APPROACHES TO MITIGATE THESE EFFECTS

9.1 New information on the effects of anthropogenic sound on cetaceans

Ritter presented SC/65a/HIM01, dealing with underwater bow-radiated ship noise in the Canary Islands (Spain), where a large fleet of commercial ferries operates on a year-round basis (up to 17,000 inter-island transects per year), and at the same time a high number of stranded cetacean carcasses in the area have shown injuries typically attributed to ship strikes. Recordings of underwater sound were made during September 2012 off the island of La Gomera after the recording vessel was positioned in the projected track of an approaching ferry. The frequency response of the recording system was 0.009-96 kHz, while real time information on ferries such as, distance to the recording vessel and speed were obtained from an automatic identification system (AIS) receiver.

Three different ferry types characterised by propulsion type and cruising speed were recorded: a regular ferry (propeller driven, travel speed: 15kn), a fast ferry (propeller driven, travel speed: 20-25kn), and a jet driven high-speed ferry (travel speed: 30-35kn). Spectral analysis of received noise levels (RLs) was performed for frequency bands at 0.5, 1, 5, 10, 15, 20, 25, 30, 50 and 90kHz. To calculate RLs of ferry noise above background noise (=critical ratio exceedance; CRE), RL of ambient noise was subtracted from the corresponding RL of frequency bands attributed to ferry noise. Peak frequencies at CRE (CR=10dB) differed between the propeller-driven ferries (1kHz) and the jet-driven high-speed ferry (5kHz). By applying a CR of 10dB, the fast ferry hypothetically was detectable at a distance of 1.67km which results in a remaining time of 2.53min to a potential collision from the distance at CRE. The regular ferry could be detected at a distance of 1.61km (remaining time: 3.50min) and the high-speed ferry at a distance of 1.37km (remaining time: 1.30min). However, increasing CR from 10dB to 20dB had a dramatic effect on the results, as the remaining time from CRE to potential collision was reduced for the fast ferry by 65% and for the regular ferry by 75%.

Each ferry type showed a unique frequency- and distance-specific energy content signature. These acoustic signatures might enable their (individual) recognition by the whales. It could be shown that the frequency bands of 1, 5 and 10kHz are essential in detecting ferries from a distance. Depending on ferry type and distance, absolute RLs ranged from 59.1 to 76.1dB for peak frequencies. The results made the authors speculate that RLs of the peak frequencies at CREs measured during this study could be above the hearing thresholds of pygmy sperm (*Kogia breviceps*) and short-finned pilot whales (*Globicephala macrorhynchus*) but below the thresholds of sperm whales (*Physeter macrocephalus*). Those belong to the species most affected by ship strikes in the Canary Islands. Compared to their swimming speeds, the calculated time frames appear to be long enough for an avoidance reaction for each of those species. However, factors affecting collision risk include animals being inexperienced or distracted by certain behaviours such as resting, foraging, or socialising. These behaviours can be gender or age-class specific, and younger animals would be more vulnerable. To summarise, this study showed that whales may be capable of hearing approaching vessels at reasonable distances enabling them to react fast enough, however there are numerous factors to be considered in evaluating the actual collision risk. The calculated remaining time frames to a potential collision probably represent overestimations. It is concluded that jet-driven ferries traveling at high speed, combined with its comparably low intensity bow-radiated noise, results in an especially high risk of collision. Overall, ferry traffic appears to significantly contribute to noise pollution in the Canary Island archipelago.

In discussion, the author noted that the sperm whales do not appear to react quickly (e.g. avoidance) to ferries in the Canary Island region, in spite of the underwater noise that the vessels produce. Hearing loss has been documented in various species of cetaceans, including sperm whales, potentially making these animals more vulnerable to vessel collisions. The SWG thanked the authors for presenting these findings.

In SC/65a/E03, the authors reported that significant progress has been made on the issue of marine noise pollution in recent years. They noted that marine noise pollution had first emerged as an issue that required regulation and management in the 1990s. Various matters came together during this period, including various atypical live strandings of groups of beaked and other whales, particularly repeated stranding events on the shores of the Canary Islands, raising suspicion that marine noise could be having a greater impact than previously thought. Within a few years, some regional conventions had acknowledged the significance of marine noise pollution to their interests, and later other legislative measures such as the EU Marine Strategy Framework Directive, which specifically addresses noise, were developed.

One milestone on the road to addressing noise pollution was the substantive review conducted by the US Marine Mammal Commission (Marine Mammal Commission, 2007). Among the Commission's recommendations were: (i) the establishment of a coordinated national research program on the effects of anthropogenic sound on marine mammals and the marine environment; (ii) the establishment of consistent standards for the regulation of sound in the marine environment; and (iii) the promotion of US leadership in international matters related to anthropogenic sound in the marine environment. Importantly, in recent years, the USA's Marine Mammal Protection Act's regulatory scheme has increasingly been applied to major producers of ocean noise, to the point where most 'incidental take' authorisations issued under the Act are at least partly, and in many cases are primarily, focused on acoustic impacts (Roman *et al.*, 2013).

In addition, this area of research is growing and any appropriate search with a web browser will now find many hundreds of scientific papers concerning noise in the marine environment. For some time much of this research was focused on physical impacts on cetaceans, especially their hearing and ears and the causes of atypical strandings. Emphasis has been given to introduced sounds within the frequency ranges that cetaceans use to vocalise but, very recently, research has shown that sounds outside of this range may also be important and attention has also expanded to include behavioural effects of noise exposures (e.g. Melcon *et al.*, 2012).

New tools are under development to assess cumulative effects. For example, the US National Marine Fisheries Service (NMFS) has produced cumulative noise and cetacean distribution maps covering, in varying degrees of resolution, the entire US EEZ, and Roman *et al.* (2013) comment that 'these maps could well become a transformative tool for cetacean management' (p.44). In recent decades, the emergence of Marine Spatial Planning and Marine Protected Areas to help manage potentially damaging activities at sea have been seen, and these are usually twinned with environmental assessment, which increasingly encompasses consideration of noise and disturbance. There has also been an increase in investment by industry in noise reduction and alternative technologies (Roman *et al.*, 2013). In general, however, regulators have still not emerged from their nearly exclusive focus on safety zone maintenance – a measure whose limitations are widely acknowledged (e.g. Barlow and Gisiner, 2006; Parsons *et al.*, 2008, J. Lubchenco, NOAA Administrator, pers. comm. to N. Sutley, Chair of the Council on Environmental Quality, 19 January 2010) – as their primary means of noise mitigation.

For at least some noise sources, there seems to be a general consensus that time-area closures represent one of the most effective available means of reducing impacts on marine mammals. Such closures have been enacted for some areas. For example, there have been no mass strandings on the Canary Islands since the Spanish government imposed a moratorium on naval exercises in the waters of these islands in 2004 (Fernandez *et al.*, 2013). Another example is provided by the rerouting of the shipping channel into Boston Harbour through the important whale habitat of Stellwagen Bank to reduce collisions with humpback and endangered right whales (Roman *et al.*, 2013). Here speed-reduction measures and passive acoustic monitoring are seen as measures that can help protect large whales and other marine mammals with likely incidental benefits in terms of noise reduction.

Following recognition by the International Maritime Organisation of the global threat posed by underwater shipping noise, efforts have been made to address this, particularly through the development of ship-quieting technologies for commercial vessels. The Design and Equipment Subcommittee of the IMO has offered technical advice and voluntary guidelines in reducing water-borne shipping noise (IMO, 2013), and their guidelines will come before the IMO's Marine Environment Protection Committee in March 2014 for potential adoption. Achieving compliance, however, will require engagement by merchant fleets, ship classification and green certification societies, and port authorities, and additional research will be needed to refine the guidelines into a working noise emissions standard for commercial ships. Operating vessels at slower than previous cruising speeds has been a way of saving fuel costs but slow steaming also has environmental benefits, including substantial noise reductions (Leaper and Renilson, 2012).

Significant efforts are also under way to reduce marine noise from other marine industries. The 2013 US Bureau of Ocean Energy Management workshop on quietening technologies for seismic surveys, pile driving, and shipping held in Silver Spring, Maryland, is an example of both the profile that this issue now has and that technological approaches are being sought (BOEM, 2013). In Europe, major progress in noise attenuation technology has been made for pile-driving, led in particular by Germany, which last year set an action-forcing standard for development of better systems (BOEM, 2013). For seismic exploration, an important alternative technology exists in marine vibroseis, a controlled source that can significantly lower peak pressure by spreading acoustic energy over time and that can largely eliminate noise output above 100Hz (BOEM, 2013; Weilgart, 2010; 2012). Numerous companies are now designing vibroseis systems, with at least one on schedule to produce a commercially available array by the end of 2013 (BOEM, 2013). Accelerating development and use of these technologies will require the engagement of regulators (Weilgart, 2010; 2012).

The SWG **encouraged** time/area closures and new quietening technologies be considered as options to address noise pollution. The SWG thanked the authors for this informative compilation of progress in acoustic impact mitigation and **encouraged** further scientific investigations to better understand the effects of sound on cetaceans and their habitats and to better understand the effectiveness of mitigation measures.

9.2 Update on new tools and approaches to mitigate effects of anthropogenic sound on cetaceans

9.2.1 Background for proposal on Workshop on Soundscape Modelling

Gedamke presented background information on the proposal for a joint IWC/IQOE (International Quiet Ocean Experiment) technical workshop on Soundscape Modeling. He provided a brief overview of the issue of anthropogenic noise, noting that more human activities are taking place in the marine environment, in more places - and that coastal and ocean waters, at least in certain measured locations, are getting noisier. This raises concerns regarding impacts to marine animals that rely heavily on their abilities to hear and to exchange information using sound. The status of current noise management, at least in US waters (though this is widely true elsewhere), is one of traditional focus on relatively short term and relatively small scale human activities, emphasising thresholds of noise exposure from high intensity and short duration sources, with limited abilities to incorporate knowledge of background noise or look at the broader cumulative impacts. However, recently there has been a shift underway to focus on more ecologically relevant spatial and temporal scales, in order to address chronic, perhaps lower intensity, sources.

Recognising the potential for much larger scale, chronic impacts due to anthropogenic noise, The Alfred P. Sloan Foundation sponsored, through the Scientific Committee on Oceanic Research (SCOR) and Partnership for Observation of the Global Oceans (POGO), an initial exploratory International Quiet Ocean Experiment (or IQOE) meeting to discuss the feasibility of conducting an experiment to examine the effects of sound on life in the ocean. This ultimately led to a publication explaining the rationale behind the IQOE and an open science meeting in 2011 to get input from a wide range of scientists and stakeholders. The development of the International Quiet Ocean Experiment (IQOE) was stimulated by the need for coordination of research, observation, and modeling activities across international boundaries and across disciplines to address the challenging questions posed by the effects of increasing ocean noise. A crucial part of the IQOE's science plan (currently in draft form) moving forward is going to be the development and application of large scale ocean noise modeling techniques to understand the changing underwater acoustic environment on a more global scale.

In a similar vein, in 2010 NOAA committed to improving the tools used by the agency to evaluate the impacts of human-induced noise on cetacean species. As a result, two data and product-driven working groups were convened in January 2011: the Underwater Sound-field Mapping Working Group (SoundMap) and the Cetacean Density and Distribution Mapping Working Group (CetMap). In May 2012, the working groups presented their products at a Symposium where potential management applications were discussed with a large multi-stakeholder audience. The work of the SoundMap group was reviewed in the presentation with examples of the mapping methods depicting the temporal, spatial, and spectral characteristics of underwater noise from a range of anthropogenic sources. The goal of the SoundMap group was to develop a first pass at quantitative tools that could support the additional management of cumulative footprints from multiple source types at large scales in both space and time.

During discussion, the SWG noted that the lack of comprehensive Automatic Identification System (AIS) monitoring in the Arctic is problematic, as there are few data available on ship presence and tracks. Gedamke recognised that the amount and quality of AIS data is extremely variable, depending upon region and that the need to fill data gaps is important. Another member of the SWG also experienced a similar issue during work on sound in British Columbia, where Voluntary Observing Ship Program (VOS) data, as well as satellite data were used to fill these gaps. In British Columbia, pop-ups (marine acoustic recording units) were used for validation purposes and significant differences were found between predicted vs. actual values. The SWG recognised the importance of sound validation and **recommended** having AIS data (both voluntary and required) made more readily available for analyses of this sort.

In addition, the SWG noted that many factors affect the sound produced by vessels, such as vessel age, speed and load. Some geographical areas may lend themselves better to the quiet ocean effort, i.e. fjords, acting as 'sound refugia', while others (e.g. busy ports) may not. An effort is underway to try and identify areas where the geography lends itself to naturally quiet soundscapes. Gedamke encouraged studies that compare similar geographic environments that are loud or quiet. For example, a closed system comparison could be made between the Mediterranean Sea and the Gulf of California.

The SWG was impressed with amount of materials and resources produced related to this work and **commended** the people involved, noting it to be an excellent product.

Gedamke and Leaper provided recommendations for a proposed Soundscape Modelling Workshop to the SWG. The creation of 'soundscapes' and noise maps was noted to be a valuable initiative. The workshop planners were urged to consider not only the identification of sites of highest noise impacts, but also the direct benefits that could be realised by the reduction of noise impacts. A direct link to conservation outcomes is of particular interest to the IWC. Discussion of 'mitigation scenario modelling' (related to the reduction of noise impacts) early in the agenda of the proposed workshop was considered useful by the SWG, as these discussions will likely affect the modelling approaches considered.

During discussion of the workshop approach, the SWG recognised that 'what if' scenario modeling is entirely feasible and that methodology could be added to address this.

In addition, the scenarios approach would be useful to many researchers. A member of the SWG noted that the IMO has already asked for an assessment of 'noisiest vessels' in order to determine which ships should be targeted and that IMO could benefit from the SWG's input on this and, specifically, which noise reductions would benefit cetaceans most.

Several members of the SWG raised concerns about the amount, quality and availability of data for modeling in some potential geographical regions that might be investigated. Specific concerns were raised about variations in ship noise. The SWG recognised the need for additional data to identify the causes of noise variation of vessels (e.g. increased noise), and that these efforts could work in parallel (and the information, when collected, could be incorporated into the model). The SWG noted that it would be beneficial to discuss noise variation earlier in the proposed workshop, as the models may change/be tailored to the individual sound data being collected. The SWG thanked both Gedamke and Leaper for their input and **strongly supported** this proposal for a workshop (Appendix 2).

9.3 Other sound related issues
No papers were submitted under this topic.

10. CLIMATE CHANGE

10.1 Update on recommendations from previous climate change Workshops
No updates on previous climate change Workshop recommendations were submitted for review and no papers were submitted under this topic.

10.2 Other climate related issues
The SWG discussed future priority setting for climate change issues. The SWG recognised that climate change is an issue of increasing importance and should be kept on the agenda. Several studies (field and modelling) express concerns that cetacean distributions may be changing. In order to better identify topics for future climate change studies, the SWG **recommended** the formation of an intersessional correspondence group. This group is charged with collating the recommendations of past workshops, identifying key research gaps and priorities, and evaluating progress in understanding the impacts or implications of climate change for cetaceans. The intersessional correspondence group will continue looking at the issue of critical habitat in the context of climate change and the SWG **agreed** to use this information to develop future priorities under this topic.

10.3 Update on the intersessional Workshop on Arctic Anthropogenic Impacts
At IWC/62, the Commission requested that the Scientific Committee develop an agenda for a Workshop on Arctic Anthropogenic Impacts on Cetaceans. The SWG drafted an agenda (IWC, 2012c) at IWC/63 and formed a Workshop Steering Group to further develop a plan for the Workshop. A revised agenda that focused on anthropogenic activities related to oil and gas exploration, commercial shipping and tourism was developed by the Workshop Steering Group and presented at SC/64 (see IWC, 2013c).

In discussion, it was noted that the initial workshop is still planned for the next intersessional period. The goals of the workshop are to facilitate an open dialogue with IGOs, national governments, environmental organisations, native governments and communities, and industry on these impacts, including: what research has been/is being conducted; what management measures have been/are being implemented; what knowledge gaps and concerns exist; and what information the IWC can provide to assist managers in preparing for these impacts. The agenda, timing and participant list was not available to the SWG.

The SWG recognised that the topic of anthropogenic impacts to cetaceans in the Arctic is broad and complex and **encouraged** further efforts to address these impacts in coordination with other ongoing efforts. The SWG noted that the activities recommended above under Item 7.2 represents one step forward in coordination with Arctic IGOs on oil-spill preparedness and response activities.

11. OTHER HABITAT RELATED ISSUES

11.1 Interaction of Marine Renewable Energy Devices (MREDs) and cetaceans
SC65a/E02 reviewed public knowledge of the Marine Renewable Energy Devices (MRED) Workshop report from SC/64 (IWC, 2013b), as well as its larger impacts, to better understand whether the recommendations from such reports are reaching the appropriate audiences and providing them with useful information. The Workshop report (IWC, 2013b) provided a review of a wide range of relevant material and included a series of recommendations relating to strategies to minimise risk, research and monitoring and was distributed on the IWC website with the other workshop reports. In order to assess how the Workshop report was being received and used by the community addressing marine renewable developments, the authors asked scientists who were involved in the 2012 Workshop conducted online surveys to determine if the workshop report was being cited.

Eight replies were received and whilst the respondents found the Workshop useful personally and the meeting had generally been well run, the replies provided very little evidence yet that the Workshop has had any influence on policy making or other processes related to marine renewables. There is also little sign of any footprint of the Workshop in any recent scientific or other related literature. Related to this, several participants raised concerns about the inability to find and access the report, as well as how to cite it.

Search engines seem to require quite precise input to find the workshop report on the IWC website, where it has been lodged as a Report to the Scientific Committee since it was submitted last year (IWC, 2013b) but vaguer searches find other related materials like submissions to the Workshop.

The SWG thanked the authors for this information. Further to this, the SWG **agreed** that the visibility and accessibility of its reports needed to be improved and **encouraged** the Secretariat and the SWG to consider additional mechanisms to enhance access to, and distribution of, SC reports.

11.2 Cetaceans and marine debris
Simmonds summarised the report (SC/65a/Rep06) of the first IWC Marine Debris Workshop held from 13-17 May 2013 at Woods Hole Oceanographic Institution (WHOI). The full report of the IWC's first Marine Debris Workshop can be found in this volume. As outlined in SC/64 (IWC, 2012a), the purpose of the Workshop was to:
- better understand the effects of debris interactions at an individual and population level;
- identify and classify key types and sources of debris that contribute to entanglements, or are ingested by cetaceans and examine the mechanisms by which they arrive in the marine environment, with the goal of identifying possible mitigation measures;

- design and develop a centralised database to collate cases of debris interactions in order to obtain more accurate estimates of the incidence of mortality and injuries, to help detect trends over time and to identify hotspots; and
- contribute towards a quantitative assessment of the extent of the threats for cetaceans.

Thirty-eight participants representing eight countries attended this Workshop. The first day of the Workshop included a public seminar consisting of a number of keynote presentations and a question and answer session. These keynote presentations illustrated the ways in which debris and cetaceans interact, including the long lingering deaths that can result from entanglement, and a growing realisation that ingestion of plastics, including microplastics, may be a significant problem. In 2012, 280 million tonnes of plastic were produced globally, less than half of which was consigned to landfill or recycled. If current rates of consumption continue, the planet will hold another 33 billion tonnes of plastic by 2050, filling about 2.75 billion standard rubbish-collection trucks (Rochman and Browne, 2013). The keynote presentations also highlighted the need for improved international cooperation.

The subsequent closed workshop sessions were separated into two key topics fundamental to assessing the impact of marine debris on cetaceans: entanglement and ingestion and inhalation of macro- and micro-debris. For a full list of scientific recommendations see SC/65a/Rep06.

Overarching conclusions from the Workshop

The participants recognised the potential significant impacts that marine debris has on both cetacean habitat and cetaceans through both macrodebris (such as fishing gear, plastic bags and sheeting) entanglement and ingestion and through microplastics and their associated chemical burden through ingestion or inhalation. The Workshop encouraged debris sampling when conducting observational cetacean research at sea (i.e. water sampling and visual observations during cetacean sightings surveys) and recommended that industry partners be involved in marine debris prevention, research and response to ensure success in reducing marine debris impacts on cetaceans.

Finally, the workshop agreed that ingestion and inhalation of marine debris may sometimes be lethal, that sub-lethal impacts may also occur with long term negative consequences, and that intake of debris is a problem, both as an individual welfare concern and potentially for some populations and species. Therefore more research was encouraged. The workshop recommended that the IWC Scientific Committee should evaluate the risks of ingestion and inhalation based upon: (1) the spatial distribution of microplastics and macro debris; and (2) the feeding strategies and location of feeding areas of cetaceans, and that the Scientific Committee prioritise studies of those cetacean that are likely at greatest risk of ingesting or inhaling macro- and micro-debris and associated pollutants (Fossi *et al.*, 2012). The workshop thus recommended that the initial focus of research be on three species of filter-feeding whales: the North Atlantic right whale, the fin whale in the Mediterranean Sea, and the gray whale in the eastern North Pacific. The workshop noted that none of its recommendations required the lethal collection of cetaceans.

The Workshop then identified the following priority mitigation measures:

(I) ENTANGLEMENT:

Since both active and derelict gear are responsible for cetacean entanglements, focus should be on the prevention of entanglement from both of these sources on cetaceans. The workshop recommended a consideration of how different managerial regimes affect (i.e., facilitate or hinder) the feasibility of implementing actions, regulatory or otherwise, intended to reduce the risk of entanglement to cetaceans, maximise the return of lost viable gear to fishers, and avoid the introduction of derelict fishing gear into aquatic environments. These actions include: (1) targeting reduction of fishing effort; (2) modifying of fishing gear; (3) developing a response system to respond to and retrieve lost gear; and (4) implementing time-area closures and marine spatial planning.

(II) INGESTED DEBRIS:

As known impacts are largely dependent on species group, the workshop strongly recommended research that allows prioritisation of relevant cetacean populations, as data does not exist at this time to allow this. The group encouraged modelling approaches that examined the relationship between marine debris ‘hot spots’ and information on distributions, feeding strategies and mortality rate data already collected by the IWC and other organisations. The workshop also recommended the determination of hazard function of specific debris with subsequent connection with the modelling data.

The workshop went on to discuss how to best liaise with other international organisations and offered some advice to the next IWC workshop on marine debris (which will have mitigation and management as its main focus) and this can be found in the full report of the meeting and included greater outreach to all stakeholders and reviewing the progress of the recommendations made by first marine debris workshop.

One of these recommendations extended to the potential development of a scale-able contingency plan for assessing impacts of major releases of marine debris on cetaceans, which offers member states guidance on mitigation options. The SWG considered that such an approach required further consideration by the Scientific Committee and some intercessional evaluations.

In discussion, the SWG noted that, although filter-feeding whales may be more susceptible to the uptake and harmful effects of marine debris than other whales, the impacts on toothed whales should also be examined (e.g. ziphiids may be especially vulnerable).

In discussion of this report, the SWG also recognised the potential importance of increased understanding of microplastic uptake by prey as increasing numbers of papers have reported detecting microplastic particles in fish, crustaceans and krill. The SWG noted that additional research studies, including modelling efforts, are needed to determine how microplastic particles are transported through marine food webs and their potential impacts to whales and their prey. In terms of estimating death rates due to entanglement, obtaining information from each fisher on use rate *vs* loss rate would be valuable to help determine if active gear poses a greater risk than lost fishing gear to whales. The SWG thanked Simmonds for this report and the tremendous work done by him and the Workshop participants.

Information was also presented to the SWG on the marine debris in the stomach contents of common minke, sei, Bryde’s and sperm whales sampled by JARPN II (SC/65a/O03, SC/65a/O06-O07). No marine debris was observed in the stomachs of Antarctic minke whales (SC/65a/O09). The SWG thanked the authors of these papers.

After review of the Workshop report and other scientific papers, the SWG **endorsed** the recommendations of the

Workshop (see SC65a/Rep06 for full details), including its recommended pathology protocol and **agreed** that:

- legacy and contemporary marine debris have the potential to be persistent, bioaccumulative and lethal to cetacean populations and represent a global management challenge; and
- entanglement in and intake of active and derelict fishing gear and other marine debris have lethal and sub-lethal effects on cetaceans.

Therefore the SWG **strongly agreed** that marine debris, and its contribution to entanglement, exposures including ingestion or inhalation, and its associated impacts, including toxicity, is both a welfare and a conservation issue for cetaceans on a global scale and a growing concern.

The SWG **recommended** that the IWC parties and the Secretariat take **immediate action** to help better understand and address this growing problem, including:

- providing data on rates of marine debris interactions with cetaceans into the national progress reports and supporting the second marine debris workshop (which will have mitigation and management as its focus);
- strengthening capacity building in the IWC entanglement response curriculum and addition of information on marine debris;
- building international partnerships with other relevant organisations and stakeholders including an effective transfer of information about ongoing research and debris-reduction and removal programmes and the international and national marine debris communities;
- developing programmes to remove derelict gear and schemes to reduce the introduction of new debris; and
- incorporating marine debris into the IWC conservation management plans and consider making it the focus of a plan in its own right.

The SWG therefore tasked an intersessional group with reviewing the research-related recommendations that came from the Workshop to identify prioritised research. It was noted that this review should give consideration to the evaluation of the efficacy of fishing practices that pose a lower risk of entanglement or loss of gear, given that active and derelict fishing gear is a major cause of injury and mortality in cetaceans; and further investigations into microplastics, their associated chemical pollutants and microbes and macrodebris ingestion. Further work on microplastics has been taken up by the Pollution 2020 work plan (see Appendix 2). The intersessional correspondence group will also liaise with the steering group for the second marine debris Workshop.

The SWG thanked the Workshop convenor, the Woods Hole for hosting the Workshop, and the tremendous work done by the organisers and participants. The SWG also appreciates the funds provided by various organisations in support of this Workshop.

12. CONSERVATION MANAGEMENT PLANS

The IWC has asked the SWG to draw up a priority list of populations for conservation management plans (CMPs) according to the criteria outlined in SC/65a/SCP01. The SWG evaluated the criteria listed in SC/65a/SCP01.

In discussion, the SWP recognised the unique role of the E SWG to evaluate both threats-based and population-based approaches in the development of CMPs. The SWG then discussed the priority issues of marine debris and pollution. As part of this approach, the SWG may choose to nominate species that may be particularly impacted by these processes/subject areas. The SWG also noted the two ways to propose a CMP: through member countries or through the Commission (itself). The SWG recommended a review of the template and criteria, then consideration of the options: a threat-based approach versus a species-based approach. The results of this evaluation should then be circulated to the SWG for comment. The SWG **recommended** that the issue of marine debris as the first threat-based CMP (see Item 11.2). The SWG noted that it has expertise available with respect to CMP development that may be of use to other sub-committees. An intersessional working group was created to examine this subject further and report back at SC/65b.

13. WORK PLAN

The SWG **agreed** to these agenda items for its work plan for the 2014 Annual Meeting (SC/65b).

1. SOCER, receive the State of the Cetacean Environment Report – Atlantic Ocean
2. Pollution
    - 2.1 Pollution 2020
        - 2.1.1 Refinement on model and website update
        - 2.1.2 Microplastics
        - 2.1.3 PAH toxicity modelling
        - 2.1.4 Other pollution related issues
    - 2.2 Oil-spill impacts and capacity building
        - 2.2.1 Arctic oil-spill preparedness and response
        - 2.2.2 Update on the Gulf oil-spill
        - 2.2.3 Other oil-spill issues
    - 2.3 Marine debris
        - 2.3.1 Update on the second Marine Debris Workshop
        - 2.3.2 Other marine debris related issues
3. Cetacean Emerging and Resurging Diseases (CERD) and mortality events
    - 3.1 CERD website
    - 3.2 CERD framework
    - 3.3 Strandings and mortality events
        - 3.3.1 Madagascar mass stranding report
        - 3.3.2 Other stranding events
    - 3.4 Other disease related issues
4. Effects of anthropogenic sound on cetaceans and approaches to mitigate these effects
    - 4.1 Joint IWC/IQOE Soundscape Modelling Workshop
    - 4.2 Efficacy of existing mitigation measures for anthropogenic sound sources
    - 4.3 Other sound related issues
5. Climate change
    - 5.1 Update on recommendations from intersessional working groups
    - 5.2 Update on intersessional Workshop on Arctic Anthropogenic Impacts
    - 5.3 Other climate related issues
6. Other habitat related issues
    - 6.1 Interaction of MREDs and cetaceans
    - 6.2 Cumulative impacts of anthropogenic activities
    - 6.3 Other habitat issues
7. Conservation Management Plans

Further, the SWG **endorsed** the following budget requests:

- a contribution towards development of the SOCER;
- funding to complete implementation of the CERD website;
- work on Pollution 2020 activities related to microplastics, polycyclic aromatic hydrocarbons and dispersants (Appendix 2):
- support for an joint IWC/IQOE Workshop on Global Soundscape Modelling to Inform Management of Cetaceans and Anthropogenic Noise (Appendix 3); and

- support for invited participants to attend the 2nd Workshop on Marine Debris.

Rowles and Parsons thanked the rapporteurs, as well as the SWG, for their efficiency and hard work in producing the report.

14. REVIEW AND ADOPT REPORT

The report was adopted at 4:33pm on 11 June 2013.

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Appendix 1

AGENDA

1. Introductions
2. Election of Chair
3. Adoption of Agenda
4. Appointment of rapporteurs
5. Review of available documents
6. SOCER, receive the State of the Cetacean Environment Report
7. Pollution
    - 7.1 Pollution 2000+
    - 7.2 Oil-spill impacts and capacity building
    - 7.3 Other pollution related issues
        - 7.3.1 New techniques for exposure and effects assessments
        - 7.3.2 Icelandic Special Permit Review
        - 7.3.3 Resolution on IWC/WHO coordination
8. Cetacean Emerging and Resurging Diseases (CERD) and mortality events
    - 8.1 Update from the CERD working group
    - 8.2 CERD website and work plan
    - 8.3 Strandings and mortality events
    - 8.4 Other disease related issues
9. Effects of anthropogenic sound on cetaceans and approaches to mitigate these effects
    - 9.1 New information on the effects of anthropogenic sound on cetaceans
    - 9.2 Update on new tools and approaches to mitigate effects of anthropogenic sound on cetaceans
    - 9.3 Other sound related issues
10. Climate change
    - 10.1 Update on recommendations from previous climate change workshops
    - 10.2 Update on intersessional workshop on Arctic anthropogenic impacts
    - 10.3 Other climate related issues
11. Other habitat related issues
    - 11.1 Interaction of MREDs and cetaceans
    - 11.2 Cetaceans and marine debris
    - 11.3 Cumulative impacts of anthropogenic activities
12. Conservation Management Plans
13. Work plan
14. Review and adopt Report

Appendix 2

WORK PLAN FOR POLLUTION 2020

Background: Resolution 2012-1 (IWC, 2013), adopted at the 64th Annual Meeting on the 'importance of continued scientific research with regard to the impact of the degradation of the marine environment on the health of cetaceans and related human health effects' welcomed the work of the Pollution 2000+ research programme and requested that the Scientific Committee remain engaged in the evaluation of the available data on organic contaminants and heavy metals in some cetaceans as well as the effect of such contamination on the health of the cetaceans and their reproduction.

A follow up initiative for the Pollution 2000+ work, named Pollution 2020, was agreed by the SWG at SC/65a with two main priority areas of research; the toxicity of microplastics and the impact of polycyclic aromatic hydrocarbons on cetaceans.

A. In support of the recommendations of the Marine Debris Workshop it is proposed that a comprehensive review of the literature and background report be produced, in collaboration with the international Marine Debris community. This would include the following sections.

(1) Origin, fate and global distribution of microplastics to highlight potential high risk areas and therefore cetacean species, with particular emphasis on the importance of krill and copepods as vectors for transfer to cetaceans.
(2) An assessment of the toxic potential of the various chemical compounds associated with microplastics, summarising the current state of knowledge from laboratory animal models and human epidemiological studies.
(3) An assessment of the direct effects of microplastic ingestion and inhalation.
(4) The utility of various matrices (e.g. skin, blubber, urine, faeces, blow etc.) for exposure determination.
(5) An assessment of the potential effect and/or biomarker measures.
(6) A list of the analytical techniques used to determine the direct ingestion of microplastics and the concentrations of their associated chemical compounds.
(7) Suggested research studies for prioritisation by the Pollution 2020 Steering Committee in their intersessional meeting.

B. Following the Deepwater Horizon oil-spill it was apparent that it was not clear how best to monitor exposure of cetaceans to polycyclic aromatic hydrocarbons. In the case of these oil-related compounds their metabolism may be so rapid that it is not possible to detect exposure through tissue levels, either because the concentrations of the parent compound are so low; because they are exhaled rather than excreted in faeces and urine or most probably because it would be more appropriate to monitor primary and secondary metabolites rather than parent compounds for estimating exposure. The work proposed here would therefore:

(1) refine the physiologically based toxicokinetic model (PBTK) model developed under phase III of Pollution 2000+ to allow researchers to determine which matrices would be most appropriate to look at (breath/blow, faeces or urine in live animals) and the likely time courses for excretion of the various metabolites given various exposure scenarios and depuration times; and
(2) review the literature on dispersants with a view to recommendations for future research priorities.

This work would be carried out during the next inter-sessional one year period 2013-14.

REFERENCE

International Whaling Commission. 2013. Chair's Report of the 64th Annual Meeting. Annex D. Resolutions Adopted at the 64th Annual Meeting. Resolution 2012-1. Resolution on the importance of continued scientific research with regard to the impact of the degredation of the marine environment on the health of cetaceans and related human health effects. *Ann. Rep. Int. Whaling Comm.* 2012:77.

Appendix 3

PROPOSAL FOR A JOINT IWC/IQOE WORKSHOP: PREDICTING SOUNDFIELDS - GLOBAL SOUNDSCAPE MODELING TO INFORM MANAGEMENT OF CETACEANS AND ANTHROPOGENIC NOISE

OVERVIEW

A two-day technical expert workshop of 20-30 invited participants intended to better inform cetacean conservation and management efforts related to the potential impacts of anthropogenic noise over regional to ocean-basin scales. Outputs would include a meeting report, including advice to the IWC and discussion paper(s) to submit to the Scientific Committee of the IWC.

RATIONALE

Nearly a decade ago, a 2004 IWC Workshop on the effects of ocean noise on cetaceans led the SC to concur that the growth of ocean noise was cause for 'serious concern'. Since then, the potential effects of anthropogenic noise have been a recurring agenda item for discussion at the SC. Initially, concern was primarily expressed over the potential effects of acute sources of sound that could lead to very near term consequences (e.g. behavioural changes, strandings). In recent years, however, there has been a distinct broadening of the focus of noise impacts to include the much larger scale, and longer term chronic effects of increases in ocean noise and changes in underwater soundscapes. An increasing number of scientific efforts (International Quiet Ocean Experiment (IQOE), US National Oceanic and Atmospheric Administration's CetSound effort) directed at this topic reflect this broader scope. In September 2011, the IQOE held an open science planning meeting (Boyd *et al.*, 2011) where research into soundscape characterisation and modelling were identified as one of the four key themes to be contained in the IQOE's draft Science Plan. NOAA has similarly recognised the need for this work through the convening of the Cetaceans and Sound (CetSound) project in which it is developing mapping tools to produce underwater sound-field maps, along with cetacean density and distribution maps (NOAA, 2012). In addition, to meet the noise-related Good Environmental Status objectives of the European Marine Strategy Framework Directive, sound field modeling and mapping comprise a substantial portion of the recommended monitoring programs for noise assessment (Dekeling *et al.*, 2013). The IWC has also exhibited an interest in the more regional effects of noise pollution (e.g. an IWC Workshop planned for the spring of 2013 covering anthropogenic impacts including underwater noise on cetaceans in the Arctic). During the meeting of the IWC Scientific Committee in June 2012, the US presented the CetSound project and its preliminary results. The IWC Scientific Committee subsequently endorsed this work and strongly recommended support for further development and improvement of these sound and cetacean mapping tools. This proposal for a joint IWC/IQOE workshop would work to expand these tools and their application to a more global scale where they can be used to inform management of potential impacts on cetaceans.

TERMS OF REFERENCE

The general terms of reference for the joint Workshop are to:

- exchange, evaluate, and analyse soundscape modelling methodologies with a view to optimising techniques and their transferability in order to increase the accessibility of these methodologies to a wider range of researchers, governments, industry, and organisations;
- examine and assess priority regions and the important sound sources within those regions for soundscape characterisation, including specifying the human use and sound source characterisation data that are necessary to model anthropogenic noise; and
- develop scientific recommendations and a two-year work plan for consideration by the IWC, IQOE and others to continue to develop, improve, and apply these sound mapping tools to more global locations.

PREREQUISITE DATA REQUIREMENTS AND ANALYSES

To be determined by the Steering Group.

LIKELY SCIENTIFIC OUTCOMES

Recommendations on:

- methodology of modelling soundscapes;
- continued development and improvement of mapping tools;
- advice for future modelling and acoustic research; and
- prioritisation of regions to assess anthropogenic noise contributions.

Expert assessment of the utility of large-scale soundscape modelling, and how it might be incorporated into more effective management of the interaction between cetaceans and ocean noise.

Expansion of modelling efforts to more global locations.

Report to the SWG/SC.

STEERING GROUP

Suggested to include: Mike Porter (Heat, Light and Sound Research, CetSound, IQOE), George Frisk or Peter Tyack (IQOE), Rene Dekeling (Ministries of Infrastructure and Environment, and Defence, Netherlands), Christine Erbe (Curtin University, Australia), Jason Gedamke or Leila Hatch (NOAA, CetSound, USA).

SUGGESTED TITLE

Predicting Soundfields - Global Soundscape Modelling To Inform Management of Cetaceans and Anthropogenic Noise.

FORMAT AND TIMETABLE OF WORKSHOP

The format of the Workshop will be by invitation only, with speakers and topics for discussion being determined by the Steering Group. A limited number of places will be made available for non-participatory observers to attend the meeting. The meeting duration is planned to be two days.

DRAFT AGENDA

This programme will be revised, updated and expanded as appropriate by the Global Soundscape Workshop Steering Group.

(1) Overview of goals of Workshop.
(2) Discussion of related efforts:
  (a) SoundMap of CetSound Project;
  (b) IQOE Science Plan; and
  (c) identification of other efforts, potential partners (e.g. EU-MSFD, LIDO, Antares, Esonet, Jamstec, Neptune).
(3) Review of modelling techniques:
  (a) spatio-temporal modelling of sources:
    (i) Metrics to use (e.g. temporal, spectral);
  (b) acoustic characterisation of sources;
  (c) new modelling approaches needed:
    (i) utilising soundscapes to inform noise reduction efforts:
      1. mitigation scenario modeling.
(4) Transferability of techniques, e.g. how other nations/organisations can apply these techniques:
  (a) Documentation; and
  (b) software - current and future.
(5) Priority regions to model and their predominant sound sources:
  (a) Arctic;
  (b) Mediterranean;
  (c) western Pacific;
  (d) southern Africa; and
  (e) other.
(6) Priority sources to model:
  (a) information needed;
  (b) characterising acoustic signature of sources; and
  (c) characterising density and distribution of sources.
(7) Shorter time/spatial scale events to model (e.g. wind farm installation, seismic surveys in a region).
(8) Future research/modelling needs:
  (a) ground-truthing modelled results with empirical measurements.
(9) Collaboration between related efforts (IQOE, SoundMap, others).
(10) Potential use in management, public education, and to support efforts to reduce anthropogenic ocean noise:
  (a) IMO ship quieting technologies; and
  (b) alternative technologies for oil and gas exploration.

DATE AND LOCATION

Exact venue and date to be determined - the Netherlands, Winter 2013/14. René Dekeling (Ministry of Infrastructure and the Environment and Ministry of Defence, the Netherlands) has confirmed interest in the workshop and will assist in arranging a venue either in Amsterdam or at The Hague.

PARTICIPANTS

The joint Workshop would bring together experts in modelling underwater sound and cetacean biology, and representatives of related efforts. Ultimately attendees and organisations to involve will be determined by the Steering Group. The following individuals and organisations are suggestions and are not intended to comprise a comprehensive list:

Organisations/groups
IQOE, CetSound working group members, Heat Light and Sound Research, EU Marine Strategy Framework Directive representatives, TNO (Netherlands), FWG (Germany), SHOM (France), DRDC (Canada), NOAA/Navy (USA), CTBTO, IMO, Scottish Association for Marine Science.

Individuals (in addition to those suggested for the Steering Group)
Michael Ainslie (TNO, Netherlands), Thomas Folegot (Quiet Oceans, France), Sergio Jesus (UALG, Portugal), Michel Andre (UPC, Spain), Steve Robinson (NPL, UK), Frank Thomsen (DHI Water and Environment, Denmark), Alec Duncan (Curtin University, Australia), Doug Cato (DSTO, Australia), Mariana Melcon (Argentina), Megan McKenna (NPS, USA), Ross Chapman (Univ. Victoria, Canada), Jen Miksis-Olds (PSU, USA), Ed Urban (IQOE, USA).

BUDGET

Two day Workshop of ~25 participants (e.g. eight from Europe, five from North America, three from Asia, three from Oceania, three from Latin America, three from Africa):

Travel: £21,800 GBP

Accommodation: £11,250

Subsistence: £5,000

Contingency/Miscellaneous: £3,000

Facilities, technical and administrative support: No additional costs foreseen (likely in-kind contribution)

Total: ~£41,050 GBP total budget

IQOE and SCOR co-funding: £8,500

NOAA co-funding: £6,666

Funding sought from IWC: £25,884

REFERENCES

Boyd, I.L., Frisk, G., Urban, E., Tyack, P., Ausubel, J., Seeyave, S., Cato, D., Southall, B., Weise, M., Andrew, R., Akamatsu, T., Dekeling, R., Erbe, C., Farmer, D., Gentry, R., Gross, T., Hawkins, A., Li, F., Metcalf, K., Miller, J.H., Moretti, D., Rodrigo, C. and Shrinke, T. 2011. An international Quiet Ocean Experiment. *Oceanography* 24(2): 174-81.

Dekeling, R.P.A., Tasker, M.L., Ainslie, M.A., Andersson, M., André, M., Castellote, M., Borsani, J.F., Dalen, J., Folegot, T., Leaper, R., Liebschner, A., Pajala, J., Robinson, S.P., Sigray, P., Sutton, G., Thomsen, F., Van der Graaf, A.J., Werner, S., Wittekind, D. and Young, J.V. 2013. Monitoring Guidance for Underwater Noise in European Seas - 2nd Report of the technical Subgroup on Underwater Noise (TSG Noise). Part I - Executive Summary. Interim Guidance Report, May 2013.

NOAA. 2012. Mapping Cetaceans and Sound: Modern Tools for Ocean Management. Final Symposium Report of the Technical Workshop held May 23-24 in Washington, DC. 83pp. [Available at: *http://cetsound.noaa/gov.*].

Appendix 4

STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER) 2013

Editors: M. Stachowitsch*, E.C.M. Parsons+ and N.A. Rose¥

INTRODUCTION

Several resolutions of the International Whaling Commission, including Resolutions 1997-7 (IWC, 1998) and 1998-5 (IWC, 1999), directed the Scientific Committee (SC) to provide regular updates on environmental matters that affect cetaceans. Resolution 2000-7 (IWC, 2001) welcomed the concept of the State of the Cetacean Environment Report (SOCER) and requested the annual submission of this report to the Commission. The first full SOCER (Stachowitsch *et al.*, 2003) was submitted in 2003 and subsequent editions initiated and continued a cycle of focusing on the following regions: Mediterranean and Black Seas, Atlantic Ocean, Pacific Ocean, Indian Ocean, Arctic and Antarctic Seas. Each SOCER also includes a Global section addressing the newest information that applies generally to the cetacean environment. The 2013 SOCER focuses on the **Mediterranean and Black Seas**, summarising key papers and articles published from *ca.* 2011 through 2013 to date.

MEDITERRANEAN SEA

General

FIRST MAJOR ATTEMPT TO QUANTIFY THE OVERALL EFFECTS OF VARIOUS STRESSORS ON MEDITERRANEAN MARINE HABITATS

An examination of 366 scientific studies and a rigorous analysis of 158 of these showed that fisheries, species invasion, aquaculture, sedimentation increase, water degradation and urbanization are having negative impacts on Mediterranean habitats and their associated species assemblages. Some, but not all, of these stressors reflect the recognised greatest global threats to the marine environment. For example, although the Mediterranean Sea is known to be undergoing 'tropicalisation', the analysis was unable to identify climate change as a major threat, because too few studies have been conducted and the examined response variables were not uniform. This first major quantitative effort draws attention to a '*critical lack of empirical knowledge about marine systems in many areas of the Mediterranean*' and insufficient studies on the cumulative and synergistic effects of multiple stressors. The authors draw attention to the shortcomings of the many efforts to develop ecological indices in the Mediterranean.

(SOURCE: Claudet, J. and Fraschetti, S. 2010. Human-driven impacts on marine habitats: A regional meta-analysis in the Mediterranean Sea. *Biol. Conserv.* 143: 2,195-2,206).

MARINE PROTECTED AREA IN THE ADRIATIC DOWNGRADED

The Cres-Lošinj Special Marine Reserve has been downgraded from Special Reserve to Regional Park. This reserve, specifically designed to conserve a local bottlenose dolphin population, was the largest marine protected area in the Adriatic for three years (2006-09). Lack of experience, governance and funding, coupled with strong opposition by the local tourism industry and economic/political paralysis in Croatia, created an imbalance between local development and international commitments. The downgrading, accompanied by movement of its boundaries to accommodate a marina, raises questions as to whether the area satisfies biological objectives. In particular, illegal and damaging fishing practices, along with aggressive dolphin watching tour boat behaviour, will continue to threaten the dolphin population.

(SOURCE: Mackelworth, P., Holver, D. and Fortuna, C.M. 2012. Unbalanced governance: The Cres-Lošinj special marine reserve, a missed conservation opportunity. *Mar. Pol.* 41: 126-133).

CALL FOR A BLUE ECONOMY TO PROTECT THE MEDITERRANEAN

A meeting between Mediterranean countries and the European Union in Paris (Paris Declaration) called for a 'blue' economy – a version of the Green Economy, applied to seas and oceans – to help fight the deterioration of the Mediterranean Sea. This effort seeks to continue the momentum provided by the entry into force of the Integrated Coastal Zone Management Protocol and the Protocol for the Protection of the Mediterranean Sea against Pollution Resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil (the 'Offshore' Protocol). The Paris Declaration: (1) reaffirms applying an ecosystem approach to the management of human activities; (2) agrees to develop a coherent, well-managed network of MPAs in the Mediterranean, the target being 10% of the Mediterranean as MPAs by 2020; and (3) agrees to intensify efforts to curb marine pollution from land-based sources, including mercury, persistent organic pollutants and marine debris.

(SOURCE: 'News' section: Countries call for blue economy to protect the Mediterranean. 2012. *Mar. Pollut. Bull.* 64: 671).

CETACEANS CAN BE USED TO HELP ESTABLISH MARINE PROTECTED AREAS IN THE ADRIATIC

Identifying Ecologically and Biologically Significant Areas (EBSAs) in the Adriatic Sea would pave *'the way for the further establishment of MPAs and, possibly, of Specially Protected Areas of Mediterranean Importance (SPAMIs) within the framework of the Barcelona Convention SPA/BD Protocol'*. The author points out that, among biogenic and physical features and various faunal elements, the presence of cetaceans can be used to refine the identification of EBSAs. Marine mammals in the Adriatic are represented by several odontocetes, although only the bottlenose dolphin is now regularly found in the northern part.

(SOURCE: Notabartolo di Sciara, G. 2010. Methods for the identification of EBSAs in the Adriatic Sea. 3rd International Workshop on Biodiversity in the Adriatic: towards a representative network of MPAs in the Adriatic. Piran, Slovenia. 16pp.)

ACCOBAMS AT THE FOREFRONT OF CETACEAN CONSERVATION IN THE MEDITERRANEAN AND BLACK SEAS

This comprehensive report provides an overview of cetacean species and their status in the region and then outlines the many threats currently facing these cetaceans. These threats – among them fisheries interactions, shipping interactions, habitat loss and pollution, noise, direct killing, and climate change – are compared to the situation eight years earlier and the changes highlighted. The legal framework is

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presented and the many deficits listed, including knowledge gaps and management shortcomings. Although the authors raise the possibility of drawing up a new strategy, they also conclude that many of the problems preventing cetaceans from reaching a favourable conservation status would be adequately addressed if the range states simply fully implemented and enforced the multiple obligations they have already committed to and that are already in force.

(SOURCE: Notarbartolo di Sciara, G. and Birkun, A. 2010. Conserving whales, dolphins and porpoises in the Mediterranean and Black Seas: An ACCOBAMS status report. ACCOBAMS, Monaco. 212 pp).

Habitat degradation

Fisheries interactions

DOLPHINS HAVE MINIMAL IMPACT ON FISHERIES IN THE WESTERN MEDITERRANEAN, BUT NOT VICE-VERSA

In a study conducted in the Ionian Sea, Greece, the local populations of short-beaked common dolphins and bottlenose dolphins consumed 105 tons of biomass, whereas the local fishing fleet removed 3,470 tons (3% vs. 97% of total biomass removed). Trophic overlap between dolphins and fisheries depended strongly on the fishing gear used, and there was only minimal overlap between the two dolphin species. Nine purse seiners (only 3% of the active fleet) removed 32% of this biomass. The authors conclude that the ecological interactions between dolphins and fisheries in the western Mediterranean have minor effects on fisheries but that, conversely, '*prey depletion resulting from overfishing can negatively impact dolphins*'.

(SOURCE: Bearzi, G., Agazzi, S., Gonzalvo, J. Bonizzoni, S., Costa, M. and Petroselli, A. 2010. Biomass removal by dolphins and fisheries in a Mediterranean Sea coastal area: Do dolphins have an ecological impact on fisheries? *Aquat. Conserv: Mar. Freshw. Ecosyst.* 20: 549-559).

BYCATCH OF ENDANGERED MEDITERRANEAN COMMON DOLPHINS COULD BE REDUCED

The common dolphin population has experienced a severe decline in the Mediterranean. In addition to reduction in prey due to overfishing, bycatch is also a threat. Annual bycatch by pair trawlers off Spain in 2001 and 2003 was estimated at 394 dolphins, with most mortalities from May to September in the vicinity of the continental shelf break. This level exceeds 2% of the population and is therefore likely unsustainable. Hauling time, fishing depth and season were the key factors influencing bycatch. The levels of bycatch may rise further as pair trawlers are increasingly used to replace the drift nets banned by the European Union (to reduce bycatch of small cetaceans). These takes could be significantly reduced by restricting trawlers to operating in water deeper than 250m and probably avoided entirely by restriction to water deeper than 300m.

(SOURCE: Fernandez-Contreras, M.M., Cardona, L., Lockyer, C.H. and Aguilar, A. 2010. Incidental bycatch of short-beaked common dolphins (*Delphinus delphis*) by pairtrawlers off northwestern Spain. *ICES J. Mar. Sci.* 67: 1732-1738)

BYCATCH OF BOTTLENOSE DOLPHINS IN THE ADRIATIC SEA

In compliance with European Regulation 812/2004, researchers coordinated a monitoring program of cetacean bycatch by Italian trawlers. The results of monitoring over 3000 hauls by pair trawlers in the Adriatic revealed a bottlenose dolphin bycatch rate of 0.0006 individuals per haul. This low number of deaths did not enable a reliable estimate of total mortality. More reliable estimates could soon be possible with the introduction of real-time electronic submission of fishing effort data, but the costs are considered to be prohibitive. Large bycatch estimates were obtained for other species of conservation concern, in particular rays and sharks, pointing to potential ecosystem-level effects from this fishery. The authors call for investing funds in testing and implementing mitigation measures rather than in the increased observer coverage necessary to arrive at better bycatch estimates.

(SOURCE: Fortuna, C.M., Vallini, C., Filidei, E. Jr., Ruffino, M., Consalvo, I., Di Muccio, S., Gion, C., Scacco, U., Tarulli, E., Giovanardi, O. and Mazzola, A. 2010. By-catch of cetaceans and other species of conservation concern during pair trawl fishing in the Adriatic Sea (Italy). *Chem. Ecol.* 26 (suppl.): 65-76).

OVERFISHING OF SARDINES MAY HAVE CAUSED A DIETARY SHIFT IN MEDITERRANEAN STRIPED DOLPHINS

The progressive decline in sardine abundance due to overfishing in the western Mediterranean has apparently led to a dietary shift in striped dolphins from sardines to juvenile hake, cephalopods, anchovies and lanternfish. The reduction of fat-rich sardines in the diet could have numerous impacts, including physiological disorders, inadequate energy budgets, lower growth rates and changes in reproductive cycles. The authors conclude that overfishing has replaced pollutants as the main threat for this species, noting further that the population has probably not recovered well from the epizootic that decimated it in 1990.

(SOURCE: Gómez-Campos, E., Borrell, A., Cardona, L., Forcada, J. and Aguilar, A. 2011. Overfishing of small pelagic fishes increases trophic overlap between immature and mature striped dolphins in the Mediterranean Sea. *PLoS ONE* 6 (9): e24554, doi:10.1371/journal.pone.0024554).

STRANDED MEDITERRANEAN CETACEANS IN TUNISIA

A survey noted 132 cetacean strandings were reported along the Tunisian coastline between 1937 and 2009. More than 70% of these were reported during the period 2004-09, after a stranding network was established. The common bottlenose dolphin and the fin whale were the main stranded species, with 83 and 21 cases respectively. Fishery interactions have the greatest impact on bottlenose dolphins. Due to a collapse in fish stocks in Tunisian waters, fishermen consider bottlenose dolphins to be direct competitors. They generally cut off the tail fluke of entangled animals to avoid greater damage to their gear, more recently resorting to intentional killings, largely of juveniles. Accidental captures of large cetaceans include two minke whales in a purse seine and drift net respectively, as well as two humpback whales in a driftnet and a gillnet respectively.

(SOURCE: Karaa, S., Bradai, M.N., Jribi, I., El Hili, H.A. and Bouain, A. 2012. Status of cetaceans in Tunisia through analysis of stranding data from 1937 to 2009. *Mammalia* 76: 21-29).

LONGLINE BYCATCH OF CETACEANS IN THE MEDITERRANEAN

An observer program on longline fishing boats investigated bycatch rates by Spanish longliners in the western Mediterranean between 2000 and 2009. Fifty-six marine mammals were reported as bycatch; 59% were Risso's dolphins (striped dolphins, short-beaked common dolphins and long-finned pilot whales were also caught). Risso's dolphins were predominantly caught by 'Japanese longlines' or an infrequently used, experimental 'home-based longline' over the continental shelf. The authors conclude that '*controlling the use of* [Japanese longline gear] *over the continental shelf could strongly reduce the impact of these fisheries on populations of Risso's dolphin in the western Mediterranean*'.

(SOURCE; Macías López, D.M., García Barcelona, S. Báez, J.C., de la Serna, J.M. and Ortiz de Urbina, J.M. 2012. Marine mammal bycatch in Spanish Mediterranean large pelagic longline fisheries, with a focus on Risso's dolphin (*Grampus griseus*). *Aquat. Liv. Res.* 25: 321-331).

FOOD PATCHES CREATED BY HUMAN ACTIVITY ALTER DOLPHIN BEHAVIOUR AND DISTRIBUTION

Anthropogenic food patches – represented by aquaculture farms and fishing trawlers – affected the behaviour of bottlenose dolphins off Lampedusa Island, Italy. The distributions of some dolphin groups were associated with such food sources. Thus, these feeding opportunities directly affected these top predators and indirectly produced complex social responses based on the cohesion of such groups. Such altered social structure '*could have considerable impact on their long-term survival*'.

(SOURCE: Pace, D.S., Pulcini, M. and Triossi, F. 2011. Anthropogenic food patches and association patterns of *Tursiops truncatus* at Lampedusa Island, Italy. *Behav. Ecol.* 23: 254-264).

INCREASING AQUACULTURE OPERATIONS IN THE MEDITERRANEAN AFFECT BOTTLENOSE DOLPHIN POPULATIONS

Marine aquaculture has increased considerably in the Mediterranean Sea in recent years. One study in western Greece showed that an increase in the number of aquaculture cages was responsible for an increase in dolphin presence near fish farms. Such open cage aquaculture benefits the dolphins by simplifying prey capture. These results were supported by a second study involving floating cages in Sardinia, Italy, where the predominant activity of bottlenose dolphins at the studied fish farm was foraging (predation and depredation). The occurrence of the dolphins was related to season and to the fish farming harvesting operations. A small part of the population interacted with the fish farm over a longer period of time. Moreover, the mean annual mortality rate related to the fish farm was 1.5% for the dolphin community: five dolphins were found entangled in predator nets around the fish farm cages between 2005 and 2008. The authors call for considering such site fidelity and residence patterns in developing coastal management initiatives. A third paper – the first on acoustic harassment devices in relation to bottlenose dolphins and a marine finfish farm – reported that these devices had no significant and immediate effect on the dolphins' presence, distance from the AHD, group size or time spent in the fish farm area.

(SOURCES: Piroddi, C., Bearzi, G. and Christensen, V. 2011. Marine open cage aquaculture in the eastern Mediterranean Sea: A new trophic resource for bottlenose dolphins. *Mar. Ecol. Prog. Ser.* 440: 255-266; Lopez, B.D. Bottlenose dolphins and aquaculture: Interaction and site fidelity on the north-eastern coast of Sardinia (Italy). 2012. *Mar. Biol.* 159: 2161-2172; Lopez, B.D. and Marino, F. 2011. A trial of acoustic harassment device efficiency on free-ranging bottlenose dolphins in Sardinia, Italy. *Mar. Freshw. Behav. Phy.* 44: 197-208).

STATUS OF MEDITERRANEAN COMMON DOLPHIN

The common dolphin was formerly the most abundant cetacean in the Mediterranean, but has declined drastically since the 1960s and now inhabits only a few delimited areas. It has been classified as 'Endangered' by the IUCN. This decline has been attributed to overexploitation of their main prey (sardines, anchovies). This study shows that, as opposed to merely closing certain fisheries, only a total closure of all fisheries would allow the common dolphin population to increase markedly. The status of the common dolphin in the Mediterranean closely reflects that of overall ecosystem change and degradation, pointing to its importance as an indicator species.

(SOURCE: Piroddi, C., Bearzi, G., Gonzalvo, J. and Christensen, V. 2011. From common to rare: The case of the Mediterranean common dolphin. *Biol. Conserv.* 144: 2,490-2,498).

Marine debris

HIGH DENSITIES OF MICROPLASTICS IN WESTERN MEDITERRANEAN

Almost all of the 40 stations sampled in one study of the western Mediterranean in 2010 contained microplastics (0.3-5mm). The abundances were significantly higher than in the Caribbean or North Atlantic, with peak values being within the same order of magnitude as in the North Pacific Gyre, a known area of heavy marine debris accumulation. The average ratio between microplastics and zooplankton was high enough to be a cause for concern regarding zooplankton feeders. Evidence for the consumption and metabolism of this material by cetaceans has recently been reported (toxic residues [phthalates] of microplastics identified in the blubber of stranded fin whales in the Mediterranean [Fossi *et al*. 2012]).

(SOURCE: Collignon, A., Hecq, J.-H-, Glagani, F., Voisin, P. and Collard, F. 2012. Neustonic microplastic and zooplankton in the North Western Mediterranean Sea. *Mar. Pollut. Bull.* 64: 861-864).

INGESTED MARINE DEBRIS KILLS A SPERM WHALE IN THE MEDITERRANEAN

A 10m long male sperm whale was found stranded in southeast Spain, its stomach containing 20kg of plastic material. The cause of death was rupture of the stomach due to plastic, coupled with starvation (intestinal blockage). Most of the material was identified as stemming from the greenhouse agriculture industry (including 30m² of greenhouse cover material), pointing to a previously unrecognized source of marine debris and insufficient waste disposal by this industry in the Mediterranean. This is the second report of sperm whale death due to debris ingestion in this area and the fourth case worldwide. Marine debris (mostly plastics) is currently one focus of the IWC's standing working group on environmental concerns.

(SOURCE: de Stephanis, R., Gimenez, J., Caropinelli, E., Gutierrez-Exposito, C. and Canadas, A. 2013. A main meal for sperm whales: Plastic debris. *Mar. Pollut. Bull.* 69: 206-214).

MICROPLASTICS IDENTIFIED FOR THE FIRST TIME AS A POTENTIAL THREAT TO LARGE CETACEANS IN THE MEDITERRANEAN

The threat of marine debris (mostly plastics) to cetaceans has been thought to involve larger items for the most part, leading to entanglement or blockage of the digestive tract after ingestion. Results from examinations of the Mediterranean fin whale suggest the emergence of a new plastics-related threat to baleen whales. The authors collected microplastics in the Pelagos Sanctuary, identified high amounts of toxic residues (phthalates) of microplastics in plankton samples, and identified these substances in the blubber of stranded fin whales. The authors conclude that phthalates could serve as a tracer for the ingestion of plastic by whales.

(SOURCE: Fossi, M.C., Panto, C., Guerranti, C., Coppola, D., Gianetti, M, Marsili, L. and Minutoli, R. 2012. Are baleen whales exposed to the threat of microplastics? A case study of the Mediterranean fin whale (*Balaenoptera physalus*). *Mar. Pollut. Bull.* 64: 2,374-2,379).

Chemical pollution

MERCURY CONCENTRATIONS IN MEDITERRANEAN DOLPHINS

Mercury is a strong bioaccumulator and species such as dolphins, at the top of the food chain, have the highest concentrations in their tissues. An investigation of bottlenose and striped dolphins stranded along Italian coasts during the period 2000-09 revealed highest concentrations in the liver. Different geographic areas in the Mediterranean are characterized by different values. The levels in these Italian specimens were exceeded only by those reported in an earlier study from French coasts. The values in the Mediterranean are generally higher than those from the same species in the Atlantic. This is partly because the Mediterranean is characterized by high natural sources of mercury (so-called mercuriferous belts), making any additional anthropogenic inputs a matter of concern.

(SOURCE: Bellante, A., Sprovieri, M, Buscaino, G., Buffa, G., di Stefano, V., Salvagio Manta, D., Barra, M, Filiciotto, F., Bonanno, A., Giacoma, V. and Mazzola, S. 2012. Stranded cetaceans as indicators of mercury pollution in the Mediterranean Sea. *Italian J. Zoo.* 79: 151-160).

TOXICOLOGICAL STRESS OF CETACEANS IN THE MEDITERRANEAN'S LARGEST MARINE SANCTUARY

The Pelagos Sanctuary is the only pelagic MPA in the Mediterranean and measures 90,000km². The levels of PCBs, DDTs and OCs in skin biopsies of striped dolphins within the sanctuary were1.7- and 1.5-fold higher than in two other tested areas (Ionian Sea, Italy; Strait of Gibraltar, Spain). The general toxicological stress level of the animals in the sanctuary was 1.4 times higher than at the other two sites, and this was correlated with lower genetic diversity in the sanctuary (i.e. supporting an association between genetic diversity and an ability to manage toxicological stress). The authors conclude that the sanctuary has '*partially failed to fulfill its goal of significantly improving the conservation status of the area's cetacean populations*'.

(SOURCE: Fossi, M.C., Pani, C., Marsili, L., Maltese, S., Spinsanti, G., Casini, S., Caliani, I., Gaspari, S., Munoz-Arnanz, J., Jimenez, B. and Finoia, M.G. 2013. The Pelagos Sanctuary for Mediterranean marine mammals: Marine Protected Area (MPA) or marine polluted area? The case study of the striped dolphin (*Stenella coeruleoalba*). *Mar. Pollut. Bull.*, in press).

THE HERBICIDE ATRAZINE STILL PRESENT IN HIGH CONCENTRATIONS IN THE MEDITERRANEAN 20 YEARS AFTER BAN

The herbicide atrazine, a lipophilic persistent organochlorine, lost its approval in most northern European countries in the 1990s and was banned by the European Union in 2004. Its widespread occurrence in aquatic environments and its properties (including toxicity) make it a priority pollutant in the European Water Framework Directive. Maximum concentrations (31-41ng/l) were found in Istanbul and the Dardanelles (indicating on-going contamination). A transformation product of atrazine, TERB, was recorded in the northern Adriatic Sea. Organochlorines have been associated with infertility, birth defects, tumours and other symptoms in cetaceans.

(SOURCE: Nödler, K., Licha, T. and Voutsa, D. 2013: Twenty years later – Atrazine concentrations in selected coastal waters of the Mediterranean and Baltic Sea. *Mar. Pollut. Bull.* in press).

DDTS, PCBS AND HEAVY METALS IN EASTERN MEDITERRANEAN BOTTLENOSE DOLPHINS

Mercury and other heavy metal concentrations in seven dolphins examined in 2006 from the eastern Mediterranean were similar to those in an earlier study conducted from 1994-2001, indicating stability over time. The total DDT and PCB concentrations were highest in the blubber. The blubber PCB values were an order of magnitude lower than those found in this and other delphinid species in the western Mediterranean, probably reflecting a lower rate of industrial waste input. Nonetheless, 15 different pesticides other than DDTs were detected in the various tissues. The high percentage of DDE in the total DDT concentration in these dolphins along the Israeli coast supports the conclusion drawn elsewhere for the Mediterranean (Wafo *et al.*, 2012) that the DDT is gradually degrading (into DDE) and that no significant new DDT is reaching the Mediterranean.

(SOURCE: Shoham-Frider, E., Kress, N., Wynne, D., Scheinin, A., Roditi-Elsar, M. and Kertem, D. 2009. Persistent organochlorine pollutants and heavy metals in tissues of common bottlenose dolphin (*Tursiops truncatus*) from the Levantine basin of the Eastern Mediterranean. *Chemosphere* 77: 621-627).

ORGANOCHLORINE CONCENTRATIONS IN MEDITERRANEAN DOLPHINS MAY BE DECLINING

A comparison of the PCB and DDT concentrations in stranded striped dolphins in the Mediterranean between 2007 and 2009 revealed that the values of these organochlorines tended to decrease compared to studies conducted in the 1990s. Nonetheless, variable levels were detected in every tissue and organ examined (lung, muscle, liver, kidney, and blubber). Total PCBs were most abundant, followed by total DDT. DDE, as a breakdown product of DDT, made up 80% of the total DDTs, pointing to the on-going aging of DDT since the ban of its use in the Mediterranean basin in the late 1970s.

(SOURCE: Wafo, E., Risoul, V., Schembri, T., Lagadec, V., Dhermain, F., Mama, C. and Portugal, H. 2012: PCBs and DDTs in *Stenella coeruleoalba* dolphins from the French Mediterranean coastal environment (2007-09): Current state of contamination. *Mar. Pollut. Bull.* 64: 2,374-2,379).

Disease and mortality events

General

UNUSUALLY HIGH RATE OF CETACEANS STRANDING ALONG TURKISH BLACK SEA COAST IN 2009

In a three week period, at least 114 cetaceans belonging to all three species known to inhabit the Black Sea (53 harbour porpoises, 9 common dolphins, 7 bottlenose dolphins, 45 unidentified) were reported dead along a 200km-long stretch of the western coast of the Turkish Black Sea. This represents 2.7 individuals per km. An additional nine common dolphins stranded alive. The authors conclude that most of the harbour porpoises found dead were related to bycatch. Two freshly stranded common dolphins were necropsied. They had empty stomachs as well as enlarged livers and spleens. The cause of this unusual mortality could not be determined, but no evidence for a dolphin morbillivirus (DMV) infection was found. An additional 23 cetaceans (mainly common dolphins) stranded alive in Ukraine (13), Georgia (5) and Bulgaria (5).

(SOURCE: Tonay, A.M., Dede, A., Öztürk, A.A., Ercan, D. and Fernández A. 2012. Unusual mass mortality of cetaceans on the coast of the Turkish Western Black Sea in summer 2009. *J. Black Sea/Med. Environ.* 18: 67-75. Birkun, A. Jr. 2009. The progress report on the implementation of the conservation plan for Black Sea Cetaceans November 2009 [October 2007-October 2009] Draft Doc. 12.6. BSC AG FOMLR Meeting Istanbul).

Harmful Algal Blooms (HABs)

HARMFUL ALGAL BLOOMS AN ISSUE IN THE MEDITERRANEAN

HABs are increasing in marine waters worldwide, including the Mediterranean. Two toxic benthic flagellates belonging to the family Ostreopsidaceae have been found with increasing frequency in several Mediterranean coastal areas. They produce palytoxin, one of the most potent non-protein marine toxins known. Palytoxin can cause mortality of benthic organisms, has noxious effects on humans, and shows high toxicity in mammals (LD50: 25-450 ng kg^{-1}). The Adriatic blooms appear to be more toxic than those occurring in other Italian areas. The authors point to the need for further studies to optimize the management of coastal monitoring.

(SOURCE: Accoroni, S. *et al*. (+14 authors). 2011. *Ostreopsis* cf. *ovata* bloom in the northern Adriatic Sea during summer 2009: Ecology, molecular characterization and toxin profile. *Mar. Pollut. Bull.* 62: 2,512-2,519).

Disease

FIRST REPORT OF HERPESVIRUS IN MEDITERRANEAN CETACEANS

The tissues of 5 of 8 striped dolphins from the cetacean morbillivirus mortality episode in 2007 contained 8 novel herpesvirus (HV) genetic sequences. The lack of HV lesions in these morbillivirus-infected individuals indicates that HV may not have contributed to mortality. Nonetheless, this is the first report of this disease agent in any cetacean in the Mediterranean and the first report of such a co-infection. The results suggest that HV may be common among Mediterranean striped dolphins, indicating further study on such co-infection and the potential pathogenicity of HV is needed.

(SOURCE: Belliére, E.N., Esperón, F., Arbelo, M., Munoz. M.J., Fernández, A. and Sánchez-Vizcaíno, J.M. 2010. Presence of herpesvirus in striped dolphins stranded during the cetacean morbillivirus epizootic along the Spanish coast in 2007. *Arch. Virol.* 155: 1,307-1,311).

STRANDED DOLPHINS AFFECTED BY TOXOPLASMOSIS ALONG TWO COASTS OF ITALY

A total of 22 dolphins stranded in Italy were necropsied – 6 striped and 8 bottlenose dolphins along the Tuscan coast and 8 striped dolphins along the coast of the Ligurian Sea. Thirteen of the animals from Tuscany (93%) and 4 from the Ligurian Sea (50%) were infected by toxoplasmosis. Di Guardo *et al.* concluded that *Toxoplasma gondii* was the likely agent of the lethal brain lesions in the Ligurian animals. Pretti *et al.* concluded that the level of *T. gondii* infection along dolphins in the marine area of Tuscany was high. This protozoan probably causes abortion and death in several marine mammal species and is '*of potential concern to cetacean health and conservation*'. The transmission pathway by which dolphins become infected remains unknown. Moreover, the fact that this part of the Ligurian Sea includes the Tuscan Archipelago National Park and is part of a cetacean sanctuary MPA underlines that protected areas afford little to no barrier to disease.

(SOURCES: Di Guardo, G, Proietto, U., Di Francesco, C.E., Marsilio, F., Zaccaroni, A., Scaravelli, D., Mignone, W., Garibaldi, F., Kennedy, S., Forster, F., Iulini, B. Bozzetta, E. and Casalone, C. 2013. Cerebral toxoplasmosis in striped dolphins (*Stenella coeruleoalba*) stranded along the Ligurian Sea coast of Italy. *Vet. Pathol.* 27: 245-253; Pretti, C., Mancianti, F., Nardoni, S., Ariti, G., Monni, G., Di Bello, D., Marsili, S. and Papini, R. 2010. *Rev. Méd. Vét-Toulouse* 161: 428-431).

FIRST REPORTS OF BRUCELLOSIS AND OF COMBINED INFECTIONS IN MEDITERRANEAN CETACEANS

An adult male fin whale found stranded on the Tyrrhenian coast of Italy had high organochlorine concentrations (DDT). The pathogens *Morbillivirus* and *Toxoplasma gondii* were also found in the animal. These pathogens have been found in several cetacean species, but these are the first reports of both occurring simultaneously in a mysticete and of DMV in the Mediterranean fin whale population. These results highlight the risk toxoplasmosis poses to cetaceans already immunosuppressed by concurrent factors such as infections and contaminants. In another report, *Brucella ceti* (dolphin type) was isolated from the brain, lung and intestinal lymph nodes of a stranded striped dolphin found in Tuscany, Italy in February 2012, on the Tyrrhenian coast of the Mediterranean Sea. The animal had severe meningoencephalitis lesions associated with the *Brucella*. *Toxoplasma gondii* was also detected in brain tissue. The authors note that '*While the occurrence of brucellosis has been reported frequently in striped dolphins from the Atlantic Ocean since 1996… no previous information on* Brucellae *colonizing marine mammals or cetaceans had been available from the Mediterranean Sea until now*'.

(SOURCES: Mazaroli, S., Marcer, F., Mignone, W., Serracca, L., Goria, M., Marsili, L., di Guardo, G. and Casalone, C. 2012. Dolphin *Morbillivirus* and *Toxoplasma gondii* coinfection in a Mediterranean fin whale. *BMC Vet. Res.* 8: 20; Alba P., Terracciano , G., Franco, A., Lorenzetti, S., Cocumelli, C., Fichi, G., Eleni, C., Zygmunt, M.S., Cloeckaert, A., and Battisti, A. 2013. The presence of *Brucella ceti* ST26 in a striped dolphin (*Stenella coeruleoalba*) with meningoencephalitis from the Mediterranean Sea. *Vet. Microbio.* 164: 158-163).

CHRONIC DOLPHIN MORBILLIVIRUS INFECTION IN MEDITERRANEAN STRIPED DOLPHINS

In 1990 and 2006-07, epizootics caused by DMV struck striped dolphins along the Spanish Mediterranean coast, with high mortality rates. This study examined 118 dolphins stranded in three regions of Spain, with 25-29% showing unusual DMV infections localized in the central nervous system (brain). Larger animals were more susceptible than smaller ones. The authors believe that the infection occurs in two different forms: acute events with massive die-offs, and sub-acute or chronic cases localized in the brain. This latter infection is thought to be a widespread phenomenon in the western Mediterranean. It constitutes the most relevant single cause of stranding following a DMV epizootic and might even have a greater effect than the epizootic itself.

(SOURCE: Soto, S., Alba, A., Ganges, L., Vidal, E., Raga, J.A., Alegre, F., Gonzalez, B., Medina, P., Zorrilla, I., Martinez, J., Marco, A., Perez, M., Perez, B., Perez de Vargas, A., Valverde, R.M. and Domingo, M. 2011. Post-epizootic chronic dolphin morbillivirus infection in Mediterranean striped dolphins *Stenella coeruleoalba*. *Dis. Aquat. Org.* 96: 187-194).

Direct exploitation

FOUR TO FIVE MILLION CETACEANS HUNTED IN 20TH CENTURY – A HISTORY OF BLACK SEA HUNTS

A recent review on the history of cetacean fisheries in the Turkish waters of the Black Sea gives an idea of the scale of depletion of these populations. Harbour porpoises, short-beaked common dolphins and common bottlenose dolphins were the main species caught in these fisheries. The first reported large-scale hunting of cetaceans in the area dates to 400 BC; hunting was outlawed in 1983. Initially dolphins were the main species targeted but by the late 1970s, 80% of the catch was harbour porpoises. An estimated 4-5 million dolphins and porpoises were hunted in the 20th century alone, but poor to no records were kept on catch composition, so extrapolating historical population data is difficult. Such large-scale hunting undoubtedly had a major impact on the ecosystem of the Black Sea.

(SOURCE: Tonay, A.M. and Öztürk, A.A.2012. Historical records of cetacean fishery in the Turkish seas. *J. Black Sea/Med Environ.* 18: 388-399).

Climate change

ON-GOING AND PREDICTED EFFECTS OF CLIMATE CHANGE IN THE MEDITERRANEAN

Using a representative area of the western Mediterranean as a case study for climate change effects on Mediterranean ecosystems, the authors report an increase in surface temperature of about 1.1°C in the last 35 years, a progressive salinization of intermediate and deep waters, and a strengthening of stratification. They predict a considerable decrease in rainfall and wind, warmer surface waters and a prolonged stratification period. The projected repercussions include mass mortalities of sessile invertebrates, increases in the smallest phytoplankton, proliferation of gelatinous carnivores, including jellyfish, and a faster acidification of seawater compared with the global oceans. These processes, along with their synergies, will affect all levels of the ecosystem and ecosystem function. These results support an earlier study (Gambaini *et al.*) predicting altered marine biodiversity and productivity, trophic web mismatches, higher incidences of diseases and toxic algal blooms. Gambaini *et al.* draw a link between climate change and cetaceans in the Mediterranean, specifically in potential changes to euphausiid shrimp species that form the main diet of Mediterranean fin whales.

(SOURCES: Calvo, E., Simó, R., Coma, R., Ribes, M, Pascual, J., Sabatés, A., Gili, J.M. and Pelejero, C. 2011. Effects of climate change on Mediterranean marine ecosystems: The case of the Catalan Sea. *Clim. Res.* 50: 1-29; Gambaini, D.D., Mayol, P., Isaac, S.J. and Simmonds, M.P. 2009. Potential impacts of climate change and greenhouse gas emissions on Mediterranean marine ecosystems and cetaceans. *J. Mar. Biol. Assoc.* 89: 179-201).

CLIMATE SHIFTS IN THE NORTH ATLANTIC UNLIKELY TO CHANGE BACK

Long-term records of air temperature, rainfall and air pressure at sea level were analysed for two periods of warm water in the Atlantic. Since 1996 there has been an increase in temperature in the Atlantic, and the last time temperatures were at this level, it took 30 years before they cooled. Therefore, species shifts due to warming temperatures in the Atlantic are unlikely to change back in the near future. In addition, this ocean temperature will mean higher summer rainfall in northern Europe and the UK (which reported its wettest summer in 100 years in 2012), and drier, hotter summers in the Mediterranean, which will have ramifications for coastal ecosystems (e.g. more fresh water runoff in Northern Europe).

(SOURCE: Sutton, R.T. and Buwen Dong, B. 2012. Atlantic Ocean influence on a shift in European climate in the 1990s. *Nat. Geosci.* 5: 788–792).

Noise impacts

NOISE AND CETACEANS IN MEDITERRANEAN WATERS

In a special issue of *Marine Pollution Bulletin* devoted to cetaceans and military sonar, one paper outlined the progress made in recognising and tackling this issue in European waters, including the Mediterranean. Six species of beaked whales have been recorded in European waters. Regional conventions (ACCOBAMS and ASCOBANS), coupled with efforts in the European Union, such as the Marine Strategy Framework and the Habitats Directive (cetaceans provided 'strict protection'), have addressed the problem of anthropogenic sound, although other regional seas organisations (e.g., OSPAR, Barcelona Convention) are still in early stages of engagement. The authors outline future proposals and recognise the difficulty in the transition from scientific research to policy implementation, underlining the urgency of this step in the case of naval sonar and associated beaked whale mortalities.

(SOURCE: Dolman, S.J., Evans, P.G.H., Notarbartolo di Sciara, G. and Frisch, H. 2011. Active sonar, beaked whales and European regional policy. *Mar. Pollut. Bull.* 63: 27-34).

LEISURE BOATING DISPLACES BOTTLENOSE DOLPHINS

Intense leisure boating in the Cres-Lošinj archipelago in the northern Adriatic Sea caused significant seasonal displacement of bottlenose dolphins from noisy areas. In coastal areas, marine tourism contributes substantially to the overall sea ambient noise level. This noise may impair the dolphins' ability to use sound to communicate, navigate and forage. The resident bottlenose population has suffered a decline of about 40% between 1995 and 2006. Moreover, this area is an important nursing area, with frequent occurrence of mother/calf groups, and the authors interpret the absence of new-borns in the high impact area during the tourist season to indicate that more sensitive animals are being displaced. The authors call for development of appropriate conservation measures – speed limits, mandatory codes of conduct – to ensure that these important habitats are not abandoned in the future.

(SOURCES: Rako, N., Fortuna, C.M., Holcer, D., Mackelworth, P., Nimak-Wood, M., Pleslić, G., Sebastianutto, L., Vilibić, I., Wiemann, A. and Picciulin, M. 2013. Leisure boating noise as a trigger for the displacement of the bottlenose dolphins of the Cres-Lošinj archipelago (northern Adriatic Sea, Croatia). *Mar. Pollut. Bull.* 68 (1-2): 77-84; Rako, N., Picciulin, M., Mackelworth, P., Holcer, D., and Fortuna, C.M. 2012. Long-term monitoring of anthropogenic noise and its relationship to bottlenose dolphin (*Tursiops truncatus*) distribution in the Cres-Lošinj Archipelago, Northern Adriatic Sea. In: Popper, A.N and Hawkins, A. (eds), The Effects of Noise on Aquatic Life, *Adv. Exp. Med. Biol.* 730, DOI 10.1007/978-1-4419-7311-5_72).

GLOBAL

General

ODONTOCETES MAY RECOVER LESS QUICKLY THAN MYSTICETES AFTER DEPLETION

Odontocete populations do not appear to recover as quickly as mysticete populations after exploitation and depletion. This may be due to the life history, behavioural ecology and social behaviour of odontocetes. For example, reproductive success may rely on social cohesion and cooperation, through e.g. food sharing or defending against predators. Depleted populations may be less successful at these group behaviours. In addition, knowledge and cultural behaviours passed on to subsequent generations are important to survival. Social groups may have knowledgeable 'leaders', which if lost can result in a decline in the group's survivability and fitness. Because of low recovery potential, removal of only a few percent annually in odontocetes can lead to over-exploitation. The authors conclude '*the evidence for a lack of strong recovery in heavily exploited odontocete populations indicates that [their] management should be more precautionary*'.

(SOURCE: Wade, P.R., Reeves, R.R. and Mesnick, S.L. 2013. Social and behavioural factors in cetacean responses to overexploitation: Are odontocetes less 'resilient' than mysticetes? *J. Mar. Biol.* 2012: doi:10.1155/2012/567276).

Habitat degradation

Fisheries interactions

MAJOR EFFORTS BEING UNDERTAKEN TO DETECT DERELICT FISHING GEAR AT SEA

Derelict fishing gear presents a threat of entanglement and ingestion to cetaceans and other marine animals. A special issue of *Marine Pollution Bulletin* has been devoted to outlining the increasing efforts to detect items such as (ghost) nets, line and buoys at sea, with a focus on the North Pacific. The efforts concentrate on understanding the characteristics of such gear, indirectly detecting them through (weather and ocean) modelling, and direct detection through remote sensing and aerial surveys. The ultimate goal of these multidisciplinary efforts, involving the so-called GhostNet Project, is to remove the items from the sea. A new project, WhaleWatch, uses satellite tracking to help reduce whale entanglement by determining areas whales are most likely to visit, thus identifying hotspots.

(SOURCE: *Mar. Pollut. Bull.* 2013. 65: 1-75; 'News' section: Satellite tracking to help reduce number of whales entangled in fishing gear. 2012. *Mar. Pollut. Bull.* 64: 1,275).

FISHERY INTERACTIONS CAUSING UNSUSTAINABLE MORTALITIES IN 86% OF ALL TOOTHED WHALE SPECIES WORLDWIDE

A report published by the Convention on the Conservation of Migratory Species of Wild Animals under the UN Environment Programme (UNEP/CMS) indicated that 86% of all toothed whales are suffering unsustainably high death tolls from entanglement in gillnets, traps, weirs, purse seines, longlines and trawls. Moreover, 50 species were affected by local hunting, deliberate killings or live-captures in 2011 (up from 47 in 2001). Finally, overfishing of predominant prey species threatened 13 species (up from 11 in 2001), which is associated with lack of food and forced dietary shifts. A Global Programme of Work for Cetaceans is being considered for adoption and would strengthen the role of UNEP/CMS.

(SOURCE: 'News' section. 2011. *Mar. Pollut. Bull.* 62: 2,584).

Acidification

DISSOLVING SHELLS OBSERVED IN SOUTHERN OCEAN INVERTEBRATES

Since the mid-1980s, the surface waters of the Southern Ocean have experienced a 30% increase in acidity due to increasing levels of dissolved carbon dioxide. Now, the shells of pteropod sea snails show evidence of dissolving. Because carbon dioxide dissolves more readily in cooler waters, the impacts of increasing ocean acidity are likely to be observed at the poles first. The impacts of increasing acidity on calcium carbonate-dependent krill, the foundation of most mysticete food webs, are unknown, but these results suggest negative impacts.

(SOURCE: Bednaršek, N., Tarling, G.A., Bakker, D.C.E., Fielding, S., Jones, E.M., Venable, H.J., Ward, P., Kuzirian, A., Lézé, B., Feely, R.A. and Murphy, E.J. 2012. Extensive dissolution of live pteropods in the Southern Ocean. *Nat. Geosci.* 5: 881-885).

EXPERT OPINIONS ON THE IMPACTS OF OCEAN ACIDIFICATION

Fifty-three climate change experts were surveyed for their opinions on the potential impacts of ocean acidification. The experts agreed that non-anthropogenic ocean acidification occurred in the (geological) past; anthropogenic carbon dioxide emissions are the main reason behind current acidification; and anthropogenic ocean acidification will have impacts for centuries to come. They generally agreed that there will be impacts on biological and ecological processes and biogeochemical cycles. There was high agreement that there would be an impact on primary productivity in the oceans but less agreement as to the impact on oceanic trophic webs.

(SOURCE: Gattuso, J.-P., Mach, K. and Morgan, G. 2013. Ocean acidification and its impacts: An expert survey. *Climat. Change* 117: 725-738).

Disease and mortality events

Oil spills

UNUSUALLY HIGH CETACEAN MORTALITY RATE IN THE GULF OF MEXICO

In April 2010, the US government declared an unusual mortality event (UME), due to an unusually high number of cetacean strandings in the Gulf of Mexico. The UME began in February 2010, with 114 cetaceans stranding before the Deepwater Horizon oil-spill into the Gulf of Mexico (30 April). During and immediately after the spill, an additional 122 cetaceans stranded. From 3 November 2010 to 7 April 2013, 694 cetaceans stranded (although six were killed in a scientific research project and one during dredging activity). The majority of the stranded animals were common bottlenose dolphins but sperm whales were also reported. From 2002-2009 the average annual number of stranded cetaceans in the Gulf was 70. The actual mortality is likely to be at least an order of magnitude higher than the stranding rate (Williams *et al.*). In the heavily oiled Barataria Bay, dolphins were reported as underweight, with low hormone and blood sugar levels and liver lesions – signs that were not seen in unoiled areas and may constitute a link between the oil-spill and delayed mortality.

(SOURCE: NOAA. 2011. *http://www.nmfs.noaa.goc/pr/health/oilspill/mammals/htm*; NOAA. 2013. *http://www.nmfs.noaa.gov/pr/health/mmume/cetacean_gulfofmexico_faq.htm*; Williams, R., Gero, S., Bejder, L., Calambokidis, J., Kraus, S.D., Lusseau, D., Read, A.J. and Robbins, J. 2011. Underestimating the damage: Interpreting cetacean carcass recoveries in the context of the Deepwater Horizon/BP incident. *Conserv. Lett.* 4: 228-233).

DECREASE IN SPERM WHALES NEAR DEEPWATER HORIZON OIL-SPILL SITE

Passive acoustic monitoring of sperm whales has been ongoing in the Gulf of Mexico for several years. Researchers compared baseline data in 2007 to those from just after the Deepwater Horizon oil-spill in 2010. They found that sperm whale abundance and acoustic activity nine miles from the spill site had decreased by a factor of 2, but there was increased acoustic activity 25 miles away. The animals may have shifted their distribution due to decreased food availability or noise disturbance from increased boat traffic in the spill area. The sperm whale population was estimated at 1,665 in 2004, with a potential biological removal level of 2.8 animals a year. This has likely been exceeded since the oil-spill, as sperm whales have been reported in the Gulf of Mexico UME; therefore, determining impacts of this spill on the sperm whale population should be prioritized.

(SOURCE: Ackleh, A.S., Ioup, G.E., Ioup, J.W., Ma, B., Newcomb, J.J., Pal, N., Sidorovskaia, N.A. and Tiemann, C. 2012. Assessing the Deepwater Horizon oil-spill impact on marine mammal population through acoustics: Endangered sperm whales. *J. Acoust. Soc. Amer.* 131 2306-2314; Waring, G.T., Josephson, E., Maze-Foley, K., and Rosel, P.E. (eds). 2012. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2011. NOAA Tech Memo NMFS NE 221. National Marine Fisheries Service, Woods Hole, MA).

Climate change

CLIMATE CHANGE IS SHIFTING THE DISTRIBUTION OF FISHERY SPECIES

Analysis of fisheries catch and survey data have found a link between climate change and shifting distributions and fishery catch levels. Warmer water species can be found at higher latitudes, whereas there has been a decrease in tropical and sub-tropical species. This is directly related to increasing sea temperatures. The authors warn that '*changes in catch composition have direct implications for coastal fishing communities, particularly those in tropical developing countries, which tend to be socioeconomically vulnerable to the effects of climate change*'. This study may have implications for cetacean prey species and also research on ecosystem modelling, especially for tropical and polar ecosystems as the warmer water species move out and into these regions, respectively.

(SOURCE: Cheung, W.W.L., Watson, R. and Pauly, D. 2013. Signature of ocean warming in global fisheries catch. *Nature* 497: 365-368).

GREENLAND ICE SHEET MAY BE MORE STABLE THAN ANTARCTIC, BUT IS VULNERABLE

Ice drilling data show that Greenland temperatures were on average 8°C higher 115,000-130,000 years ago, but 75% of the ice sheet remained intact. These data help allay concerns regarding present-day ice sheet melting; complete melt could increase sea levels by ~8m. However, during this prehistoric warm period there was in fact an 8.5m rise in sea level, and if this rise was not due to massive loss of Greenland ice, it is believed that it was due to loss of ice in Antarctica. The temperature threshold for completely melting the Greenland ice sheet was estimated to be approximately 0.8°C (which has already happened) to 3.2°C, with a best estimate of 1.6°C above pre-industrial temperatures. Complete melt of the >3km thick ice sheet in an 8°C increase scenario would potentially take 2,000 years. A 2°C temperature increase (the current upper level limit for international policy makers) would lead to complete melt in 50,000 years.

(SOURCES: Dahl-Jensen, D. *et al*. 2013. Eemian interglacial reconstructed from a Greenland folded ice core. *Nature* 493: 489-494; Robinson, A., Calov, R. and Ganopolski, A. 2012. Multistability and critical thresholds of the Greenland ice sheet. *Nat. Clim. Change* 2: 429-432).

ICE SHEET DYNAMICS IN GREENLAND AND ANTARCTICA AND SEA LEVEL RISE

Analysis of satellite data and ice sheet loss estimates determined that ice sheets in Greenland and Antarctica are losing three times as much ice as 20 years ago. The rate of melting in Greenland is particularly fast – five times greater than in the mid-1990s. This ice loss is contributing 0.6mm to the current observed sea level rise of 3mm per year. Furthermore, data from the ICESat satellite indicate that the thickness of ice shelves surrounding Antarctica has decreased. This thinning is attributed to warming patterns in underlying Southern Ocean waters, rather than air temperatures. As ice sheets lose mass, they can no longer hold back land-based glaciers; glacier speed increases, which increases deposition of land-based ice into the ocean, which in turn contributes to sea level rise. Warm water currents are also likely to cause significant melting of the Filchner-Ronne ice shelf in the Weddell Sea by 2100. The shelf is currently lying on the rim of a basin in the underlying bedrock and an influx of warmer water could cause the shelf to detach into the ocean. Researchers warn that loss of the Filchner-Ronne ice sheet will lead to additional losses of the West Antarctic Ice Sheet, whose total loss could lead to a 6m or more increase in sea level.

(SOURCES: Humbert, A. 2012. Cryospheric science: Vulnerable ice in the Weddell Sea. *Nat. Geosci.* 5: 370-371; Pritchard, H.D., Lightenberg, S.R.M., Fricker, H.A., Vaughan, D.G., van den Broeke, M.R. and Padman, L. 2012. Antarctic ice-sheet loss driven by basal melting of ice shelves. *Nature* 484: 502-505; Ross, N., Bingham, R.G., Corr, H.F.G., Ferraccioli, F., Jordan, T.A., Le Brocq, A., Rippin, D.M., Young, D., Blankenship, D.D. and Siegert, M.J. 2012. Steep reverse bed slope at the grounding line of the Weddell Sea sector in West Antarctica. *Nat. Geosci.* 5: 393-396; Shepherd, A. *et al.* 2012. A reconciled estimate of ice-sheet mass balance. *Science* 338: 1,183-1,189).

ANTHROPOGENIC CARBON DIOXIDE EMISSIONS ARE STILL INCREASING

In 2011, anthropogenic greenhouse gas emissions rose by 3%, to a total of 38.2 billion tons of carbon dioxide. Most of this increase was the result of higher levels produced by China (whose emissions rose by 10%) and India (7%). Of the ten highest carbon dioxide emitting countries, only the USA and Germany decreased their emissions in 2011. The authors state that '*significant emission reductions are needed by 2020 to keep 2°C as a feasible goal*' and '*A delay in starting mitigation activities will lead to higher emission rates, higher costs, and the target of [a global warming temperature rise] remaining below 2°C may become unfeasible*'.

(SOURCE: Peters, G.P., Andrew, R.M., Boden, T., Canadell, J.G., Ciais, P., Le Quéré, C., Marland, G., Raupach, M.R. and Wilson, C. 2013. The challenge to keep global warming below 2 °C. *Nat. Clim. Change* 3: 4-6).

SEA LEVEL RISE IS HIGHER THAN PREDICTED AND MAY BE EXTREME IN THE FUTURE

While temperature rises appear to be consistent with the projections made in the Intergovernmental Panel on Climate Change's (IPCC) most recent report (i.e. 0.16°C per decade), sea levels are rising 60% faster than its central projections. Satellite data show sea levels rising at a rate of 3.2mm a year, as opposed to the IPCC's most recent best estimate of 2mm a year. Data collected on rates of sea level rise along the coast of the northeastern USA found levels increasing at rates 3-4 times the global average due to oceanographic effects. These areas include critical habitat for right whales, amongst other species. A modelling exercise showed that introducing emissions caps limiting global temperature rise to 1.5°-2°C will nonetheless result in a 75-80cm rise in sea level in the next 100 years. If emissions were left unchecked, sea level rise would be 1m or more. With emissions caps, sea level increase was projected to be 2.7m – but potentially up to 4m – by 2300.

(SOURCES: Rahmstorf, S., Foster, G. and Cazenave, A. 2012. Comparing climate projections to observations up to 2011 *Environ. Res. Lett.* 7:doi:10.1088/1748-9326/7/4/044035; Sallenger, A.H., Doran, K.S. and Howd, P.A. 2012. Hotspot of accelerated sea-level rise on the Atlantic coast of North America. *Nat. Clim. Change* 2: 884–888; Schaeffer, M., Hare, W., Rahmstorf, S and Vermeer, M. 2012. Long-term sea-level rise implied by 1.5°C and 2°C warming levels. *Nat. Clim. Change* 2: 867-870).

CURRENT TEMPERATURES UNPRECEDENTED

A recent Bayesian analysis of ice cores, tree rings and lake sediment samples going back 600 years found that current northern hemisphere temperature extremes have been unprecedented. The temperatures in the summers of 2005, 2007, 2010 and 2011 were significantly higher than the average summer temperatures going back to 1400. Going back 11,300 years (i.e., the onset of the Holocene era), 73 temperature proxy studies found a ~0.7°C cooling beginning less than 5,000 years ago (with a ~2°C cooling in the North Atlantic), with the coolest period during the 'little ice age' 200 years ago. Current temperatures are warmer than 75% of the Holocene era, and IPCC temperature predictions for 2100 are warmer than the temperatures for the entire Holocene.

(SOURCES: Tingley, M. and Huybers, P. 2013. Recent temperature extremes at high northern latitudes unprecedented in the past 600 years. *Nature* 496: 201-205; Marcott, S.A., Shakun, J.D., Clark, P.U. and Mix, A.C. 2013. A reconstruction of regional and global temperature for the past 11,300 years. *Science* 339: 1,198-1,201).

Noise impacts

EFFECTS OF SONAR SIGNALS ON BOTTLENOSE DOLPHINS

Thirty common bottlenose dolphins in the US Navy program were exposed to mid-frequency sonar signals (1 second duration; 3.25-3.45 kHz) and their behaviours recorded, e.g. changes in breathing rate and fluke/flipper slapping. Dolphins were exposed to signals at 115, 130, 145, 160, 175 or 185 dB re 1 μPa (rms) sound pressure level (SPL). The study found the occurrences and 'severity' of behaviours increased with SPL. Although 'habituation' was reported at SPLs below 160dB, SPLs above 175 dB always caused responses and at 185 dB, all dolphins '*refused to participate*' in the study. The researchers noted that the responses of the dolphins '*are likely not directly transferrable to conspecifics in the wild. The dolphins have years of experience under stimulus control, which is a necessary condition for the performance of trained behaviors, and they live within an environment with significant boating activity. These factors likely impact the threshold of responsiveness to sound exposure, potentially in the direction of habituation or increased tolerance to noise'*.

(SOURCE: Houser, D.S., Martin, S.W. and Finneran, J.J. 2013. Exposure amplitude and repetition affect bottlenose dolphin behavioral responses to simulated mid-frequency sonar signals. *J. Exp. Mar. Biol. Ecol.* 443: 123-133).

COMMON DOLPHIN STRANDING IN UK LINKED TO NAVAL EXERCISES

At least 26 dolphins died in a mass stranding event in Falmouth Bay, Cornwall on 9 June 2008. The animals had been feeding well and their auditory tissues appeared normal, although five animals had microscopic haemorrhages in the ear and one of these had inflammation of the inner ear. The animals did not test positive for algal toxins and contaminant levels were low. No signs of gas/fat embolism, disease, bycatch or ship strike were noted. Four days before the stranding event, military exercises (incorporating sonar use) were used in the area, with helicopter exercises on the morning of the stranding event. The authors determined *naval activity to be the most probable cause of the Falmouth Bay [mass stranding event]*. The authors suggest that the stranding event was a two-stage process; the exercises drove these pelagic dolphins into the inshore waters of Falmouth Bay and then helicopter exercises drove them to strand.

(SOURCE: Jepson, P.D., Deaville, R., Acevedo-Whitehouse, K., Barnett, J., Brownlow, A., Brownell, R.L., Clare, F.C., Davison, N., Law, R.J., Loveridge, J., Macgregor, S.K., Morris, S., Murphy, S., Penrose, R., Perkins, M.W., Pinn, E., Seibel, H., Siebert, U., Sierra, E., Simpson, V., Tasker, M.L.,Tregenza, N., Cunningham, A.A. and Fernández, A. 2013. What caused the UK's largest common dolphin (*Delphinus delphis*) mass stranding event? *PLoS ONE* 8: e60953).

BELUGA HEART RATE SIGNIFICANTLY INCREASES DURING SOUND EXPOSURE

A beluga whale was exposed to sound of differing durations and frequencies while monitoring its heart rate. Heart rate increased significantly, to over double the control heart rate, with the maximum heart rate occurring when the whale was exposed to sound frequencies of 19-27 kHz. The whale had a significantly higher heart rate at higher frequencies (54-78 kHz and 78-108 kHz). Not only did heart rate increase significantly when the noise was initiated, but when the noise stopped, heart rate decreased significantly, regardless of duration of exposure. The heart rate was also affected by sound intensity, with heart rate increase at 140dB exposure significantly less than at 150dB exposure, and significantly higher at 160dB exposure. Heart rate response showed no signs of habituation. The respiration rate of the animal also increased significantly during the first minute of exposure, but this was not correlated with heart rate. '*Tachycardia is considered a cardiovascular component of the stress reaction, indicator of animal defense reaction and level of 'social' stress*' and '*severe tachycardia*' developed in the beluga at even relatively low noise intensities (i.e., 140dB). These results could be an indicator of a relatively severe physiological stress response to anthropogenic noise exposure in beluga whales at levels as low as 140dB.

(SOURCE: Lyamin, O.I., Korneva, S.M., Rozhnov, V.V. and Mukhametov, L.M. 2011. cardiorespiratory changes in beluga in response to acoustic noise. *Doklady Akademii Nauk* 440: 704-707 [In Russian]).

BEHAVIOURAL CHANGES IN BEAKED WHALES IN RESPONSE TO SHIPPING NOISE

The acoustic responses of Blainville's beaked whales to ship noise (206 dB re 1 µPa broadband) were recorded using hydrophones in a military range in the Bahamas. The authors report '*that broadband ship noise caused a significant change in beaked whale behavior up to at least 5.2 kilometers away from the vessel*'. At this distance, the received level of sound was estimated at 135 dB re 1 µPa, using simple sound propagation models. Although the whales did not cease foraging, '*[t]he concern about such behavioral changes is thus likely to be chronic rather than acute, with a progressive reduction of condition associated with the cumulative behavioral disruption. Such energetic deficiencies have the potential to lead to impacts on individual survival and reproductive capability and, ultimately, could lead to population decline*'. The authors warn that this adds to increasing evidence that broadband shipping noise can negatively affect odontocetes.

(SOURCE: Pirotta, E., Milor, R., Quick, N., Moretti, D., Di Marzio, N., Tyack, P., Boyd, I., and Hastie, G. 2012.Vessel noise affects beaked whale behavior: Results of a dedicated acoustic response study. *PLoS ONE* 7: e42535, pp 1-8).

SHIPPING NOISE CAUSES CHRONIC STRESS IN WHALES

After 11 September 2001, there was a dramatic decrease in shipping traffic in the Bay of Fundy, Canada and a 6dB shift in associated low frequency (<150Hz) shipping noise. An analysis of stress-related hormone markers in faecal samples of North Atlantic right whales reported a decrease in stress hormones coincident with this decrease in ocean noise. The authors note that '*[t]his is the first evidence that exposure to low-frequency ship noise may be associated with chronic stress in whales*' and, as stress can affect reproduction and other life history and health parameters, this has implications for the recovery of depleted whale species.

(SOURCE; Rolland, R.M., Parks, S.E., Hunt, K.E.,Castellote, M., Corkeron, P.J., Nowacek, D.P., Wasser, S.K., and Kraus, S.D. 2012. Evidence that ship noise increases stress in right whales. *Proc. Royal Soc. B* 279: 2,363-2,368).

MINKE WHALE HEARING AND ANTHROPOGENIC NOISE

The hearing abilities of baleen whales are difficult to ascertain. An anatomically accurate computer model was developed of northern minke whale hearing structures to determine their hearing range. The model estimated that a minke whale's best hearing range was 30Hz-7.5 kHz or 100Hz-25 kHz. The exercise determined that '*many anthropogenic noise sources operate at similar frequencies to those heard by the minke whale*', including shipping noise, seismic surveys and military sonar (*i.e*., 1-10 kHz). The latter is of particular interest, as several minke whales have stranded during atypical mass strandings linked to military exercises (e.g. in 2000 in the Bahamas).

(SOURCE: Tubelli, A.A., Zosuls, A., Ketten, D.R., Yamato, M. and Mountain, D.C. 2012. A prediction of the minke whale (*Balaenoptera acutorostrata*) middle-ear transfer function. *J. Acoust. Soc. Amer.* 132: 3,263-3,272).

Table 1

PCB levels in striped dolphins from the Italian coast of the Adriatic Sea (*n*=17).

Maximum levels (µg.g^{-1} wet weight)	Melon	Blubber	Liver	Kidney	Lung	Heart	Muscle
ΣPCB	61.869	69.822	17.270	1.191	2.277	2.011	2.104
ΣTEQ ng.g^{-1} wet weight	56.813	120.205	16.908	1.874	1.673	1.413	0.391

(SOURCE: Storelli, M.M., Barone, G., Giacominelli-Stuffler, R. and Marcotrigiano, G.O. 2012. Contamination by polychlorinated biphenyls (PCBs) in striped dolphins (*Stenella coeruleoalba*) from the southeastern Mediterranean Sea. *Environ. Monit. Assess.* 184: 5,797-5,805).

Table 2

Toxic trace element levels in dolphins from the Croatian coast of the Adriatic Sea.

Maximum levels (µg.g^{-1} wet weight)	Common bottlenose dolphin (*n*=14)	Striped dolphin (*n*=5)	Risso's dolphin (*n*=4)
As (liver)	8.95	5.06	4.69
Cd (kidney)	10.1	17.6	16.8
Hg (liver)	1,790	295	1,738
Pb (liver)	0.38	0.094	1.15

(SOURCE: Bilandžić, N., Sedak, M., Đokić, M., Gomerčić, M.Đ., Gomerčić, T., Zadravec, M., Benić, M. and Crnić, A.P. 2012. Toxic element concentrations in the bottlenose (*Tursiops truncatus*), striped (*Stenella coeruleoalba*) and Risso's (*Grampus griseus*) dolphins stranded in Eastern Adriatic Sea. *Bull. Environ. Contam. Toxic.* 89: 467-473).

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GLOSSARY OF TERMS

Species glossary	
Beluga whale	*Delphinapterus leucas*
Blainville's beaked whale	*Mesoplodon densirostris*
Common bottlenose dolphin	*Tursiops truncatus*
Common dolphin (short-beaked)	*Delphinus delphis*
Fin whale	*Balaenoptera physalus*
Harbour porpoise	*Phocoena phocoena*
Humpback whale	*Megaptera novaeangliae*
Long-finned pilot whale	*Globicephala melas*
Minke whale (northern)	*Balaenoptera acutorostrata*
Risso's dolphin	*Grampus griseus*
Sperm whale	*Physeter macrocephalus*
Striped dolphin	*Stenella coeruleoalba*
Anchovy	*Engraulis encrasicolus*
Hake	*Merluccius merluccius*
Lanternfish	*Diaphus* spp.
Sardine	*Sardina pilchardus*
Krill	*Euphausia* spp.

ACCOBAMS: Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area.

AHD: Acoustic harassment device – these devices are intended to produce high intensity sounds that will actively displace predators from an anthropogenic food source, such as a fish farm cage.

ASCOBANS: Agreement on Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas.

Atypical mass stranding: A stranding of two or more animals, not a mother-calf pair, that occurs over an extended geographical area (in a relatively short period of time) instead of in a single location.

Barcelona Convention and SPA/BD Protocol: The Barcelona Convention is the Convention for the Protection of the Mediterranean Sea against Pollution. The SPA/BD Protocol is the Mediterranean's main tool for implementing the 1992 Convention on Biological Diversity.

Benthic: Of or related to the bottom level of the ocean, including the sediment or ocean floor.

Bioaccumulator: A pollutant that increases in concentration from the environment to the first and subsequent organisms in a food chain.

Cephalopod: Marine molluscs, such as squid or octopus.

dB: Decibel – a logarithmic measure of sound pressure level.

DDE: The organochlorine dichlorodiphenyldichloroethylene, a breakdown product of the pesticide DDT.

DDT: The organochlorine pesticide dichlorodiphenyl-trichloroethane, which tends to accumulate in the ecosystem and in the blubber and certain internal organs of cetaceans.

Depredation: In ecology, when animals feed on anthropogenically available resources, such as dolphins taking fish on lines or elephants eating crops.

DMV: Dolphin morbillivirus.

EBSA: Ecologically and Biologically Significant Area(s).

Epizootic: A rapid outbreak of disease in an animal population.

Euphausiid: Of the family Euphausiidae, to which krill belong (may also include the single species found in the family Bentheuphausiidae).

Flagellate: An organism with a whip-like organelle called a flagella – some zooplankton are flagellates.

HAB: Harmful algal bloom.

HV: Herpesvirus, a large family of viruses that cause disease in animals, such as chicken pox or mononucleosis.

Hz: Hertz, a measure of sound frequency (pitch), in wave cycles per second (kHz = 1,000 Hertz).

Holocene era: Geological epoch that began about 12,000 to 11,500 years ago and continues to the present.

Indicator species: Species that can provide information on ecological changes and give early warning signals regarding ecosystem processes due to their sensitive reactions to them. They can also be called sentinel species.

IPCC: International Panel on Climate Change.

IUCN: International Union for Conservation of Nature.

Lipophilic: Capable of dissolving in lipids (fats); having an affinity for lipids.

Meningoencephalitis: A medical or veterinary condition that simultaneously resembles both meningitis, which is an infection or inflammation of the membranes that envelop the central nervous system, and encephalitis, which is an infection or inflammation of the brain.

MPA: Marine protected area.

Morbillivirus: A family of viruses that are typically highly infectious and pathogenic – the family includes measles, dog distemper and dolphin morbillivirus. A number of mass mortality events have been associated with viruses from this family.

ng: Nanogram.

OC: Organochlorine – organic compounds that contain chlorine. Many are toxic and used as pesticides. Most of these compounds persist in the environment (are not biodegradable) and also tend to accumulate in fatty tissue (e.g., blubber) of cetaceans and other marine organisms.

OSPAR: Oslo/Paris Convention for the Protection of the Marine Environment of the North East Atlantic.

Pathogen: A disease-causing agent (e.g. bacterium, virus).

PCB: Polychlorinated biphenyls (209 different forms that contain differing numbers of chlorine atoms arranged in various positions on the aromatic rings) are industrial organochlorines that were manufactured to be used in electrical transformers and other applications. These man-made chemicals do not occur naturally and all traces reflect pollution.

Phthalates: Esters of phthalic acid, used mainly as plasticizers (substances added to plastics to increase their flexibility, transparency, durability, and longevity). They are used primarily to soften polyvinyl chloride.

Pteropod: Specialised free-swimming pelagic sea snails and sea slugs.

Sessile: Fixed in one place or immobile – organisms such as sponges and barnacles are sessile.

SPL: Sound pressure level – a measure of the intensity of sound, in decibels.

Stratification: The formation of water layers based on salinity and temperature.

Tachycardia: Heart rate that exceeds the normal range for a species.

TEQ: Toxic equivalent; the overall toxicity or environmental threat posed by a set of closely related pollutants.

TERB: Terbuthylazine, a breakdown product of atrazine.

Toxoplasma gondii: A parasitic one-celled organism that causes the disease toxoplasmosis.

Toxoplasmosis: See *Toxoplasma gondii.*

Trophic web: Levels or connections of consumption (e.g. plant-herbivore-carnivore) in an ecosystem.

UME: Unusual mortality event.

UNEP/CMS: The Convention on the Conservation of Migratory Species of Wild Animals under the United Nations Environment Programme.

µPa: Micropascal, a unit of pressure.

Wet weight: A basis of measurement whereby concentrations of a substance are compared with content of a material without water removed.

Annex K1

Report of the Working Group on Ecosystem Modelling

Members: Palacios (Convenor), Baulch, Bell, Bjørge, Brownell, Butterworth, Chilvers, Cooke, Cury, de la Mare, De Moor, Diallo, Double, Dupont, Elvarsson, Feindt-Herr, Funahashi, Gunnlaugsson, Hakamada, Heppell, Iñíguez, Kanaji, Kanda, Kim, Kitakado, Kock, Lang, Legorreta-Jaramillo, Marzari, Mate, Murase, New, Øien, Palsbøll, Park, Pastene, Peres, Plaganyi, Porter, Punt, Ridoux, Roel, Rojas-Bracho, Rowles, Sakamoto, Santos, Skaug, Smith, Solvang, Tajima, Tamura, Víkingsson, Vinnikov, Wadley, Walløe, Williams, Wilson, Yasokawa.

1. INTRODUCTORY ITEMS

1.1 Opening remarks
Palacios welcomed the members of the Ecosystem Modelling Working Group (hereafter, Working Group), and indicated that presentations on the main topic for this year would be delivered by three invited participants: Prof. Tony Smith (Australia), Dr. Éva Plaganyi (Australia), and Prof. Selina Heppell (USA). Because Smith was unable to be present, his contribution would be by video link. Plaganyi was also available via video link to help address questions, given her involvement and broad expertise in the main topic for this year. There would be no joint sessions this year: topics that overlapped with other sub-committees (such as RMP and IA) would be handled within EM.

1.2 Election of Chair
Palacios was elected Chair.

1.3 Appointment of rapporteurs
Cooke was appointed rapporteur.

1.4 Adoption of Agenda
The agenda in Appendix 1 was adopted.

1.5 Review of available documents
The documents presented to and considered by the Working Group were SC/65a/EM01-05, SC/65a/O02, SC/65a/SCP01, Smith *et al.* (2011), Pikitch *et al.* (2012), Cury *et al.* (2011), Daníelsdóttir and Ohf (2013), de la Mare (2013), Víkingsson *et al.* (2013b), Ólafsdóttir *et al.* (2013) and Petursdóttir *et al.* (2013). SC/65a/EM03 was a summary of a presentation that would be given by video link. Smith *et al.* (2011), Pikitch *et al.* (2012) and Cury *et al.* (2011) were available but their contents were covered by the PowerPoint presentations given under Item 2.1.

2. REVIEW ECOSYSTEM MODELLING EFFORTS UNDERTAKEN OUTSIDE THE IWC

2.1 Modelling of the direct relationship between baleen whale populations and the abundance of their prey
2.1.1 Presentations on the effects on predators of fishing on forage fish
There have been several recent research initiatives and major scientific papers on the effects of fishing on forage fish on predators (Cury *et al.*, 2011; Pikitch *et al.*, 2012; Smith *et al.*, 2011). The matter had been identified last year as a priority topic for this meeting.

Paper SC/65a/EM03 summarised a presentation by Smith on modelling the impact of low trophic level (LTL) fisheries, summarising the results of the study reported in Smith *et al.* (2011). The study used three existing ecosystem models to explore the effects of different levels of depletion of LTL species − Ecopath with Ecosim (EwE), OSMOSE, and Atlantis – applied to five different ecosystems – the southern Benguela Current, the northern Humboldt Current, the California Current, the North Sea, and southeastern Australia. The simulation protocol involved selecting LTL species one at a time for each model and applying fishing mortality rates from zero up to the level that resulted in extirpation of the stock. The impacts on other parts of the ecosystem (species and groups in the ecosystem model) were evaluated for various levels of depletion. The main performance measure used was the proportion of groups whose abundance changed by more than 40%, relative to the level where fishing mortality on the LTL species was zero. The results showed a trade-off between yield from the LTL species and impacts on the rest of the ecosystem. The broad results were relatively robust to the type of ecosystem model used, but predictions about impacts of and on particular species or groups varied considerably between models, suggesting that their use for tactical purposes is not yet warranted. Attempts were made to identify characteristics of LTL species that might be used to predict the impacts of their depletion. The relative size of the group in the ecosystem was important, and there was some relationship with the level of connectance of the species in the food web (proportion of total trophic linkages). Both the EwE and Atlantis models used in this study included marine mammals in one or more groups, but the OSMOSE models did not.

Heppell presented paper SC/65a/EM05, a summary of the report presented in Pikitch *et al.* (2012): '*Little Fish - Big Impact: Managing a Crucial Link in Ocean Food Webs*' by the Lenfest Forage Fish Task Force. This study reviewed the role of forage fishes and fisheries in marine ecosystems, and provided general recommendations for conservative fisheries management based on a meta-analysis of Ecopath and Ecosim models. Forage fish are defined as mid-trophic level, small-bodied fish and krill that serve as prey for high-level consumers, which include cetaceans, pinnipeds, sea birds, and large fish. An analysis of 72 Ecopath models indicated that the supportive value of forage fish (as food for commercial fish species) is about twice that of their targeted value, and a majority of ecosystems include some 'highly dependent' predators that are at greater risk of decline when their forage fish prey are reduced. An evaluation of management strategies for forage fisheries using Ecosim models for 10 ecosystems suggested that minimum biomass levels to avoid predator declines must be much higher than those predicted by single-species, Maximum Sustainable Yield-based management – about 75% of expected unfished biomass. A tiered management approach was recommended where more conservative harvest limits are applied when there is high uncertainty about forage fish dynamics or predator dependencies.

The study consisted of a meta-analysis of a wide range of systems with the aim of developing broad recommendations. The addition of the Management Strategy Evaluation simulator to Ecosim allowed the modelers to compare the effects of a suite of management options across the 10 systems, leading to some potentially robust relationships between predator impacts and forage fisheries. However, the objectives of the Taskforce did not include evaluation of impacts to specific predators (e.g. cetaceans) and the general approach would need modification to address many of the questions posed by the Working Group. Importantly, the ecosystem models were not able to fully capture the high degree of variability that is often observed in forage fish populations, nor the effects of 'prey switching' that occurs when several forage prey species are present in an ecosystem.

2.1.2 Discussion

In discussion, several points were raised with respect to the issue of variability, on which the studies to date had not focused. Forage fish often show extreme variations, as with capelin, or can even virtually disappear for many years in a row, such as California Current sardine.

The natural variability is typically greater than the impact of fishing. The Working Group considered that effects on cetaceans were likely to be felt mainly when food abundance is low rather than in average conditions. Cetaceans have low maximum growth rates, and therefore cannot take full advantage of temporary high levels of forage fish. A key issue for future research would be the impact of fisheries on the minimum abundances of prey species rather than on their average levels. The potential importance of including external climatic and oceanographic drivers should also be considered.

In view of the importance of variability, the Working Group was cautious about some of the rules of thumb that had been proposed, such as 'one-third for the birds' from Cury *et al.* (2011). The effect of the fishery may be greatest at times where abundance of the prey species is at a minimum. Historical examples include the collapse of the Peruvian anchoveta fishery in the 1970s, where it is believed that the fishery greatly exacerbated the effect of an El Niño, particularly as both predators and prey tended to be confined to a smaller area when the prey stock was at its El Niño-induced minimum (Clark, 1977).

The Working Group noted that the reverse impact – of predators on the fisheries for their prey – could also be examined using the models presented. This issue had last been addressed by the Scientific Committee at the Workshop on modeling cetacean-fishery competition in 2002. At the time the Workshop concluded that there was an insufficient basis to make quantitative predictions (IWC, 2004).

The Working Group noted that the performance of the models presented with respect to the matching of observed trends in prey and predator abundance was at best moderate. The presenters suggested, and the Working Group agreed, that performance should be assessed in terms not only of the ability to track the observed trends in the species of interest, but also of the species most strongly linked to them in the ecosystem model. It was suggested that the models should routinely be subject to analyses of retrospective effects, that is, how well recent observed trends are predicted when the last few years of data are omitted.

Punt brought to the attention of the Working Group a list of questions developed by the Bering Sea Integrated Ecosystem Research Program (BSIERP) Ecosystem Modeling Committee (EMC), aimed at providing guidance to modelling practitioners. The Working Group noted that these questions offer a very useful basis for model evaluation, but there was no time to give them due consideration at this year's meeting. The Working Group therefore decided to devote time to consider them at future meetings. The list of questions identified by the BSIERP EMC is included as Appendix 2.

The Working Group heard that the question of fitting the models to the data was still very much a developing field, and that while there are a number of promising approaches being developed, including exploratory and evolutionary algorithms, there is considerable scope for progress. It is always advisable to start the model simulations well before the first year of data, to reduce the impact of starting assumptions.

It was noted that to date the ecosystem models do not encompass very well the distributional factors and behavioural differences that could explain the coexistence of different predator species. Studying the differences in feeding strategies between predators may provide insights into how they are affected by changes in prey species abundance.

2.1.3 Conclusions

The Working Group concurred with the presenters that the models used in the studies to date were useful for their broad-scale strategic conclusions, but were not suitable guides for short-term tactical management decisions. The Working Group concluded that, in broad terms, the case has been established that forage fisheries are expected to impact predator populations including cetaceans, and considers that the priority for this Working Group should now be on more detailed models for specific cases involving whales, with more attention being paid to the dynamics, including stochastic factors. The Working Group considered that the framework discussed in Item 3 is a promising basis for modeling the effect of changes in prey species on whale populations (see also Item 7, the work plan).

The Working Group thanked Smith and Heppell for their presentations, and Plaganyi for being available to answer questions. The Working Group was particularly appreciative of Smith and Plaganyi's stoic perseverance in the face of severe technical problems with the video link.

2.2 Update from CCAMLR's Ecosystem Monitoring and Management Programme (WG-EMM) on krill and its dependent predators

Kock provided a brief summary of recent activities of the CCAMLR Working Group on Ecosystem Monitoring and Management. CCAMLR has considerable expertise with respect to the following two items of the nine items that this Working Group identified in Item 3 as issues to explore with respect to ecological scenarios for whale management:

- prey species spatial variability and trends; and
- relationships between predators-prey and effects of environmental variability on predators.

The Working Group **recommends** that the Scientific Committee chair write to CCAMLR in time for CCAMLR's WG-EMM meeting in Bremerhaven, Germany, in the first days of July 2013, to discuss future collaboration with respect to the two items above and to provide their view of how and to what extent this collaboration could best be established.

3. EXPLORE HOW ECOSYSTEM MODELS CONTRIBUTE TO DEVELOPING SCENARIOS FOR SIMULATION TESTING OF THE RMP

De la Mare (2013) was presented, which describes a modelling framework previously presented to the Fourth MSYR Workshop in March 2013 (SC/65a/Rep05) that uses spatially resolved individual animal models and detailed energy budgets to determine reproductive success and mortality in an environment where food has a patchy spatial distribution. All the major processes of the animal's seasonal activities are modelled including migration, breeding and feeding. Animals have to search for food and look for new food patches when local food abundance falls due to the effects of local intra-specific competition. The feedbacks inherent in the model lead to a population structure with high mass per individual and high birth masses. Thus, high fecundity that leads to lower mass of the mother and lower birth mass for calves is a less favourable strategy and may only exist at a residual level. However, such a strategy is not bred out of the population since it is modelled as a phenotype that can again be expressed when the population abundance is reduced relative to its food supply. These dynamics play out over long periods – it can take multiple generations (up to 1,000 years) with this model for the population to achieve a relatively stable and efficient reproductive structure. The relevance to the work of the Working Group is that the modelling framework implements a predator-prey model and can be set up to allow for populations of different species of whales to exploit one or more common prey populations. Prey populations are spatially resolved and can have different productivities and abundances in different places. This allows for the exploration of biogeographical effects using concepts from 'basin models'. (In a basin model, the spatial and temporal distributions of habitat suitability are specified. Animals occupy the most favourable locations preferentially, but eventually the animals are distributed so that no marginal improvement for any animal is possible by moving to a different location – often termed the 'ideal free distribution' (McCall, 1990)).

In discussion, the Working Group agreed that in principle, individual-based simulation (IBM) models, with the incorporation of feeding ecology, such as those developed in de la Mare (2013) were a good basis for generating population dynamic scenarios for evaluation in the RMP context. However, there were considerable technical challenges, not least the computationally intensive nature of the model. The Working Group considered that, depending on the particular issue being addressed, it may be better to use the full model to predict certain relationships that are expected in the general case, and then to devise a simpler emulator model that implements these relationships and that can be incorporated with relative ease into the RMP management simulations.

After discussion, the Working Group identified the following issues as ones that could usefully be explored using IBMs.

(1) Plausible effects of prey species spatial variability and trends on the dynamics of baleen whale populations.
(2) Plausible effects of competition, including the effects on whales from fisheries on prey species.
(3) Effects of foraging strategies in environments that have spatial structure in prey abundance and production (basin models). Feeding ground fidelity.
(4) Effects on natural mortality and its age dependence.
(5) Spatial characteristics of exploitation, e.g. basin-driven effects, distribution of effort when RMP '*Small Areas*' are not small, effects from different stock mixing rates.
(6) Combinations of some of the above issues may need to be considered.
(7) Characterisation of yield curves for populations in stochastic environments including the relative advantages of defining yield curves in terms of number or biomass. In particular to explore: (i) relationships between $MSYR_{1+}$ and $MSYR_{mat}$; and (ii) relationships between *K* and MSYR.
(8) Observable environmental and population characteristics likely to be sensitive indicators of the possible magnitudes of plausible effects.
(9) The development of tuneable, computationally efficient models that can emulate the range of results of the process-driven models (useful in *Implementation Simulation Trials*). In abstract simulations there may be no compelling reason not to use an IBM directly.

Because it is not expected that all of these issues can be explored by the next Annual Meeting, it will be necessary to prioritise. The Working Group **agreed** to give Item 7 highest priority, both because of its importance for the RMP, and because it is believed that it is possible to make rapid progress on it. The Working Group noted that it will be necessary to consider how *K* is best defined in the stochastic context, or possibly to explore the implications of different definitions of *K*. In cases where *K* is highly variable it may be appropriate to define management performance criteria that measure the ability of a management procedure to conserve the population through periods of low *K*.

A Correspondence Group was appointed to develop specific trials of the RMP for this case (see Item 7, the work plan). The Group would determine whether it was more feasible to link in the de la Mare IBM model directly, or to devise a simpler emulator model to mimic the behaviour of the IBM model, and proceed accordingly.

Two additional items in the above list, (1) and (2), that could be explored with IBMs were considered to be relevant to the work currently covered by CCAMLR's Ecosystem Monitoring and Management Programme (WG-EMM) on krill and its dependent predators. The Working Group therefore **recommended** consultation with CCAMLR for future collaboration through the formal channels of the Scientific Committee, as noted in Item 2.2.

Finally, the Working Group **agreed** to seek external input to continue making progress on Items 2 and 8 by bringing two invited experts to next year's meeting (see Item 7, the work plan).

4. REVIEW OTHER ISSUES RELEVANT TO ECOSYSTEM MODELLING WITHIN THE COMMITTEE

4.1 Update on Antarctic minke whale body condition analyses

At SC/63 the variance of the trend in blubber thickness reported by Konishi *et al.* (2008) was found to have been underestimated due to the nature of the sampling, which led to omission of the associated variance components, including a lack of balance in the structure of the data. A reanalysis by Skaug (2012) using a mixed-effects model resulted in the same point estimate for trend as in Konishi *et al.* (2008), but with a much higher variance, while the trend was still significant. The Working Group agreed that further analysis was warranted and requested at the time that results from analysing the two sexes separately be conducted, and that the interaction of slopes by latitudinal band with year be included as a random effect.

These analyses have not yet been conducted but Butterworth presented SC/65a/EM04, which provided jackknife estimates of the variance of the trend estimate by taking individual years or groups of three years as the jackknifing unit. Unexpectedly, the variance of the trend estimate resulting from the jackknifing procedure was much less than the variance calculated by Skaug (2012) from the model itself.

Cooke and Bravington noted that the application of resampling techniques (such as jackknifing or bootstrapping) to a mixed-effect model leads to an underestimation of the variance, as pointed out by Laird and Louis (1987) and subsequent authors. An explanation is given in Appendix 3, with a formula for the extent of the negative bias in variance. This derivation is aimed at explaining one possible source of bias in mixed-effects models, i.e. when there is correlation between the fixed and the random effects. Cooke and Bravington emphasised that this kind of bias arises only when the experimental design is unbalanced, since it is a function of the covariance between the fixed and random effects.

De la Mare conducted some numerical simulations using simulated data with a similar structure to the data used in the analysis in SC/65a/EM04, and likewise found a negative bias in the jackknife variance estimates. These simulations are documented Appendix 4. It was not possible to verify in the time available whether the extent of the bias shown in the numerical studies presented De la Mare (Appendix 4) agreed with the algebraic formula for the bias given by Cooke and Bravington in Appendix 3.

The Working Group considered it desirable to try to calculate the bias in resampling variance using the formula in Appendix 3 applied to the fit of Skaug's 2011 analysis (Skaug, 2012). If possible, the additional factors identified at SC/63 (see above) should be included in the model.

Because these analyses could not be accomplished in the time available at this meeting, the Working Group considered that these analyses should be performed for the JARPA II review meeting scheduled for February 2014. The Working Group understood that for this review meeting any member of the Committee could apply for access to the data to perform the requisite analyses under the guidelines for data availability under special permit, as set forth by the Commission (IWC, 2009; 2013).

Skaug and Kitakado remained unconvinced by the theoretical explanation and derivation of the bias in jackknife variance given in Appendix 3 because it used the formulation of the model with random effects as parameters, rather than the marginal likelihood formulation, and also because some equations did not address the issue of variance estimation appropriately. The latter formulation − in which the random effects do not appear as explicit parameters but are handled through covariance between the observations − was preferred by these members on conceptual grounds, as detailed in Appendix 5. Cooke explained that the two approaches should be mathematically and numerically equivalent in the case of linear models with normally distributed residuals, despite their differing conceptual basis. The Working Group requested Kitakado and Cooke to attempt to resolve the differences of opinion between them. Unfortunately, there was insufficient time during the sub-committee's meeting to conclude this matter, and Cooke and Kitakado were encouraged to report back to the Committee, if possible.

Despite the unresolved questions, Butterworth considered that the numerical evidence provided did seem to suggest that the jackknife variances calculated in SC/65a/EM04 were negatively biased, and that the conclusions of that paper are invalidated.

The Working Group also reiterated the recommendations from previous years that the outstanding issues raised at SC/63 and SC/64 (IWC, 2011; 2012) should be examined. The results of these analyses would desirably be reported to the JARPA II review. These included: (i) the year/latitude interaction (to be included as a random effect); and (ii) consideration of the transect as the sampling unit. With respect to (i), it was noted this year that, in some areas, latitude was a poor proxy for distance from the ice edge. The latter is likely to be the actual variable of interest. If possible, approximate distance from the ice edge (perhaps stratified into broad bands, one near the ice edge and one away from the ice) should be included in the analysis as an alternative to latitude.

Solvang and Walløe presented a new analysis using total body fat as the dependent variable (see Appendix 6). This had been routinely collected from the first whale of the day, from the second JARPA cruise onwards. Application of a random-effects model similar to that used by Skaug (2012) for the blubber thickness showed a significant negative time trend in total body fat for the preferred model. The authors considered this to be consistent with the findings of the blubber thickness analysis of Konishi *et al.* (2008), and that it provided strong evidence of a decline in energy storage in Antarctic minke whales during the JARPA period. De la Mare considered that the problems caused by the unbalanced design of the data also applied to this analysis, even though the sampling of just one whale per day could partially ameliorate the problem of pseudo-replication inherent in the full data set (see Appendix 4).

The Working Group concluded by **strongly encouraging** members to prepare relevant analyses for the JARPA II review where they could be examined in more detail than was possible in the time available to this Working Group.

4.2 Other, if new information is available

Elvarsson presented SC/65a/EM01 as a preliminary report from a multi-species modelling effort that studies the role of minke whales in Icelandic waters. In this initial phase the emphasis has been on developing single-species models in a statistical framework (Gadget) with the aim of connecting it to a previously implemented model for cod (*Gadus morhua*) (Taylor *et al.*, 2007). The paper identifies available data sources, such as abundance data from aerial surveys (Gunnlaugsson *et al.*, 2013a-rev), length distributions both from commercial catches and surveys and, various information regarding growth and maturation (Auðunsson *et al.*, 2013; Hauksson *et al.*, 2013). The model, in its current form, is an age-length based, forward-simulation model of two stock components, mature and immature whales with a Pella-Tomlinson type recruitment function. Based on the results from Víkingsson *et al.* (2013b-rev), where a preference to sand eel is suggested, the abundance of minke whales in Icelandic waters is controlled by an index of sand eel. Parameter estimates are obtained through a weighted likelihood function comparing the simulated results to the various datasets. Future work in the short-term will mainly focus on the link between cod and minke whales using information obtained in Víkingsson *et al.* (2013b-rev), in particular prey frequency of occurrence and length distributions. The effect of minke whale consumption will be assessed. The uncertainty of that estimate would then be calculated using a newly developed bootstrap approach based on independent geographical units. The single-species model of the common minke whale will also require further work; in particular processes that affect the prey species abundance, such as temperature, could potentially be incorporated into the model. In the medium to long-term other ecosystem modelling efforts are on the way, notably the MAREFRAME project (Daníelsdóttir and Ohf, 2013). One of the aims of that project is to compare different modelling approaches such as the Gadget, FishSums, EwE and Atlantis and assess their value to the management of living resources in various regions, including Icelandic waters.

The Working Group welcomed this report and asked for clarification as to whether the Gadget model was to be used directly for management advice, or as a more strategic ecosystem modelling exercise. Elvarsson confirmed that Gadget models had been used for management in a multi-species context, in particular cod and shrimp in Icelandic waters (Taylor, 2011). In addition Stefánsson *et al.* (1997) made preliminary attempts to incorporate baleen whales into such models. It was planned to include the possibility of prey switching in the next version. Environmental changes, such as temperature-related shifts in sand eel distribution, are not yet included.

The Working Group had a number of questions about how to interpret the results. For example, it was asked why the abundance of minke whales outside the area near Iceland was predicted to increase so much, by more than the amount by which the population in the area near Iceland decreased, such that the sum of the two increased. While stressing the preliminary status, Elvarsson replied that this was due to a combination of a shift in the initial number whales between the two areas and how the recruitment process responded to this shift. In moving forward with ecosystem models for whales, the Working Group recognised that results from this and other models will typically require a substantial amount of explanation as to what is driving them.

Víkingsson *et al.* (2013b-rev) reported the first systematic research programme into the feeding ecology of common minke whales in Icelandic waters based on analysis of stomach contents data collected in Icelandic waters during 2003-07. The results show pronounced spatial and temporal variation in the diet. Most (97.4%) of the stomachs contained food remains, up to 106kg. A total 12 prey species were identified. The diet was primarily composed of fish, with invertebrates (krill) contributing only 9% to the diet. Sand eel (*Ammodytidae* sp.) was the most important prey type overall constituting almost half of diet. Together, large demersal fish, mostly cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) constituted 22% of the diet. The size range for prey varied from less than one to over 90 cm and the age of cod prey ranged 0-14 years. The diet composition varied considerably with geographic location. Sand eel dominated the diet in the southern and western areas, while the diet was more diverse off northern and eastern Iceland. The temporal changes include a decrease in the proportion of sand eel in the diet over the study period and a corresponding increase in herring (*Clupea haerengus*) and haddock particularly in the southern area. The diet also differed markedly from the limited previously available data from Icelandic waters with less krill and the cold-water species capelin (*Mallotus villosus*) and more gadoids and herring in the more recent period. These changes in diet composition are consistent with recent changes in the Icelandic continental shelf ecosystem including increased sea surface and bottom temperatures and changes in distribution and abundance of several fish species including sand eel and capelin. Although natural fluctuations cannot be ruled out at this stage, these dietary changes, together with decreased abundance in coastal waters, may reflect the responses of minke whales to a changed environment possibly driven by global warming.

Tamura stated that this information was welcome, and noted that there are geographical, seasonal and yearly changes in the prey of common minke whales in the western North Pacific, as observed in the JARPN and JARPN II programmes. These data are very important and useful for consideration in ecosystem models in order to reflect realism. Tamura pointed out that these data must be obtained over long-term periods, because the yearly change of prey could not be detected in a few years.

Petursdóttir *et al.* (2013-rev) compared different methods to estimate diet composition. Fatty acid (FA) profiles of the total lipids were analysed in tissues of 23 minke whales from Icelandic waters during 2003-06. The tissues were outer blubber (adjacent to skin), inner blubber (adjacent to muscle), and blood. Additionally, fatty acids were analysed in some potential prey species of the minke whales. The main objective was to study whether FA profiles reflect the diet of minke whales around Iceland as inferred from stomach content analysis. The results for the three investigated tissues were tissue-specific (i.e. samples from each tissue group together in multivariate analysis) with the inner blubber apparently best reflecting diet. The FA profiles did not reflect the stomach contents of the minke whales. However, the large variance in FA composition of the inner blubber indicates a diverse diet of the minke whales in agreement with the stomach contents. The FA profiles indicated that the food variety of minke whales in 2003 was more diverse than in the year 2006, possibly related to the collapse of the Icelandic sand eel stock around 2005. In 2006 the *Calanus*-based food web was of higher importance than in 2003. The use of FA analysis in trophic studies of whales are promising but must be interpreted with caution and with their limitations in mind.

Tamura stated that this information was welcome, and noted that minke whales in the Northern Hemisphere have various food habits in their feeding ground, and that the diet information of whales obtained by fatty acid analyses should complement the information obtained by stomach contents in systematic research.

Ólafsdóttir *et al.* (2013) reported on an attempt to evaluate the applicability of stable isotope analyses as an alternative method in feeding ecology studies of the common minke whale and to evaluate how stable isotopes may reflect stock delineations between the minke whale in Icelandic waters and other regions in the North Atlantic. A total of 94 and 92 tissue samples from 36 whales were analysed for $\delta 13C$ or $\delta 15N$, respectively. The tissues analysed were blood, muscle, and skin samples at two locations (mid-dorsal and mid-lateral). Samples of common prey species of the minke whale were collected from 2003 to 2007. The overall level of $\delta 15N$ in minke whale tissues was at the level of herring, above the levels of krill and sand eel and below adult codfishes, suggesting that krill and small sand eels may be important in the minke whale diet. The overall level of $\delta 13C$ was at level with adult codfishes but higher than krill, sand eel, herring and capelin. A GLMM fitting best to the $\delta 13C$ data included tissue type, region, length and period as explanatory variables, and for $\delta 15N$ data the best model included tissue type and length as explanatory variables and paired comparisons of isotope levels in skin (mid-dorsal) to other tissue types gave similar results. Thus, both these comparisons indicate tissue specificity that needs to be taken account of in studies based on skin biopsies. Comparison of the results from the δ15N levels and stomach content analyses indicate somewhat lower trophic level in the isotope study. Spatial and temporal difference observed in the δ13C is more complex and difficult to interpret.

The observed tissue specificity, unknown turnover rates and the generalist and opportunistic feeding and seasonal migratory behaviour of the minke whale make the interpretation of stable isotope analyses difficult without supplementary information from other sources. The method may, however, be useful in monitoring signals of relative changes in the diet or changes further down the food chain. The isotope results show strong indications of separation of the minke whale in Icelandic waters and animals from other areas of the North Atlantic during the summer months.

In conclusion, the authors of Ólafsdóttir *et al.* (2013), Víkingsson *et al.* (2013b-rev) and Petursdóttir *et al.* (2013-rev) surmised that the differences between the stomach contents, fatty acid and stable isotope analyses can best be explained by the different time periods reflected by these methods. Thus, the stomach content analysis represents the most recent feeding and is therefore the best measure for diet composition in the spatio-temporal window represented by the study (Icelandic continental shelf waters during May-September), while the other two methods may reflect feeding before arrival on the Icelandic feeding grounds in spring.

Murase welcomed the presentations of these papers. He supported the conclusion drawn by the authors. Further, he considered that the diet data obtained from stomach contents are suitable as input parameters in ecosystem models.

SC/65a/O02 presented estimates of seasonal energy deposition in minke whales from Icelandic waters. Energy deposition was estimated from measured increase in weight (Víkingsson *et al.*, 2013a-rev) and energy density (Gunnlaugsson *et al.*, 2013b-rev) of different tissues. Weight data from Norwegian waters were also used for estimating seasonal increase. The estimated increase in blubber weight was in agreement with an independent estimate from blubber thickness measurements (Christiansen *et al.*, 2013). According to these results, minke whales increase their weight by 27% during an assumed 180 day feeding season. However, due to large increases in energy density of tissues, the total increase in energy content of the body is much higher, or around 90% over the feeding season. Most of the energy is stored in adipose tissue (blubber and visceral fat), but posterior dorsal muscle and bone tissue are also important sites for energy storage.

SC/65a/EM02 provided brief information on the authors' plan for ecosystem modelling for baleen whale species in Area IV, which is a part of the research area of JARPA and JARPA II. Two types of modelling approaches will be employed; one is the EwE, a comprehensive (whole-of-ecosystem) model, and the other is a multi-species production model (a model of intermediate complexity for ecosystem assessments). There are differences in the component species between them, but the baleen whales and krill play key roles in both. For the EwE approach, the authors are nearing completion of mass-balancing for Ecopath for 27 functional groups, and will then be moving on to projection forward (and backward if possible) by using the Ecosim framework, where statistical estimation is conducted for tuning the parameters of the dynamics. Regarding the multi-species production model, the observation and process errors will be accounted for by fitting the time series of population sizes with consideration given to reducing the parameters to be estimated using random effects. The model will be applied to the data of time series of baleen whales, seals and krill. This sort of model has the potential to estimate the extent of competition between the baleen whales, and therefore some multispecies adjustment would contribute to improvement of operating models and harvest controls to make more effective use of this resource, which is a reason for the further development of multi-species production models. Results from these two approaches will be reported at the JARPA II review.

The Working Group welcomed these plans but noted lack of clarity as to the aims of the modelling exercise. The author explained that one aim is to compare the results from a broad-sweep model such as EwE that encompasses most components of the ecosystem, to a model that includes more detail on the dynamics of the main species of interests. The models will be fitted to the available data, but currently there is no provision for using specific datasets for diagnostics. The Working Group suggested that options for diagnostic tests of model predictions be developed.

The Working Group noted that a large amount of the information input into the model had been taken from the literature, and asked that more documentation of the sources of information be provided when the results are presented to the JARPA II review.

5. DEVELOPMENT OF A LIST OF PRIORITY POPULATIONS AS CANDIDATES FOR CONSERVATION MANAGEMENT PLANS (CMP)

This item was added to the agenda at the Commission's request for the Scientific Committee to develop a list of priority populations as candidates for Conservation Management Plans (CMP). Paper SC/65a/SCP01 provided a template and a draft set of criteria, and was distributed to all Sub-Committees for discussion.

After consideration, the Working Group concluded that given that the Committee is still at the stage of identifying populations as possible candidates for CMP, other sub-committees should complete this process first, in order for the Ecosystem Modelling Working Group to provide specific input to the criteria and guidance being developed by the Commission.

6. OTHER BUSINESS

No other business was brought up by the members of the Working Group.

7. WORK PLAN

As noted in Items 2.2 and 3, the Working Group identified the effects of competition and of environmental variability on whale populations as priority topics for next year's agenda. The Steering Group formed last year to plan the agenda (Table 1) was re-appointed to continue its task. The Steering Group will identify two potential invited participants intersessionally to cover these topics at next year's meeting.

Table 1

Intersessional Steering Group for the preparation of next year's Working Group agenda.

Group	Terms of reference	Membership
EM planning (SG)	Solicit contributions Liaise with prospective invited participants Prepare the agenda	Butterworth, de la Mare, Palacios (Convenor), Punt, Walløe

Table 2

Intersessional Correspondence Group for the development of RMP trials using IBMs.

Group	Terms of Reference	Membership
Applications of IBMs to RMP (CG)	Liaise with Allison to ensure compatible model currencies Explore feasibility of linking IBMs directly; otherwise develop simple IBM emulator	Allison, Butterworth, Cooke, de la Mare (Convenor), Kitakado, Punt

A second Correspondence Group (see Table 2) was appointed to develop specific trials of the RMP using the lessons learned from the individual based model (IBM) presented by De la Mare at this meeting (de la Mare, 2013).

Proposed Agenda for next year:

1. Review ecosystem modelling efforts undertaken outside the IWC
   1.1 Competition among baleen whales: how can we measure and model it?
   1.2 Update from CCAMLR's Ecosystem Monitoring and Management Programme (WG-EMM) on krill and its dependent predators
2. Explore how ecosystem models contribute to developing scenarios for simulation testing of the RMP
3. Review other issues relevant to ecosystem modelling within the Committee
   3.1 Case studies of the effects of long-term environmental variability on whale populations
   3.2 Other, if new information is available
4. Other business

8. ADOPTION OF THE REPORT

The report was adopted on 10 June 2013 at 22:35.

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Appendix 1

AGENDA

1. Introductory items
   1.1 Opening remarks
   1.2 Election of Chair
   1.3 Appointment of rapporteurs
   1.4 Adoption of the Agenda
   1.5 Review of available documents
2. Review ecosystem modelling efforts undertaken outside the IWC
   2.1 Modelling of the direct relationship between baleen whale populations and the abundance of their prey
   2.2 Update from CCAMLR's Ecosystem Monitoring and Management Programme (WG-EMM) on krill and its dependent predators
3. Explore how ecosystem models contribute to developing scenarios for simulation testing of the RMP
4. Review other issues relevant to ecosystem modeling within the Committee
   4.1 Update on Antarctic minke whale body condition analyses
   4.2 Other, if new information is available
5. Development of a list of priority populations as candidates for Conservation Management Plans (CMP)
6. Other business
7. Work plan
8. Adoption of the Report

Appendix 2

LIST OF QUESTIONS IDENTIFIED BY THE BERING SEA ECOSYSTEM RESEARCH PROGRAM ECOSYSTEM MODELLING COMMITTEE (BSIERP EMC)[1]

(a) What is the model intended to predict?
(b) What specific aspect of the prediction is anticipated to be of direct value for fisheries management?
(c) What measure of 'accuracy' in the prediction is crucial to determining the usability of that prediction to fisheries management?
(d) What alternative models (other mechanisms, greater degrees of spatial and temporal aggregation, simple statistical predictors) are plausible competitors whose performance should be tested against the model being developed?
(e) How will the achieved predictive power of the model be compared against the performance of plausible alternatives, and how will this guide subsequent choices about model form and parameterisation?
(f) What data are available (temporal and spatial resolution, time span covered, data quality) to drive, calibrate, and test the model?
(g) How will the existing data be used to quantify model fit and predictive power?
(h) What pertinent future data are anticipated to become available within the time frame of the project?
(i) How will the future data be used to quantify model fit and predictive power?
(j) How has it been determined that the proposed quantity and quality of data can be expected to be sufficient for the intended use in tuning and testing the model?
(k) How will the probabilistic nature of model forecasts be represented in model output, and how will this be communicated to eventual users of the model predictions?

Given their potential relevance to the objectives of Ecosystem Modelling, the Working Group decided to devote time to these questions at future meetings.

[1]See *http://bsierp.nprb.org/modeling/*.

Appendix 3

A NOTE ON THE USE OF RE-SAMPLING METHODS TO ESTIMATE THE VARIANCE OF REGRESSION COEFFICIENTS FROM MIXED-EFFECT MODELS FOR BLUBBER THICKNESS

Justin Cooke and Mark Bravington

[NB: This derivation is aimed at explaining one possible source of bias in mixed-effects models, i.e. when there is correlation between the fixed and the random effects. This kind of bias arises only when the experimental design is unbalanced, since it is a function of the covariance between the fixed and random effects.]

Paper SC/65a/EM04 (Butterworth and Konishi) re-examines the significance of estimates of trend in blubber thickness, originally obtained by Konishi *et al.* (2008), by applying a jackknife analysis to the results of a mixed-effect model fitted by Skaug (2012). The resulting jackknife variance estimates are lower than the model variance estimates provided by the mixed-effects analysis. The authors of SC/65a/EM04 conclude that this confirms the significance of the estimated time trend in blubber thickness.

Paper SC/65a/EM04 overlooks a known issue with the application of resampling techniques, such as the bootstrap or jackknife, to fits of random- or mixed-effect models. The issue has been pointed out *inter alia* by Laird and Louis (1987), or see Higgins *et al.* (2009) for a more recent exposition. The unmodified application of resampling techniques to the fits of random- or mixed-effect models leads to underestimation of the variance of the parameter estimates.

The problem is that traditional resampling methods only account for the variability of the estimates of random effects under repeated sampling, which is less than the true uncertainty in the random effects due to the 'shrunken' nature of random effect estimates. As an extreme case, consider a model that includes a random effect with very few associated observations: because its point estimate will be close to zero in all bootstrap replicates, a standard bootstrap will report the lowest uncertainty for the parameter for which there are the least data! Depending on the model structure and the design of the data (and in particular how balanced the design is), this phenomenon can affect the estimation of uncertainty in all the model parameters included the fixed effects.

The essence of the matter is most easily demonstrated in the context of the simple linear regression model:

$$y = X\beta + \varepsilon \qquad (1)$$

where $y=\{y_1, ..., y_n\}$ is the observation vector, β is the vector of parameters to be estimated (potentially including both 'fixed' and random effects), X is the data matrix, and ε is a maximum likelihood estimator for β is given:

$$\hat{\beta} = \left(X^T WX\right)^- X^T Wy \qquad (2)$$

where the diagonal weight matrix W is given by W_1=var(ε). If there are some random effects, then the mixed-effect estimator for β is given by:

$$\hat{\beta} = (S^- + X^T WX)^- X^T Wy \qquad (3)$$

where S is the matrix of the random effect variances. S is usually diagonal. The rows and columns of S relating to the fixed effects are set to zero. S^- denotes the Moore-Penrose generalised inverse of S, where the zero rows and columns for the fixed effects remain zero in the generalised inverse[1].

If we treat S as known, then the variance-covariance matrix of the estimates of the components of β about their true values is given by:

$$V_E\left(\hat{\beta}\right) = E\left[\left(\hat{\beta}-\beta\right)^T\left(\hat{\beta}-\beta\right)\right] = (S^- + X^T WX)^- \qquad (4)$$

S is usually estimated by maximising the Residual Likelihood. Taking into account the variance of the estimate of S yields a more complicated expression for the variance of $\hat{\beta}$, which results in slightly higher variance estimates for $\hat{\beta}$ than those given by (4), but the difference in practice is usually negligible.

Resampling techniques do not provide estimates of the full estimation variance (4) but instead of the quantity:

$$V_R = E\left[\left(\hat{\beta} - E\left(\hat{\beta}\right)\right)^T\left(\hat{\beta} - E\left(\hat{\beta}\right)\right)\right] \qquad (5)$$

Using $E(\hat{\beta}) = (S^- + X^TWX)^- X^TWX\beta$, the difference between V_R and V_E is given by:

$$V_R - V_E = -\left(S^- + X^T WX\right)^- S^- \left(S^- + X^T WX\right)^- = -V_E S^- V_E \qquad (6)$$

This difference is a zero or negative quantity. Therefore, V_R underestimates the variance of $\hat{\beta}$ by the this amount. Only in the case S=0, i.e. where there are no random effects, is the difference zero. When the experimental design is unbalanced, such that V_E has non-diagonal terms representing covariances between random and fixed effects, then the estimates of the fixed variances are also affected.

[1]The term 'fixed effects' has historical roots and can be confusing. The values of the fixed effects are not fixed, but are free parameters. The entries in S for the fixed effects are, strictly speaking, undefined, and are only conventionally set to zero. The matrix actually used in the analysis is S^-, in which the entries for the fixed effects are genuine zeroes.

The motivation for using resampling techniques such as jackknife and bootstrap is to produce estimates of variances of effects that can be more robust than the model-based estimates of variance, to the extent that the former may reflect components of variance that are missed by the latter. Thus one expects the resampling estimates of variance to be similar to or higher than the model-based variance estimates. However, in the case of models with random effects, unadjusted resampling variances are subject to the negative bias given by expression (6) and can, consequently, yield estimates of variance that are lower than the model-based estimates.

Random- and mixed-effect models offer many benefits: in particular they can enable us to obtain useful estimates of parameters of interest even in cases where these parameters are unidentifiable in the corresponding fixed-effects model. However, if resampling techniques are to be used with models that include random effects, then the resampling estimates of variance need to be adjusted upwards to correct for the bias given by expression (6).

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Appendix 4

BLUBBER THICKNESS: THE JACKKNIFE DOESN'T CUT IT

William de la Mare

Paper SC/65a/EM04 purports to provide support for the view expressed at last year's meeting that the jackknife should robustly correct for spatial heterogeneity in whale distribution and abundance. In the words of those who held this view:

> Other members considered that non-independence can be accounted for by using jack-knife methods, as was done during last year's meeting with the blubber thickness data, using one year as the jack-knifing unit. This approach showed that while the estimated SE increased from 0.0225 to 0.0836 on the regression slope (-0.213 mm/year), the slope estimate itself did not change and thus was still significantly different from zero at the 5% level. This jack-knife result should, according to these members, take care of concerns about dependence between observations.

However, the jackknife presented in SC/65a/EM04 is not the jackknife that was discussed in 2012, which was a jackknife by year applied to the original Konishi *et al.* (2008) linear model.

The trials reported here use the simulator for JARPA data described in de la Mare (2011) to generate data where the slopes and intercepts for the blubber growth coefficient include random effects for each Area-Stratum. Only data for mature males are modelled. In each year a common random year effect is added to the blubber growth coefficient in each Area-Stratum. This means that the random effects are correlated across the region. As in my original simulations the variability is set so that the linear model mean of the estimated residual standard deviation is maintained at 0.701. In this case this requires a pure error standard deviation=0.485. On average there is no trend in simulated blubber thickness, and so the number of apparently statistically significant results is an indication of the true probability of making a type I error. The nominal probability of making a type I error used is α=0.05.

The first trial uses the Konishi *et al.* (2008) model that was used in the jackknife as described in the quote above. The same linear model was run here for 1,000 replicates with the estimates being jackknifed by omitting each year of data one year at a time in each replicate. The distribution of estimates of year trends obtained is shown in Fig. 1a, with the distribution of apparently statistically significant estimates shown in Fig. 1b. There were 703 apparently statistically significant estimates of the year trend, which is much greater than the 50 cases that would be expected for α=0.05.

Fig. 2a shows the relationship between the model estimates of the year trend and the means of the jackknifed estimates. Naturally, the estimates of jackknife means are highly correlated with the corresponding point estimates because, although the jackknife can remove statistical bias (if any), it is only of the order of 1/n, which in this case is 1/18. Fig. 2b shows the relationship between the linear model standard error estimates versus the corresponding jackknife

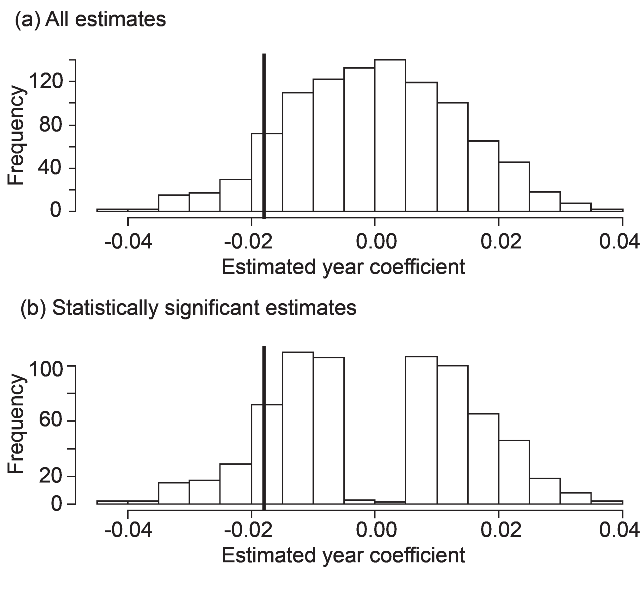

Fig. 1a. (upper figure) the distribution of estimates obtained using the Konishi *et al.* (2008) model. Fig. 1b (lower figure) is the distribution of the estimates that are apparently statistically significant.

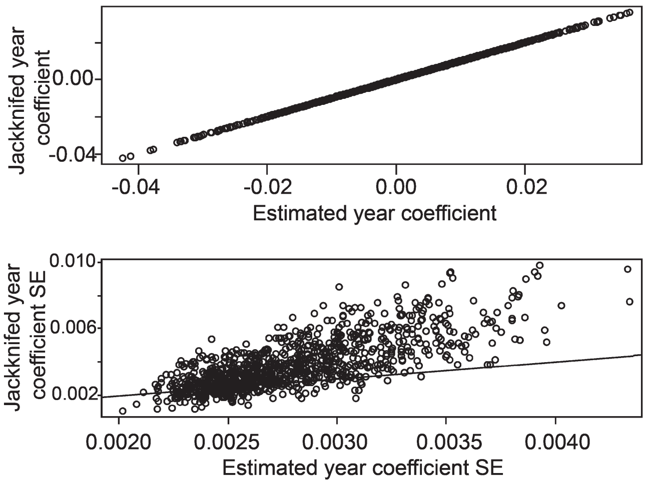

Fig. 2a. (upper figure) the correlation between the linear model and jackknife estimates. These are so close that the histogram in Fig. 1a is also the histogram for the jackknife estimates. Fig. 2b (lower figure) shows the relationship between the linear model and jackknife estimates of standard error. The line is 1:1.

values. As expected in data with random effects, the values of the jackknife standard error are generally greater than the estimates from a linear model.

There are 607 apparently statistically significant year trends based on the jackknife estimates of the standard error. Although this is an improvement over the linear model estimates, it is still much greater than the 50 that would be expected if the standard error estimates were unbiased. This demonstrates that the proposition by some members in the 2012 Scientific Committee meeting that the jackknife estimates will have robustly corrected for random effects and heterogeneity in sampling is not supported.

The second trial fits the same mixed effects model as in SC/65a/EM04 (except the term for sex is omitted because the simulator produces data for only mature males). The distribution of estimates of year trends obtained is shown in Fig. 3a with the distribution of apparently statistically significant estimates shown in Fig 3b. There were 135 apparently statistically significant estimates of the year trend, which is a substantial improvement over the linear model, but is still greater than the 50 cases that would be expected for α=0.05.

Fig 4a shows the relationship between the model estimates of the year trend and the means of the jackknifed estimates. As before, the jackknife estimates of the trends are highly correlated with the corresponding point estimates. Fig 2b shows the relationship between the linear model standard error estimates versus the corresponding jackknife values. Contrary to what would normally be expected, the jackknife standard errors are almost all substantially less than the corresponding estimates from the mixed effects model.

The estimates of standard errors from the jackknife applied in SC/65a/EM04 have the same property. The standard error reported in Skaug (2012) was 0.007 (cm year^{-1}); the corresponding value from the jackknifed estimate in SC/65a/EM04 is 0.002. This indicates that applying a jackknife to mixed effects models is not as straightforward as in the linear model case.

Following the presentation of the analyses above, Solvang and Walløe presented analyses of a different (but related) dependent variable (total fat weight) using a similar linear model with a jackknife applied and several mixed effects models fitted to the same data (see Appendix 6).

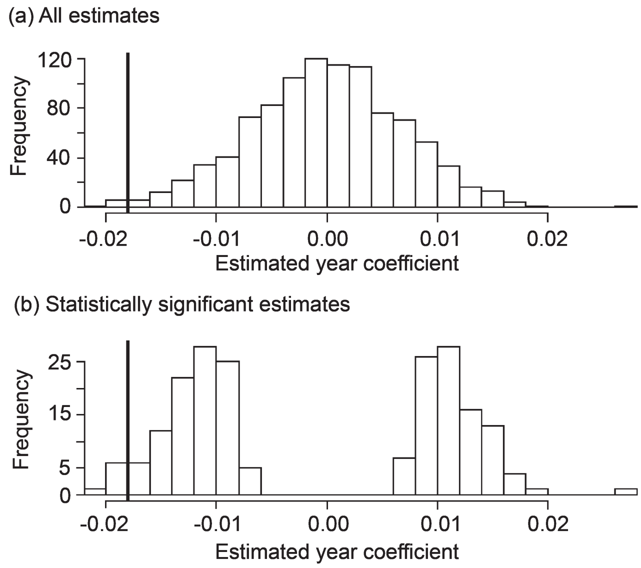

Fig. 3a. (upper figure) the distribution of estimates obtained using the Konishi *et al.* (2008) model. Fig. 3b (lower figure) is the distribution of the estimates that are apparently statistically significant.

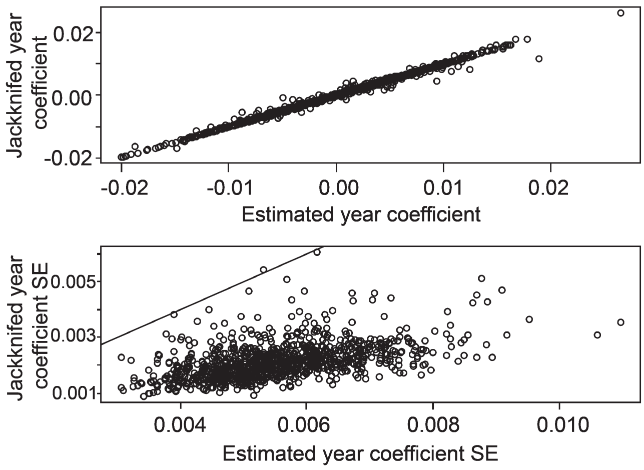

Fig. 4a. (upper figure) the correlation between the linear model and jackknife estimates. These are so close that the histogram in Fig. 3a is also the histogram for the jackknife estimates. Fig. 4b (lower figure) shows the relationship between the mixed-effects model and jackknife estimates of standard error. The line is 1:1.

They conclude that because there is only one observation per day on the dependent variable there should be less dependency between successive observations. However, this improvement does not solve the difficulties demonstrated by the simulations above because the simulations do not actually include any serial dependency in observations; the simulated data are already randomly sampled from each stratum. The failure of the jackknife demonstrated above arises because of the heterogeneous sampling with respect to the stratification used in JARPA, not because of any daily serial correlation. Thus the new analyses in Appendix 6 do not alter the conclusion that jackknife estimates will not have robustly corrected for random effects and heterogeneity in sampling.

Leaving aside the problems with the analyses in SC/65a/EM04 and Appendix 6, it is important to be clear about their relationship to the further analyses requested in the Reports of the Scientific Committee. In 2011 (IWC, 2011) the Committee:

> ... **agrees** that further analysis of the data was warranted to determine: (1) whether the models fitted so far captured all the main features of the data; and (2) whether the estimate of trend (whose confidence limits using the best fitting model ranged from near zero to values that could be of appreciable biological significance) could be made more precise. Inter alia, revised analyses should consider the two sexes separately and consider latitudinal band as a random effect.

The analysis subject to jackknifing in SC/65a/EM04 is one that had already been considered at the point when the agreement above had been reached. Although Appendix 6 considers a different (but related) dependent variable, the stratification used does not consider the north-south stratification either. Consequently the analyses in SC/65a/EM04 and Appendix 6 do not address the questions raised above, particularly with respect to the effects of the north-south stratification.

At the 2012 (IWC, 2012) meeting:

> Some members emphasised that failing to estimate the variance associated with random transect placement means that the variances in the analyses of biological parameters will be underestimated such that hypothesis tests will be invalid.

Subsequently:

> The Committee noted that valid conclusions can often be drawn from non-random samples as long as this is accounted for in the analysis. It further **recommends** that the authors of Konishi *et al.* (2008) investigate independence issues by using mixed-effects models with track line as a random effect to address the concerns raised above. These authors will consider carrying out such analyses before next year's meeting.

The analyses in SC/65a/EM04 and Appendix 6 do not provide the recommended analyses.

In summary, the simulation analyses of the properties of the 2011 jackknife estimates using the linear model show that the jackknifing based on year alone is not sufficiently robust to overcome the effects of spatial random effects. The new analyses in SC/65a/EM04 and Appendix 6 do not address the Scientific Committee's recommendations for further analyses set out in 2011 and 2012. In any case, the analyses in SC/65a/EM04 seem to be an invalid application of the jackknife.

Consequently the conclusion of Konishi and Butterworth in SC/65a/EM04 that the issue of the statistical significance of the body condition analysis 'might be considered by the Scientific Committee to have been resolved' is in fact not correct, and accordingly these issues have not been resolved.

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Appendix 5

COMMENT TO COOKE AND BRAVINGTON (APPENDIX 3): RESAMPLING UNDER THE MARGINAL LIKELIHOOD PERSPECTIVE IS NOT PROBLEMATIC IN THE VARIANCE ESTIMATION IN MIXED-EFFECT MODELS

Toshihide Kitakado and Hans J. Skaug

Appendix 3 raised an issue in re-sampling methods for estimating the variance of regression coefficients from mixed-effect models. Originally, a reason that the random effects were incorporated into the regression model of Skaug (2012) was to introduce correlations between observations within each year. Since the model is linear, one may take a 'marginal likelihood' view without any explicit random effects. Such a model gives identical estimates for the parameters of interest, which are fixed effects in the analysis.

Confusion occurs if the random effects are estimated through the posterior distributions, which provide shrinkage estimators of parameters. In theory, those shrinkage estimators have the advantage of smaller risks (e.g. in terms of the mean square error) through sacrificing bias. A quadratic form for the bias is essentially equal to the difference of the two variances shown in Equation (6) in Appendix 3 (although V_E is not the variance). The evaluation in Appendix 3 was conducted along these lines, which constitute a framework for given random effects as well as for the posterior estimates.

However, the estimation by Skaug (2012) was conducted completely in the marginal likelihood world, in which the parameters of interest are all fixed effects. In this framework, when 'resampling' (including jackknifing) is conducted in the marginal world, all the randomness which the observations have is virtually resampled and taken into account in the variance estimation, and therefore in a sense of 'marginal' the underestimation of variance discussed in Appendix 3 does not happen (precisely speaking, there is a 'plug-in' effect of to the variance component but it might be 'negligible').

In conclusion, the jackknife seem unproblematic from a marginal likelihood perspective in addition to the fact of balanced design of the data in JARPA, and therefore it is unclear how (and if) the arguments in Appendix 3 apply to the situation at hand.

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Skaug, H.J. 2012. Report of the Scientific Committee. Annex K1. Report of the Working Group to Address Multi-Species and Ecosystem Modelling Approaches. Appendix 2. Results of mixed-effects regression analyses of blubber thickness in Antarctic minke whales from data collected under JARPA. *J. Cetacean Res. Manage. (Suppl.)* 13: 262.

Appendix 6

DECREASE IN MINKE WHALE FAT STORES DURING 17 JARPA YEARS

Hiroko Kato Solvang and Lars Walløe

In the regression analyses reported in Konishi *et al.* (2008) the development with time of three variables were studied and reported: mid lateral blubber thickness directly below the dorsal fin, girth at the level of the umbilicus, and total fat weight. The criticism raised by de la Mare at the Scientific Committee meeting in 2011 (de la Mare, 2011) concerned the reported decline of blubber thickness over the 18 JARPA years. One of his arguments which was repeated in the 2012 Scientific Committee meeting (de la Mare, 2012) is that neighbouring sample points in space and time could be correlated, and thus that the SD of the regression coefficient with time (year) could be too low.

In this Appendix we have investigated the development of the variable 'Total fat weight' with time over the JARPA years. Every day during the JARPA cruises the first whale caught was subject to special investigations: the subcutaneous fat (the blubber) was dissected off from the carcass, and the intestinal fat in the omentum was also dissected out. The sum was weighed and the variable is called the 'Total fat'. These two deposits of fat represent the main fat storages in a mammalian body. The 'Total fat weight' is of course part of the 'Total body weight', so in the analyses we have established a new variable, called 'Lean body weight'. 'Lean body weight'='Total body weight'–'Total fat'.

The advantage in the use of 'Total fat' for the analysis is that there is at the maximum only one data point per day. The points are therefore presumably far from each other in time (at least one day) and space, and de la Mare's correlation argument should be less relevant. The disadvantage is fewer data points than for 'Blubber thickness' and 'Girth'. The whales were not weighed during the first JARPA year, so the data file covers only 17 years.

As a first step in the analysis an ordinary linear regression was carried out, with a subsequent jack-knife analysis:

Total number of samples without missing values is 647.

Number of explanatory variables is 9.

The regression model used all variables:

Fat_in_ton~Date+Lean Body Weight+Diatom+Body Length +Longitude+ Sex+Year+Age+Latitude

AIC and BIC selected the following model:

Fat_in_Ton~Date+LBW+Diatom+BL+Sex+Year+Age+ Latitude

Table 1

Estimated coefficients, standard errors and p-values.

	Estimate	Std error	p-value
Intercept	-3.4688	0.4146	< 2e-16
Date	0.0041	0.0005	1.83e-15
Lean body weight	0.2443	0.0285	< 2e-16
Diatom	0.0733	0.0113	1.90e-10
Body length	0.5068	0.0488	< 2e-16
Longitude	0.0003	0.0003	0.2827
Sex	0.2786	0.0364	7.81e-14
Year	**-0.01856**	**0.002806**	**7.87e-11**
Age	0.0055	0.0013	4.35e-05
Latitude	0.0105	0.0043	0.0164

Even if Longitude was not included in the final regression model, this variable was included in the jackknife analysis.

Re-sampling data analysis by the Jackknife method:

The samples were excluded one year at a time, the same model as in Table 1 was applied.

Mean of the estimated 17 coefficients is -0.01855. The jack-knife SD for slope on year is 0.004544, which should be compared to the slope -0.01856 and to the SD=0.002806 for year in Table 1. The slope coefficient is about four SDs away from zero.

These results indicate that the decline in 'Total fat' during the JARPA years is statistically significant at far below the 5% level.

As a second step we considered the same linear model but with different random terms:

The models that we considered were:

V1: Fat_in_Ton~(Date|year)+LBW+Diatom+BL+Longit+ sex+year+age+latit

V2: Fat_in_Ton~(Date|year)+LBW+Diatom+BL+(Longit |year)+sex+ year+age+latit

V3: Fat_in_Ton~(Date|year)+LBW+Diatom+BL+Longit+ sex+year+age+(latit|year)

V4: Fat_in_Ton~(Date|year)+LBW+Diatom+BL+(Longit| year)+sex+year+age+(latit|year)

Summary of results for year effect:

Model	AIC	BIC	Estimates	SD	t-value
V1	479.8	538.0	-0.01218	0.004370	-2.789
V2	468.7	535.8	-0.01229	0.004056	-3.030
V3	477.0	544.1	-0.01542	0.004029	-3.829
V4	468.7	544.7	-0.01219	0.004032	-3.024

As a third step we analysed the same four random effect models with the longitudinal area divided in six half-Management Areas treated as categorical variables (set as 'cat_longit'):

Adding categorical 'longitude':

V5: Fat_in_Ton~(Date|year)+LBW+Diatom+BL+Longit+ sex+year+age+latit+cat_longit

V6: Fat_in_Ton~(Date|year)+LBW+Diatom+BL+(Longit| year)+sex+year+age+latit+cat_longit

V7: Fat_in_Ton~(Date|year)+LBW+Diatom+BL+Longit+ sex+year+age+(latit|year)+cat_longit

V8: Fat_in_Ton~(Date|year)+LBW+Diatom+BL+(Longit| year)+sex+year+age+(latit|year)+cat_longit

Summary of results for year effect

Model	AIC	BIC	Estimates	STD	t-value
V5	494.4	570.5	-0.014701	0.004764	-3.086
V6	488.0	573.0	-0.014019	0.004287	-3.270
V7	490.8	575.8	-0.018091	0.004291	-4.216
V8	485.6	579.5	-0.016652	0.004166	-3.997

Conclusion: All analyses show that the 'Total fat' in minke whales has declined over the JARPA period with significance probabilities far below 5%.

It is difficult to imagine that any remaining spatial or temporal correlation can change this main conclusion. The preferred model according to both AIC and BIC is the random effect model V2.

The two other variables related to energy storage in whales investigated in Konishi *et al.* (2008) all show a similar decline which was not changed by either jackknife analyses or by the use of generalised linear models similar to V1 to V8 above (IWC, 2011; Skaug, 2012; SC/65a/EM04). All the different analyses point in the same direction: **Fat storage in Antarctic minke whales has declined substantially over the 18 year long JARPA period.**

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Annex L

Report of the Sub-Committee on Small Cetaceans

Members: Fortuna (Convenor), Aizu, Baker, Baulch, Bell, Bjørge, Brownell, Chilvers, Cipriano, Collins, Cooke, Currey, Diallo, Double, Dupont, Feindt-Herr, Funahashi, Gallego, Galletti, Hammond, Heyliger, Hoelzel, Holm, Hughes, Iñíguez, Jaramillo-Legorreta, Kasuya, Kim, H-W., Kim, S., Kimura, Kock, Koh, Kurihara, Lang, Liebschner, Luna, Maas, Marzari, Nelson, Palacios, Palsbøll, Park, Parsons, Peres, Perrin, Porter, Reeves, Ridoux, Ritter, Rojas-Bracho, Rosenbaum, Rowles, Santos, Scheidat, Shpak, Siciliano, Simmonds, Stachowitsch, Suydam, Tajima, Thomas, Tiedemann, Urbán, Vinnikov, Williams, Wilson, Yamada, Ylitalo.

1. INTRODUCTORY ITEMS

1.1 Opening remarks, election of Chair and appointment of rapporteurs

Fortuna welcomed the participants to the meeting and informed that from this year Meike Scheidat was appointed as co-Convener of the sub-committee. Fortuna was elected Chair and Scheidat co-Chair. Reeves, Thomas and Collins undertook the duties of rapporteurs.

1.2 Adoption of Agenda

The adopted agenda is given as Appendix 1.

2. REVIEW OF AVAILABLE DOCUMENTS

The following available documents contained information relevant to the work of the sub-committee: SC/65a/SM01, SC/65a/SM03-13, SC/65a/SM15-29; SC/65a/IA13; SC/65a/O01; SC/65a/SH25; Bjørge *et al.* (2013); Comisión Asesora de la Presidencia de México para la Recuperación de la Vaquita (2012); Currey *et al.* (2012); Iriarte and Marmontel (2013); Jefferson and Wang (2011); Kim *et al.* (2010); Kurihara and Oda (2007); Mei *et al.* (2013); Oremus *et al.* (2013); a summary of Park *et al.* (2012); Peltier *et al.* (2014); Shirakihara and Shirakihara (2012); Smith *et al.* (2013); Song *et al.* (2008); Wang *et al.* (2008); Wang and Reeves (2012); and Wang *et al.* (2013).

3. REVIEW CURRENT STATUS OF SELECTED POPULATIONS OF SMALL CETACEANS IN EAST ASIAN WATERS [CHINA (INCLUDING TAIWAN), KOREA, JAPAN AND RUSSIA (BELUGA ONLY)]

At SC/64 the sub-committee had decided that Southern Hemisphere ziphiids would be the priority topic at this year's meeting. However, because of the subsequent change in planned location of this meeting, the Convener foresaw that it would be difficult or impossible to get the right people to attend. Therefore the priority topic was changed to this

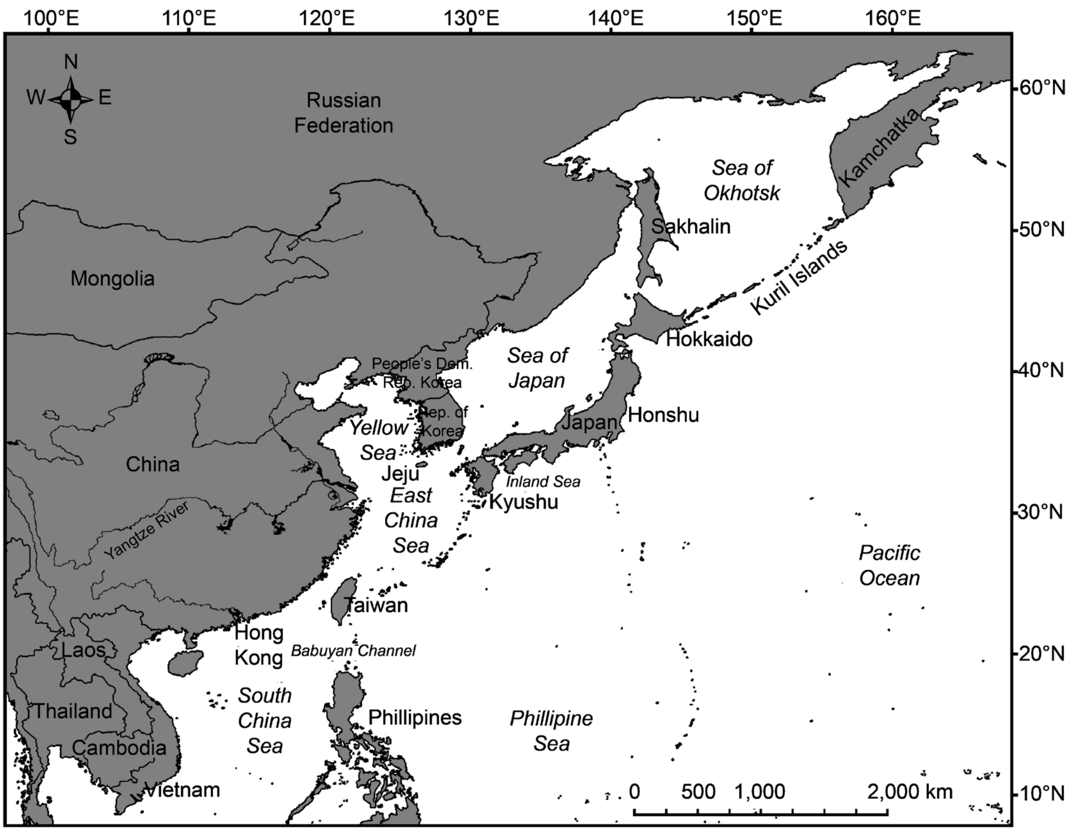

Fig. 1. Map of the relevant portion of east Asia.

one – review of the current status of selected populations of small cetaceans in east Asian waters (Fig. 1). The selection of species was based primarily on concerns about conservation status and the expectation that new information would be available.

3.1 Narrow-ridged finless porpoise (*Neophocaena asiaeorientalis*)

3.1.1 Taxonomy and nomenclature

It was proposed in document SC/65a/O01, and the sub-committee **agreed**, that the general acceptance of two identified species in the genus *Neophocaena* should be recognised by the IWC in its list of cetacean species. The change in taxonomy was based on clear morphological differences, genetic data and partial sympatry of the two forms in the Taiwan Strait (Jefferson and Wang, 2011). Specifically, the agreed change would be to list the following two species: narrow-ridged finless porpoise *N. asiaeorientalis* and Indo-Pacific finless porpoise *N. phocaenoides*.

Evidence presented in SC/65a/SM03 supported the existence of two species of finless porpoises. The analyses were based on cytochrome *b* sequences from 12 specimens from Korea and GenBank sequences from China compared with sequences from India and Arabia in GenBank. Two lineages corresponding to the two species *N. phocaenoides* and *N. asiaeorientalis* were supported by 100% bootstrap values due to four fixed differences in the sequences. SC/65a/SM03 also addressed the issue of the existence of two subspecies of *N. asiaeorientalis*. Comparison of sequences from mainland China, including the Yangtze River, and the east coast of Korea did not indicate separate lineages corresponding with the putative subspecies *N. a. asiaeorientalis* and *N. a. sunameri*. It is important to acknowledge that this study was not 'comprehensive' as it did not include any samples from Taiwan, Taiwan Strait or Japan.

SC/65a/SM18 considered the long and somewhat complicated history of nomenclature for the genus *Neophocaena*. It concluded that the proposal of Pilleri and Gihr (1972) and Jefferson and Wang (2011) that there are two subspecies within the narrow-ridged species *N. asiaeorientalis* needs more study. For example, the five populations in Japanese waters are significantly different from one another at least in terms of external morphology including the dorsal ridge and tubercles. Therefore, more effort should be made to determine the exact type locality of *N. a. sunameri*.

SC/65a/SM24 analysed 853bp of the mtDNA control region (*n*=91) and 10 loci of microsatellite DNA (*n*=105) of finless porpoises in Japanese waters and confirmed the existence of five distinct populations. Haplotypes obtained from Japanese finless porpoises fell into two groups which accumulated different mutations from those of haplotypes of Chinese porpoises analysed in published studies. Two Japan haplotypes were shared with the China group and one of them was present in all three Chinese populations.

Kasuya noted that the area considered in SC/65a/SM24 covered a latitudinal range from 35°N to 38°30'N, extending more than 300km along the Pacific coast of Japan. Two studies (Amano *et al.*, 2003; Shirakihara *et al.*, 2013) that surveyed this area identified a gap in distribution at around 37°N, and suggested the possibility that porpoises on either side of this gap constitute separate populations. Yoshida *et al.* (2001) had identified some differences in mtDNA haplotype composition between the animals north and south of the distribution gap, but acknowledged that his study was inconclusive given the small sample sizes used in the analysis. According to Kasuya, the habitat of porpoises in Tokyo Bay seems to be discontinuous with the above-mentioned habitat areas to the north and south of the distribution gap. He therefore cautioned that there is a good possibility that waters between 35°N and 38°30'N contain more than one population of finless porpoises.

The key finding of SC/65a/SM24 was that it confirmed previous studies based on ecological, morphological and molecular data that there are five separate local populations in Japanese waters that should be treated as different management units for conservation. The sub-committee therefore **recommends** that this approach continue.

3.1.2 Bycatch: Republic of Korea

The 2012 Progress Report for the Republic of Korea indicated a total bycatch of more than 1,000 finless porpoises in 2011, including 249 porpoises that died after being trapped inside the Saemangeum reclamation project after a 33km long dike was constructed (information from Park *et al.*, 2012, was summarised for the sub-committee). The water behind the dike froze during the winter and the porpoises apparently suffocated under the ice.

In its 2013 National Progress Report to IWC, the Republic of Korea reported bycatches of 2,050 finless porpoises in the Yellow Sea and 128 in the Sea of Japan/East Sea in 2012. The breakdown showing numbers caught by various types of gear is given in Table 1.

An reported that the deliberate killing of cetaceans has been legally prohibited in Korean waters since 1986 and a requirement has been in place since 1996 to monitor whale meat coming from incidental catches. This notification was amended in 2011 to intensify monitoring of the circulation of whale meat in markets. Currently, every incidental catch must be reported to the Korean Coast Guard and every tissue

Table 1

Republic of Korea finless porpoise bycatch from the 2012 National Progress Report.

Total	Bycatch per gear	Gear	Reported by
Yellow Sea			
2,050	72	[NK] gear not known or not specified	Not reported by fishermen
	1,911	[FSN] traps: stow nets	
	67	[GN] gillnets and entangling gear: gill-nets (not specified)	
Sea of Japan/ East Sea			
128	9	[NK] gear not known or not specified	Fishermen
	2	[FIX] traps: traps (not specified)	
	3	[FSN] traps: stow nets	
	4	[FYK] traps: fyke nets	
	13	[GN] gillnets and entangling gear: gill-nets (not specified)	
	97	[TBB] trawls: bottom trawls	

sample is required to be submitted to the Cetacean Research Institute for its DNA registry intended to detect and trace illegal catches.

According to An, fishermen in the Yellow Sea have not reported their incidental catches of finless porpoises in the past because there is no market demand for whale meat on the west coast of Korea and dead marine mammals are regarded as 'misfortune'. However, the Government of Korea has intensified its monitoring effort since 2011 and consequently the reported number of finless porpoises bycaught in the Yellow Sea has increased dramatically. An indicated that the Korean Government will prepare a mitigation program to reduce the finless porpoise bycatch, including consideration of gear modifications, changes to fishing practices and pingers.

In discussion, it was noted that two estimates of finless porpoise abundance were available. Zhang *et al.* (2005) reported a line-transect survey conducted for finless porpoises that resulted in an abundance estimate of 21,532 in offshore waters and 5,464 in near-shore waters along the west coast of the Korean Peninsula (South Korean waters) to Jeju Island. The sub-committee noted that as these estimates assumed $g(0)=1$ they should be viewed as minimum estimates but otherwise warmly welcomed the studies and looked forward in the future to their refinement (IWC, 2006). The sub-committee also noted that the current bycatch of 2,000 porpoises would be about 7.4% of the estimated total abundance of 27,000 porpoises in 2004.

In response to a question regarding what proportion of the bycaught porpoises were necropsied or at least sampled for DNA and other analyses, An indicated that most of the animals bycaught in both the Yellow Sea and the East Sea are kept frozen and made available for sampling because the fishermen are interested in being compensated for damage to their gear and in selling the meat. It was unclear, however, what proportion was examined. Participants stressed the importance of at least obtaining and reporting information on external morphology (for species verification). Also, it is important to clarify exactly where the boundary is drawn between the Yellow Sea and East Sea/Sea of Japan.

The sub-committee **appreciates** the substantial and useful information on finless porpoise bycatch provided by South Korean scientists. It **encourages** researchers and managers to continue their efforts to improve reporting and investigate ways to assess and manage the bycatch, particularly given the uncertainty regarding sustainability. The sub-committee **recommends** that an analysis be conducted to estimate past bycatches of finless porpoises using data on historical and recent fishing effort (e.g. numbers of relevant types of fishing gear, vessels) together with recently documented bycatch levels. As well, the sub-committee **recommends** that available abundance data on finless porpoises in Korean waters be summarised for consideration at next year's meeting together with bycatch data and that all of these data are presented in such a way that removals can be compared to abundance estimates by area. Also, the sub-committee was pleased to learn that the South Korean government is making efforts to reduce the bycatch of finless porpoises and it **recommends** that a report be provided at next year's Scientific Committee meeting summarising progress with the programme to mitigate bycatch of finless porpoises in fisheries in the Yellow Sea.

3.1.3 Bycatch: Japan

Reported bycatch in Japan is low. For example, according to the Progress Report on small cetacean research, April 2011 to March 2012[1] only 15 finless porpoises were reported as bycaught between January-December 2011. This is a provisional figure based on the reports of prefecture governments to the Fisheries Agency of Japan and the data come from reports by individual fishermen or fishery cooperative unions. Provisional data on strandings in Japan over the same time period indicated a total of 181 finless porpoises of which 178 were necropsied. It was not possible to determine from the available information to what extent the strandings were a result of bycatch.

3.1.4 Red List status

The species *N. asiaeorientalis* was redlisted by IUCN in 2012 as Vulnerable based on the following reasoning (Wang and Reeves, 2012, quoted but with minor updates here - references are incorporated into the main reference list.).

> 'Although the data are far from sufficient to make a rigorous quantitative assessment of population trend for *N. asiaeorientalis* throughout its range, the scale of threats is large enough over enough of the range to suspect and infer a decline of at least 30% over the last three generations (about 50 years, see Taylor *et al.*, 2007). The factor most responsible for such a decline would be incidental mortality in fisheries, but the loss and degradation of habitat (including chemical pollution) and vessel strikes (at least in the Yangtze River system - Turvey *et al.*, 2013) are likely contributing factors as well. As the Scientific Committee of the International Whaling Commission concluded after a review of the species (both *N. phocaenoides* and *N. asiaeorientalis*) in 2005 (IWC, 2006), 'human populations adjacent to the finless porpoise's habitat are increasing in size and becoming more industrialised so the expectation should be that anthropogenic pressures will continue and intensify.' None of the threats has been seriously addressed in any part of the species' range, even though threat levels are likely increasing.
>
> 'Partly because of their small size, phocoenids are exceptionally vulnerable to incidental mortality in gillnets (Jefferson and Curry, 1994). Incidental mortality in fishing gear is either known or presumed to occur throughout the range of narrow-ridged finless porpoises (IWC, 2006; Reeves *et al.*, 1997).
>
> 'There is clear evidence of a declining trend in two major parts of this species' range [Inland Sea of Japan and Yangtze River]. In the Inland Sea of Japan, a decline of nearly 70% was estimated over a period of 22 years, from 1976-78 to 1999-2000 (Kasuya *et al.*, 2002). There is also evidence of a rapid decline in recent decades in the Yangtze River and adjoining lake systems of China (Wang, 2009; Zhao *et al.*, 2008); the subspecies there (*N. a. asiaeorientalis*), which was classified as Endangered in 1996 under the IUCN 1994 Red List Categories and Criteria, is currently being reassessed to determine whether it should be uplisted to Critically Endangered.
>
> 'Therefore, as is true of the other species of finless porpoise (*N. phocaenoides*), the Narrow-ridged species qualifies for Vulnerable A2cde, considering that the causes of the suspected/inferred decline in population size -bycatch and mortality from vessel strikes (both interpreted here as 'exploitation'), decline in habitat quality, and possibly pollution - have not ceased and are not well understood.
>
> 'There should be sufficient information for separate assessment of at least two threatened subpopulations or subspecies – the subpopulation in the Inland Sea of Japan, which likely qualifies for Endangered (Shirakihara *et al.*, 2007), and the Yangtze River subspecies for which a new assessment is underway [see below].'

Reeves reported that a new assessment of the Yangtze subspecies *N. asiaeorientalis asiaeorientalis* will soon be published redlisting the subspecies as Critically Endangered (Wang *et al.*, 2013).

3.2 Populations of *Tursiops aduncus* in Korean and Japanese waters

3.2.1 Japan

Bottlenose dolphins (genus *Tursiops*) occur worldwide in tropical and warm-temperate waters and include both coastal and pelagic populations (Mead and Brownell, 1993;

[1]*http://www.jfa.maff.go.jp/j/whale/w_document/pdf/130531_progress_report.pdf.*

Rice, 1998). Given the wide distribution of the genus and the variability in external and osteological characters, many species and subspecies have been described (True, 1889). The lack of large samples, except for *T. truncatus*, Montagu, 1821, originally described from the eastern North Atlantic Ocean, has resulted in over a century of taxonomic confusion (Mead and Brownell, 1993; True, 1889). During the late 1990s, Wang, J.Y. and colleagues (Wang *et al.*, 1999; 2000a; 2000b) showed that the Indo-Pacific bottlenose can be distinguished from the common bottlenose dolphin using genetic, osteological and external morphological data. Around Japan specimens of *Tursiops* were studied by Kurihara and Oda (2007); who concluded that *T. aduncus* occur in at least three locations: (1) Amami Islands; (2) Amakusa-Shimoshima Island; and (3) Mikura Island. Recently, Kim *et al.* (2010) confirmed the presence of *T. aduncus* around Jeju Island, Korea.

SC/65a/SM26 summarised available information on population size of and current threats to populations of Indo-Pacific bottlenose dolphins in the Japanese Archipelago, a group of more than 3,000 islands extending some 1,300 miles from the Sea of Japan and western Pacific Ocean south towards the northern Mariana Islands and southwest towards Taiwan. The information is presented below for each of nine locations/populations (see Fig. 2 for the locations):

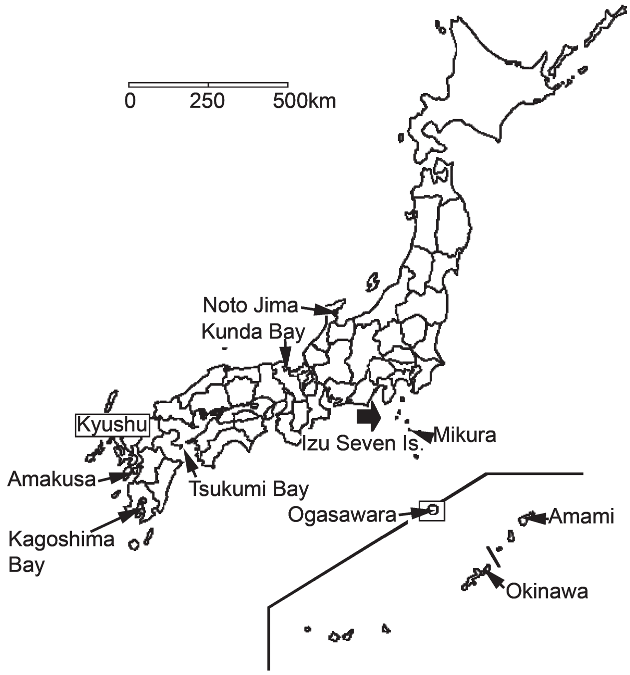

Fig. 2. Locations of Indo-Pacific bottlenose dolphin populations in Japan.

(1) *Okinawa Islands*. Indo-Pacific bottlenose dolphins are poorly known from the main island (Nishiwaki and Uchida, 1977; Uchida, 1994). There is no population estimate for these dolphins and the past problem of species identification (both *T. aduncus* and *T. truncatus* occur in this region) makes it impossible to know if they were hunted there historically. The harpoon fishery for cetaceans off Okinawa may have eliminated any population around this island.

(2) *Amami Oshima*. In 1974, 58 *T. aduncus* were captured for the Okinawa Expo which is now Churaumi Aquarium in Okinawa (Miyazaki and Nakayama, 1989; Uchida, 1994; 2006). Funasaka (2013) summarised recent studies of these dolphins around Amami Island. Nearly 100 individuals were photo-identified between 2007 and April 2012 but no population estimate is available. Funasaka (2013) also noted that the first live captures were conducted in 1974. At this time there appears to be no bycatch or other fisheries conflict.

(3) *Ogasawara (Bonin) Islands (approximately 1,000km south of Tokyo)*. The dolphin population has been estimated to consist of 200 to 300 animals (Mori, 2005)[2]. Mori and Okamoto (2013) reported that the species is distributed around the three main islands (Muko Jima, Chichi Jima and Haha Jima) and the number of known individuals identified since 2003 was 216. At this time there appears to be no bycatch or other fisheries conflict.

(4) *Tori Shima, Izu Archipelago* (located midway between Ogasawara and Mikura). Morisaka *et al.* (2013) reported that 26 individuals use Tori Shima. Many of these individuals moved to Tori Shima from Mikura Island. At this time there appears to be no bycatch or other fisheries conflict.

(5) *Mikura Jima, in the Izu Seven Islands (Izu Shichito Shoto)*. Mikura Island is approximately 185km south of Tokyo off the Izu Peninsula. Kakuda *et al.* (2002) first reported that bottlenose dolphins are resident around Mikura Island. Dolphins regularly occur around Mikura Island but not around the other Izu Islands, except for Miyake and Toshima Islands. Between 1994 and 2001, a total of 169 individuals were photo-identified around Mikura (Kogi *et al.*, 2004). Since 1995, some dolphins have been found around Toshima Island and some of these are known individuals from Mikura Jima. Kogi (2013) provided new details from their long-term field project around Mikura Island. The author noted that 225 individuals were photo-identified from 1994 to 2011 but that both calf survival and the total population had declined since 2007. In 2011 the population was estimated at only 109 individuals. Kogi (2013) was unable to determine the reason for this large decline. However, some dolphins are known to have moved to other islands. At this time there appears to be no bycatch or other fisheries conflict at Mikura.

(6) *Kagoshima Bay, southern Kyushu.* Nanbu *et al.* (2006) estimated that there were 50 animals in this bay in 1999, 40 in 2000 and 50 again in 2001. Hirose *et al.* (2013) estimated that a maximum of 50 dolphins occur in this area and that some individuals have large swellings on their sides (see their fig. 10, page 250). Shirakihara *et al.* (2012) reported long-distance movements by dolphins between Kagoshima Bay and Tsukumi Bay, Oita, northeastern Kyushu. At this time there appears to be no bycatch or other fisheries conflict in Kagoshima Bay.

(7) *Amakusa-Shimoshima Island, western Kyushu*. Shirakihara and Shirakihara (2012) updated information on their long-term studies in this region and provided new population estimates of 230 (CV=2.5%) in 2007 and 216 (CV=2.1%) in 2008 based on photo-identification mark-recapture. These authors also estimated the average bycatch as 13 animals per year based on interviews with fishermen (2007-08), which is six times higher than their estimated PBR of two animals/year. Matsuda *et al.* (2011) discussed the effects of dolphin watching boats on the behaviour of these dolphins.

(8) *Kunda Bay, Kyoto*. Morisaka *et al.* (2013) reported small numbers of dolphins in this bay, and two of them were determined to be from the Amakusa population,

[2]This estimate was not reviewed by the sub-committee.

having been documented there in 2006 and 2007. At this time there appears to be no bycatch or other fisheries conflict.

(9) *Noto Jima (eastern side of Noto Peninsula), Ishikawa Prefecture (Sea of Japan)*. Mori (2013) reported that a small number of dolphins (9) use this location, and two of them have been matched to animals previously photo-identified in the Amakusa region. Mori (2013) also noted that there is a great deal of dolphin-watching and swimming with the animals in the Noto Peninsula area. At this time there appears to be no bycatch or other fisheries conflict.

The sub-committee **thanked** Funahashi and Brownell for compiling this information on Indo-Pacific bottlenose dolphins in Japan and noted with particular concern that there appears to be a serious bycatch problem for the population around Amakusa-Shimoshima Island in western Kyushu (Shirakihara and Shirakihara, 2012). It **recommends** that this problem continue to be monitored closely and that efforts be made to reduce the risk of bycatch.

Funahashi attempted to illustrate on maps the movements of individual dolphins documented through various photo-identification programmes in Japan. Numerous examples exist of long-distance movements and various hypotheses have been suggested to explain them. In some instances such movements could reflect a process of local populations that were extirpated by the past dolphin fisheries becoming re-established. Alternatively, they could indicate range expansion in response to changes in ocean conditions. In some instances, immigrant dolphins have reproduced successfully and the sizes of the newly established local populations have increased. Monitoring of this process of long-distance movement and the interchange of individuals between local populations may provide valuable information on the structure and dynamics of metapopulations of the species. Therefore the continuation of such efforts is **encouraged**. Brownell drew attention to the well-documented long-distance relocation of coastal bottlenose dolphin communities off California, apparently in response to large-scale El Niño events. Similar processes could be at work in the western Pacific.

SC/65a/SM29 reported on a stranding of a 2.7m male *T. aduncus* in Kagoshima, southern Japan. Upon necropsy, serious skin lesions were found on various portions of the body including the top of the melon and the ano-genital region. Both gross and histological examinations suggested the animal had a Lobomycosis-like disease. PCR analysis and special staining are under way to confirm this diagnosis. Van Bressem *et al.* (2012) documented a cutaneous nodular disease in this same dolphin population.

The sub-committee **noted** that it was important to understand the origins and routes of spreading of these diseases and **recommended** further investigation and continued close monitoring of the population around Amakusa-Shimoshima Island in western Kyushu.

3.2.2 Korea

H-W Kim and his colleagues from the Cetacean Research Institute provided information on the year-round resident population of Indo-Pacific bottlenose dolphins in coastal waters of Jeju Island, Korea. The total population was estimated as 124 (95% CI=104-143) in 2008 and 114 (95% CI=109-133) in 2009 using photo-identification mark-recapture methods. The animals are most regularly observed along the northern coast of the island. Bycatch has been investigated since 2009 and the annual bycatch rate was estimated at 7%, with most of the animals being trapped in pound nets (a type of set net or trap). According to Kim, more than 80% of the dolphins have been alive when found in pound nets. He noted that if all of the live animals were released, a gradual increase in the local dolphin population might be expected.

It was noted in discussion that an effort was under way to release three dolphins back into the wild in the area of Jeju Island where they were caught before being sold illegally to Korean oceanaria. These dolphins are scheduled to be released in the summer of 2013 after being instrumented with satellite tags. They are among at least 11 bottlenose dolphins brought into captivity from the Jeju population in the last four years. In response to a question concerning whether the meat of dolphins that die in fishing gear around Jeju is sold, Kim stated that this might be attempted but there is not much local demand and few people would want to buy it. He also emphasised that the government of South Korea is concerned about this population and has committed resources to improve their protection. Given that entrapment in pound nets appears to be the most serious immediate threat, the cooperation of fishermen in reporting and mitigating the bycatch problem around Jeju is essential. It was pointed out that in Denmark, cooperation with fishermen has provided opportunities for researchers to instrument and release harbour porpoises caught in fishing gear. This has enabled collection of valuable data on movements and habitat use. Similar efforts may be worth considering in Jeju.

Kim noted that dolphin watching tourism was not highly developed on Jeju and was mostly opportunistic. Land-based watching has some potential. Kim also indicated that some dolphins bear scars or wounds likely to have been caused by either entanglements or vessel strikes, and his institute is preparing guidelines to reduce the risks of such encounters. Finally, Kim reported that he has been routinely checking available photo-identification catalogues of Indo-Pacific bottlenose dolphins in Japan (particularly western Kyushu) but with no matches thus far.

The sub-committee **thanked** Kim and his Korean colleagues for providing new information on the bottlenose dolphins around Jeju and **encouraged** them to continue their work to conserve and monitor this small local population, including the results of the satellite-tagging of the released animals this year. The sub-committee also **requests** that it be updated at future meetings on the results of monitoring and of the efforts to release entrapped dolphins from fishing gear.

3.3 Short-finned pilot whales (*Globicephala macrorhynchus*) in Japan

SC/65a/SM12 reviewed available information on the status of the southern and northern form short-finned pilot whales in Japan. Northern form abundance was estimated as 4,239 (CV=0.61) and southern form abundance as 14,000 (CV=0.23) in inshore waters north of 30°N and west of 145°E based on line transect surveys from 1983-1991 (Miyashita, 1993). More recent assessments of southern form whales made in 1998-2001 (Minamikawa *et al.*, 2007) cover a much broader area than the earlier published surveys and do not provide separate abundance estimates for the population(s) targeted by hunting. Abundance estimates of both forms are therefore more than twenty years old. Catches have declined but the cause or causes are uncertain. Changes in catch composition of the northern form in the 1980s, with a declining proportion of old and large individuals (likely mostly males) observed in the catch, was inferred to indicate a decline in the population (IWC, 1987). No recent information has been published on catch composition of either form.

One recent assessment concluded that current catch limits (2012-13) and average catches (2006-10) of southern form pilot whales exceeded levels likely to be sustainable since they were 1.8 and 1.9 times higher than a PBR threshold, respectively (Funahashi and Baker, 2011). Catches of northern form whales have not been assessed but the Scientific Committee has previously concluded that available data suggest the population was reduced by whaling, with a decline in the number and size of adult males having the potential to cause a decline in the reproductive potential of the stock (IWC, 1987).

Kasuya noted that prices of toothed whale meat in Japan had declined over the last ten years and that recent hunting on northern form short-finned pilot whales involved the same vessels and occurred in the same time period as Baird's beaked whale hunting. Thus the whaling effort was likely to be directed more towards Baird's beaked whales which have a larger body size and greater value per capita. Such dynamics could help explain, at least in part, the decline in northern form short-finned pilot whale catches in recent seasons. The situation for southern form short-finned pilot whales is slightly different. Since 1993, when the quota system was introduced into Japanese small cetacean fisheries, the whalers have always failed to reach the pilot whale quotas even though these have themselves been progressively reduced. In the absence of an actual analysis of relevant data on effort, catch locations etc., the most parsimonious assumption would be that the decline in catches has been due to a decline in the availability of pilot whales in the whaling areas.

Noting that abundance estimates for the populations of southern and northern form short-finned pilot whales targeted by hunts are now more than twenty years old and that catch composition (i.e. proportion of large animals, mostly adult males) changed rapidly within several years after the resumption of exploitation in 1982 (IWC, 1987), the sub-committee is **concerned** that catch limits exceed levels likely to be sustainable. The sub-committee therefore **reiterates** its previous concerns (Funahashi and Baker, 2011; IWC, 1987; 1995) and **recommends** that:

- up-to-date assessments of these exploited populations be undertaken, including studies of population structure and life history;
- up-to-date data on struck and lost rates, bycatch, directed hunting effort, and reproductive status and age composition of catches be collected and made available; and
- catch limits take into account struck and lost and bycatch rates, be based on up-to-date population assessments and be sustainable with allowance for population recovery.

3.4 Dall's porpoise (*Phocoenoides dalli*)

SC/65a/SM11 reviewed available information on the status of Dall's porpoise populations taken in hand harpoon hunts in Japan. Abundance of the hunted *dalli*-type population was estimated at 173,368 (CV=0.21) and the *truei*-type population at 178,157 (CV=0.23) based on surveys from 2003 (Miyashita *et al.*, 2007)[3]. These estimates represented a 23% and 18% decrease from previous estimates (Miyashita, 1991). The sub-committee previously noted that the extrapolation of density and abundance into unsurveyed areas, as was done for the most recent abundance estimate, was undesirable and recommended that a complete survey of the ranges of the populations be undertaken as soon as feasible (IWC, 2009). Okamura *et al.* (2008) concluded that given the uncertainties regarding population size and productivity rates the current management procedure 'could fail to manage the stocks at a considerably high probability'.

In the last fifty years, over 500,000 Dall's porpoises have been killed in hand harpoon hunts in Japan. In the 1980s the geographic range of the hunt expanded and catches peaked in 1988 with the removal of over 40,000 Dall's porpoises in that year (Kasuya, 2007). Since the 1980s, catches have declined and fishermen have reported increased difficulty in filling the quota (Perry *et al.*, 1999). Changes in catch composition observed in the 1990s were thought likely to result in a decline in recruitment potential and increased risk of at least localised depletion (IWC, 2000). Catches of both forms have since declined, particularly those of the *dalli* form, with only 16% of the quota taken in 2010. Available data are insufficient to determine the cause of catch declines and no up-to-date information on catch composition has been published for either form of the species.

Catch limits introduced in 1993 remained the same until 2007 since which time they have been reduced. In 2012-13 the limits were set at 7,147 *dalli*-type and 6,908 *truei*-type porpoises. These equate to 3.9% (*truei*-type) and 4.1% (*dalli*-type) of the 2007 abundance estimates. If assumptions on population growth rates are correct, allowing a catch of >4% will cause the population to decline to levels approaching zero, and will prevent future recovery (Wade *et al.*, 2008). Based on recent assessments, current catch limits (2012-13) and average catches (2006-10) significantly exceed likely sustainable levels (Wade *et al.*, 2008). Up-to-date estimates of other sources of mortality, including struck and lost individuals and bycatch, are not available. Abundance estimates are now 10 years old and therefore exceed the maximum period for which a population estimate should be considered reliable (Moore and Merrick, 2011) and there is therefore insufficient information to determine the status of exploited populations.

Kasuya reported that since the 1980s the Dall's porpoise fishermen have maintained or increased catch levels by lengthening the hunting season and expanding the hunting grounds. It appears that there is no longer any scope for such adjustments to compensate for lowered porpoise abundance.

The sub-committee was **concerned** that abundance estimates are now more than ten years old and catch limits are still likely to be unsustainable (Wade *et al.*, 2008). The sub-committee **reiterates** its previous concerns (IWC, 1984; 1991; 1992; 1993c; 1994; 1999; 2001; 2002; 2008) and **recommends** that:

- up-to-date assessments of the exploited populations be undertaken, including studies of population structure and life history;
- up-to-date data on struck and lost rates, bycatch rates, directed hunting effort, stock identity and reproductive status and age composition of catches be collected and made available; and
- catch limits take into account struck and lost and bycatch rates and be based on up-to-date population assessments, and be sustainable with allowance for population recovery.

3.5 Belugas from the Okhotsk Sea

SC/65a/SM23 summarised available information on population structure, abundance and historical catches of white whales in the Sea of Okhotsk. Based on aerial surveys in

[3]Estimates presented in this study were not assessed by the sub-committee.

2009-10, the entire Okhotsk Sea (OS) beluga population was estimated to be a minimum of 6,113 (CV=0.068), and when corrected for availability bias this gave an estimate of 12,226 (see Appendix 2 for more details). Abundance estimates were also calculated separately for different sub-regions of the survey area in order to improve management advice.

Based on the satellite tracking data (2007-10, 22 tags), the authors of SC/65a/SM23 reported that two thirds of tagged belugas that summered in the Sakhalin-Amur region stayed in or visited the eastern part of the Shantar region in the autumn. In the winter, the whales travelled northward and offshore, where they used different wintering grounds. None of the tagged whales from the Sakhalin-Amur summer aggregation area went where, according to data obtained from a single tracked individual, belugas from the western Kamchatka region spend the winter.

SC/65a/SM23 also reported genetic data showing significant differences in allele frequencies between whales sampled in north-eastern Okhotsk Sea (off western Kamchatka) and those sampled in the western Okhotsk Sea, which suggests the existence of at least two Okhotsk populations. Belugas summering in the western Okhotsk Sea (Sakhalin-Amur and Shantar regions) belong to a single highly heterogeneous 'Western-Okhotsk' population. Unique sets of matrilines in the different summering aggregations provide evidence of strong philopatry, indicating that those aggregations constitute separate demographic units, which probably mix during the mating season in offshore waters in the late winter and early spring.

According to data reported in SC/65a/SM23, belugas from the Sakhalin-Amur population have been subject to live-capture for the last 30 years under an annual quota system. The average number captured per year from 2000-12 was 23, with a range from 0 to 44. In 2012 the quota for the North-Okhotsk subzone was increased by a factor of five (to 212) and the actual number live-captured in that year was 44. The total North-Okhotsk quota for 2013 is 263 whales and this number is to be allocated to 14 different organisations. Two new capture teams, in addition to the one that has been operating in Sakhalinsky Bay since 1980s, have announced plans to operate in this same area.

In the discussion, Shpak explained that some portion of the live-capture quota is for scientific research, which means capture, sampling, tagging and release. However, most of the quota is for permanent removal for maintenance in captivity – for display and other purposes either within Russia or exported. Information on exact numbers for export *vs* animals to be kept within Russia was not available.

Participants noted that it was difficult to imagine that sufficient capacity exists in display facilities to receive and accommodate such large numbers of belugas. Rose stated that the primary current destination for live-captured belugas is Asia, especially China, where there is a high demand for such animals.

The 2013 quotas apply to the North-Okhotsk (including Sakhalinsky Bay) and West-Kamchatka subzones of the Okhotsk Sea. The two subzones have live capture quotas of 263 and 45 whales, respectively. No information was presented at the meeting that could be used to evaluate the sustainability of the West-Kamchatka quota. However, the data presented on whales within the North-Okhotsk subzone were sufficient for a simple assessment. An independent panel had used the PBR approach to evaluate essentially the same data as presented in SM23 and concluded that the PBR should be 29 whales removed per year from the Sakhalin-Amur population (Reeves *et al.*, 2011). Reeves *et al.* (2011) used a recovery factor of 0.5 because of the history of heavy commercial exploitation and continuing uncertainty regarding the extent to which recovery has occurred since the end of commercial whaling for belugas in this region. The authors of SC/65a/SM23 used a higher, less precautionary recovery factor, 0.65, to estimate a PBR of 42 whales for Sakhalin-Amur, on their assumption that the population is 'stable'. The sub-committee did not take a position on which of the two PBR estimates was the more appropriate. SC/65a/SM23 noted that intensive capture operations in a very small part of the total range of belugas in the North-Okhotsk subzone would result in considerable stress to the animals and possibly also accidental mortality that may or may not be documented and counted against the quota. In view of this, the sub-committee **agreed** that this additional concern should affect the choice of recovery factor for any PBR (or similar) calculation.

Regardless of which PBR value is used, 29 or 42, it is clear that the quota of 263 for the North-Okhotsk subzone is at least 6 to 8 times higher than what would likely be sustainable for the Sakhalin-Amur portion of the total regional population. In practical terms, the live captures are likely to be conducted at a single site which means they will target only the Sakhalin-Amur summer aggregation, and this raises concerns about local depletion (Reeves *et al.*, 2011; SC/65a/SM23). Although the whales distributed from Sakhalin-Amur all the way to the Shantar Archipelago may constitute a single biological population, there is clear evidence of strong philopatry and discrete summer aggregations. Therefore, the sub-committee **recommends** that at least four such aggregations should be managed separately. Thus, the total allowable take (quota) should be broken down into separate quotas for Sakhalin-Amur, Ulbansky Bay, Tugursky Bay and Udskaya Bay (a fifth aggregation, in Nikolaya Bay, should have a zero quota as the number of animals using that bay is very small; see SC/65a/SM23).

The sub-committee **agreed** that the current scheme for managing beluga live-capture operations in the Sea of Okhotsk is very likely to lead to unsustainable removals, placing at least the Sakhalin-Amur summer aggregation in Sakhalinsky Bay at high risk of depletion. It **recommends** that the live-capture quota for the North-Okhotsk subzone be reduced to a level that is more consistent with available scientific data. The sub-committee further **recommends** that before any removals are authorised for the West-Kamchatka subzone, data and analyses be provided that are similarly rigorous to those currently available for the North-Okhotsk subzone.

4. REPORT ON THE VOLUNTARY FUND FOR SMALL CETACEAN CONSERVATION RESEARCH

4.1 Update on the 2011 awarded projects

Of the nine projects awarded in 2011 (IWC, 2012, table 3, p.283), four were completed in 2012 (Danilewicz: franciscana; Aguilar Ramirez: vaquita; Turvey: Yangtze finless porpoise; Oremus: traditional drive hunt in the Solomon Islands). Two further projects will be completed in 2013 (Collins: Atlantic humpback dolphin; and Minton: coastal cetacean populations in Sarawak) and three will end at the beginning of 2014 (Wang, J.Y.: Eastern Taiwan Strait Indo-Pacific humpback dolphin; Smith: Indo-Pacific humpback dolphin in Bangladesh; and Cerchio: Indo-Pacific humpback dolphin in Madagascar).

Table 2

Summary of projects recommended by the Review Group for funding (2013 call).

PI	Project title	Funding
Chen	Defining the units of conservation and historic population dynamics for two small cetacean species affected by directed and incidental catches in the North Pacific.	F
Kelkar	Strengthening the meaning of a freshwater protected area for the Ganges River dolphin: looking within and beyond the Vikramshila Gangetic Dolphin Sanctuary, Bihar, India.	P
Mustika	A pilot study to identify the extent of small cetacean bycatch in Indonesia using fisher interview and stranding data as proxies.	P
Rajamani	Capacity building in conducting cetacean abundance surveys in southeast Asia through a training workshop and actual surveys.	P
Wakid	Investigating the abundance of Ganges River dolphin (*Platanista gangetica gangetica*) and factors affecting their distribution in Indian Sundarban.	F

Key: F=full funding, P=partial funding.

At this meeting information was received from Collins (SC/65a/SM16), Salvatore Cerchio, Marc Oremus (SC/65a/SM08 and Oremus *et al.*, 2013), Brian Smith, and John Y. Wang. The Secretariat will prepare a dedicated section for the IWC website on projects funded by the Small Cetacean Conservation Research Fund that will summarise projects' main achievements and ongoing activities.

4.2 Update on the 2013 selection process

Thanks to recent voluntary funding from Italy, the Netherlands, United Kingdom, United States of America, WWF-International and World Society for Protection of Animals, the Small Cetacean Conservation Research Fund was replenished sufficiently to allow funding for a few new projects, fully or partially depending on their budget requests. A new call for proposals was announced by the Secretariat in April 2013. A total of 19 proposals were received by the deadline. As a first step, the Review Group (Bjørge, Donovan, Fortuna, Gales, Reeves, Rojas-Bracho) independently assessed all proposals and a shortlist of the seven best was identified. The Group then met in Jeju for the final evaluation. All details on the review procedure and criteria can be found in Annex L of the 2011 Scientific Committee report (IWC, 2012). Table 2 contains the list of recommended projects from this year's call for proposals.

Given the large number of requests and the limited funding available, for future calls the Review Group recommended that priority is given to projects with clear potential for effective conservation outcomes in areas of particular need (e.g. critical conservation problem known or suspected, but not likely to be addressed without support).

5. PROGRESS ON PREVIOUS RECOMMENDATIONS

5.1 Vaquita

SC/65a/SM13 provided information on the continuation of the Acoustic Monitoring Scheme for Vaquita (*Phocoena sinus*) designed in 2010 (Jaramillo-Legorreta *et al.*, 2011) and deployed in 2011 (Jaramillo-Legorreta *et al.*, 2012). In particular this report presented data collected during the 2012 sampling season inside the Vaquita Protection Refuge for the species. This was the second of a total of six annual deployment periods required in the monitoring plan.

SC/65a/SM13 gave details on the deployment of the acoustic array and the problem of loss of acoustic detectors. The loss rate from the array was reduced in 2012 but losses remain high for detectors on the buoys delimiting the Vaquita Protection Refuge. Successful deployment of acoustic detectors on these buoys is important because is the only means of obtaining year-round data.

The current acoustic sample (2011 and 2012) consists of 6,382 days of effort and 4,107 acoustic encounters with vaquitas. A preliminary analysis of the data was presented, with the principal aim of showing the intended use of the information. The acoustic encounter rate followed a negative binomial distribution, showing an over-dispersion with an excess of zeroes. This finding is relevant for the analysis of data under a Bayesian framework. It was noted that the acoustic encounter rate is not evenly distributed in the sampling area; it is highest in the southern portions of the Refuge. Also, all detectors did not operate uniformly during the season. For these reasons, not all of the data from the entire set can be included in the analysis without introducing potential biases. To address this, only days when all acoustic detectors were operating were included in the analysis. Two models were used to compare acoustic encounter rates between years. The first used a parameter to estimate the change of the average acoustic encounter rate between years. The second used an exponential function with two parameters, one being the slope. Under a Bayesian framework both models estimate with about 60% credibility that the acoustic encounter rate decreased between the two years. Because the encounter rate was assumed to be proportional to abundance, it was estimated that the vaquita population has continued to decline.

The acoustic encounter rate is highest in the southern, triangular portion of the refuge near San Felipe Bay. Participants recalled that the size and shape of the refuge was determined through a combined biological and policy process that considered the range of vaquitas as well as areas of fishing activity in the upper Gulf of California. The buoys are used to mark the borders of this irregularly shaped exclusion area.

Rojas-Bracho reviewed developments in vaquita management and conservation in Mexico since SC/64. After the Presidential election in December 2012, the new Mexican Administration established the 'Advisory Commission to the Presidency of Mexico for the Recovery of Vaquita' which includes the Ministers of Environment and of Fisheries, two members of Congress, NGO representatives, four scientific advisors, fishing representatives, and the Navy. At its first meeting members of the Advisory Commission reached the following agreements (among others):

- to strengthen the inter-agency program of inspection and surveillance of PROFEPA, SEMAR, and CONAPESCA, guaranteeing compliance with the law; and
- in coming months, to eliminate gillnets and other entangling nets throughout the vaquita's range and to establish a compensation program for fishermen.

At its second meeting members of the Advisory Commission reached the following agreements:

- INAPESCA will carry out the necessary tests with the alternative fishing gear (RS-INP-MX) in El Golfo de Santa Clara and the corresponding fishermen training;

- scientists suggested that an independent steering committee of scientists, including biologists with expertise in experimental design and statistics as well as at least one resource economist, be established to agree an experimental design and to oversee the data analyses;
- officials from CONAPESCA, CONANP and INAPESCA will visit the fishing communities together with representatives of the governments of the states of Sonora and Baja California as well as civil society organisations. The main objective of the visits is to inform the fishermen of the alternatives that the federal government has prepared to address the social problems arising from the switch out processes in the region; and
- the General Director of INECC will explore the feasibility of carrying out a new vaquita population survey cruise. Currently expected to take place Oct.-Nov. 2013.

In 1999 the International Committee for the Recovery of Vaquita (*Comité Internacional para la Recuperacíon de la Vaquita* or CIRVA) recommended that research be started immediately to develop alternative gear types and techniques to replace gillnets. This effort has taken a long time and involved a number of initiatives and many people but finally in 2011 a joint INAPESCA and US National Marine Fisheries Service (NMFS) team developed and successfully tested a new small-scale shrimp trawl to be used by artisanal fishermen in place of gillnets. One of the recommendations of the fourth CIRVA meeting in 2012, which were all endorsed at SC/64, was that all gillnets and other entangling nets need to be removed from the entire range of the vaquita. In addition, last year's meeting called for 'expedited approval and adoption of the small shrimp trawls as an alternative to gillnets and prohibition of shrimp fishing with gillnets throughout the entire range of gillnets.' On 6 June 2013 the Mexican government approved the new Mexican Official Standard NOM-002-PESC that requires fishermen to switch from shrimp gillnets to alternative fishing gear over a three-year period (30, 30 and 40% annual reduction over the three-year period). The same step still needed for finfish gear. Promising alternatives to gillnets are being developed, including a successful modification of the small super-light shrimp trawl developed by INAPESCA, NMFS and WWF.

The sub-committee welcomed these developments. On the question of illegal fishing and enforcement there are several overlapping levels of illegal activity to be combatted in the upper Gulf of California. These include illegal fishing in the Vaquita Refuge, fishing with gillnets longer than allowed, fishing without permits and fishing for protected species. A ban on gillnets may simplify enforcement because fishing gear can be monitored at the point of embarcation.

Jaramillo-Legorreta presented a document (see Appendix 3) co-authored by CIRVA members that reports on the implementation of a model developed on the basis of recent data to estimate current (2013) abundance of the vaquita population. This effort was undertaken following a request from agencies of the Federal Government of Mexico (SEMARNAT and CONANP). Data available for the modelling were:

(a) abundance estimates from 1997 and 2008;
(b) acoustic encounter rates in 2011 and 2012 (supposed to be proportional to abundance);
(c) the number of boats actively fishing; and
(d) the number of boats taken out of fishing activity through the PACE-Vaquita recovery program.

The last two parameters were used as proxies to estimate the fraction of reduction, since 2007, of fishing effort that has the potential to cause vaquita bycatch. Under a Bayesian framework, the model uses 1997 abundance, the 1997-2008 rate of population decline, the 2007-13 fraction of reduction of the fishing fleet and a factor to convert acoustic rates to abundance as parameters to be estimated. Prior distributions are described in Appendix 3. Likelihood was driven by the 2008 abundance estimate and 2011-12 acoustic encounter rates. Basically the model projected 2008 population abundance forward until 2013, carrying forward and reducing the estimated population decline rate between 1997 and 2008 in direct proportion to the reduction in size of the fishing fleet. A table with posterior distributions of primary and derived parameters was provided. The posterior distribution for 2013 abundance shows that the best estimate is **189 individuals**, with most of the distribution density between 150 and 200 individuals. This result confirms the urgent requirement to remove all fishing nets from the vaquita range to allow the population to recover.

In response to questions, Rojas-Bracho noted that previous reports of the Scientific Committee and CIRVA document the many years of conservation efforts on this species and the history of scientific recommendations to the Mexican Government which centre on the determination that the only way to save the species is to eliminate gillnets from the entire range of vaquitas.

The sub-committee **recalled its recommendations** from last year's meeting and the continued relevance of the recommendations from the Fourth Meeting of CIRVA that were strongly endorsed at SC/64.

The sub-committee **commended** the Government of Mexico for establishing the Advisory Commission to the Presidency of Mexico for the Recovery of Vaquita.

The sub-committee **welcomed** the final approval of the Mexican Official Standard NOM-002-PESC which mandates a three-year phase-out of shrimp gillnets in the upper Gulf and **reiterated** its previous recommendation from last year for continued research on technologies to replace gillnetting for finfish or otherwise address the bycatch of vaquitas in the finfish nets as quickly as possible. In this regard the sub-committee noted the ongoing project funded under the Voluntary Fund for Small Cetacean Conservation Research, 'Supporting the assessment of alternative fishing gears for replacing gillnets that cause bycatch of vaquita (*Phocoena sinus*) in the Upper Gulf of California'.

In light of the significance of the updated estimate of vaquita abundance, the sub-committee agreed to include the full analysis as an appendix to its report. It is a recurring problem in conservation biology that the rarer a species is, the harder it becomes to collect a sufficient number of sightings to generate robust abundance estimates and detect population declines. As a result, the sub-committee **strongly endorsed** the decision to embed empirical estimates of vaquita abundance and trends (such as in this case the acoustic monitoring data) into rigorous statistical models, using all available relevant data and information to predict population trajectories. The sub-committee **asserted** its confidence that the best estimate of vaquita abundance in 2013 is 189 individuals (see Appendix 3). The sub-committee also noted the model's prediction that if the status quo is maintained, the species population will continue to decline towards extinction. Finally, the sub-committee **reiterated** its recommendation that further actions to eliminate bycatch should not be delayed in favour of efforts to collect more population survey data.

5.2 Hector's dolphin

SC/65a/SM07 reported on efforts to improve estimates of abundance for local populations of Hector's dolphins using capture-recapture (CR) methods based on genotyping and photo-identification. Estimating the abundance of endangered Hector's dolphins is listed as one of the four highest research priorities by the Hector's and Maui's Dolphin Threat Management Plan (TMP) (DOC and MoF, 2007). Biopsies and photographs were collected during 14 small-boat surveys in February of 2011 and 2012. From a total of 263 biopsies, 148 individuals were identified by microsatellite genotyping with up to 17 loci. Of these, 28 genotypes were recaptured between the two years. Using a two-sample, closed population model (Lincoln-Petersen estimator with Chapman Correction), the genotype CR provided an abundance estimate of n=272 (CV=0.12). The lack of genetic differentiation between the two years and the absence of any detectable migrants from other regional populations supported the assumption of demographic closure in Cloudy Bay. From photographs collected in parallel with the biopsies, the proportion of distinctively marked individuals was estimated to be 21%. After extrapolating to include the non-marked individuals, the photo-identification CR provided an estimate of n=230 (CV=0.30). These two CR estimates were larger than those from previous boat line-transect surveys in 1999/2000 (Dawson *et al.*, 2004), but considerably smaller than aerial line transect surveys in 2006-09 (Du Fresne and Mattlin, 2009). The authors also took advantage of the additional information provided by the genotypes to extend the usual timescale of individual CRs by estimating the effective population size (*Ne*). Using the single-sample, linkage disequilibrium method, the effective number of breeding individuals in the parental generation was estimated to be *Ne*=207 (95% CL: 127, 447). The authors concluded that genotype CR, as used previously for the critically endangered Maui's dolphin (Baker *et al.*, 2012), is a powerful method for estimating current abundance and genetic monitoring of coastal small cetaceans more generally.

5.2.1 Maui's dolphin

Maui's dolphin is a North Island (New Zealand) coastal endemic sub-species of Hector's dolphin. The sub-committee was informed that the management measures it endorsed at SC/64 were incorrectly attributed to a proposal by the New Zealand Government. The sub-committee acknowledges and regrets this mistake.

SC/65a/SM06 presented an update on the status of Maui's dolphins, which live off the west coast of the North Island. The population was estimated as 134 (95% CI=not available; distance sampling: line transect small boat survey) or 140 (95% CI=46-280; bootstrap of data from the same survey applied to a wider area to derive an estimate) in 1985 (Dawson and Slooten, 1988; Martien *et al.*, 1999, respectively), 111 (95% CI=48-252; distance sampling: line transect aerial survey) in 2004 (Slooten *et al.*, 2006) and 55 (95% CI=48-69; individuals one year and older, based on a genetic mark-recapture analysis) in 2010/11 (Hamner *et al.*, 2012). The author of SC/65a/SM06 suggested that unless their full range out to the 100m depth contour (including harbours) is protected against gillnetting and trawling - 95.5% of human-caused mortality or five dolphins/year (Currey *et al.*, 2012), Maui's dolphins will decline to 10 adult females in six years and become functionally extinct (<3 breeding females) in less than 20 years, even under maximum population growth (0.018 according to Slooten and Lad, 1991). Additional threats to Maui's dolphins (besides bycatch) include seismic survey work in or near their habitat and a plan to begin development of the world's largest marine iron sand mining operation.

SC/65a/SM22 also provided an overview of recent research and existing protection measures for Maui's and Hector's dolphins with the intent of assessing whether the New Zealand Government has adequately responded to the 2012 IWC Scientific Committee recommendations for urgent action to halt the decline of Maui's dolphins and allow the population to recover. According to SC/65a/SM22, although the Government of New Zealand has taken some measures to limit bycatch and allow the long-term recovery of Maui's dolphins, those measures are insufficient because they do not cover the entire known range of the sub-species and as a result both gillnetting and trawling continue to occur within these dolphins' habitat. Again according to SC/65a/SM22, the management options considered under the draft review of the Maui's component of the New Zealand TMP were inconsistent with the outcomes of the risk assessment workshop report and with recommendations made by various international organisations. Accordingly, SC/65a/SM22 stated that the protected area from Manganui Bluff in the north should extend south at least to Wanganui and out to the 100m depth contour, all gillnetting and trawling should be banned within this area (including harbours), and restrictions should be placed on oil and gas exploration and exploitation and on other potentially harmful activities where the dolphins are found, including a buffer zone.

Currey *et al.* (2012) described the spatially explicit, semi-quantitative risk assessment conducted in June 2012 that was undertaken to inform the formal review of the Maui's Dolphin TMP. The risk assessment identified 23 separate activities or processes that pose a threat to the sub-species, with bycatch in commercial set net, commercial trawl, and recreational/customary set net fisheries assessed as likely to have the greatest impacts. The risk posed by the cumulative impact of all threats was assessed as significant, resulting in a high likelihood of, and a potentially rapid rate of, population decline. The spatial overlap between dolphin distribution and commercial fishing effort helped to identify specific areas where risk posed by commercial fishing activities remained given management measures already in place. Currey noted the reported capture of a Maui's or Hector's dolphin in the south end of the range of Maui's dolphins in January 2012 and indicated that no specimen was available to determine whether it was or was not a Maui's dolphin. In response to that event, interim measures were put in place in July 2012 that either restrict fisheries activities or require 100% observer coverage in the set net fishery in much of the area where the risk assessment indicated a continuing risk to Maui's dolphins from commercial fisheries.

When asked why the January 2012 dolphin had not been examined to determine its subspecies identity, Currey indicated that this was due to a policy in place at the time, and subsequently changed, requiring that any bycaught dolphin be returned to the sea.

Maas clarified that the 100m depth contour is used to define the offshore limit of the range of Maui's dolphins. The distance from shore of this depth line can vary from 4n.miles to 39n.miles. The fishery restrictions are based on distance from shore and also vary a lot. Maas stated that fishing effort is high in the areas where Maui's dolphins occur. Currey noted that an expert panel estimated the offshore distribution as going out to 7n.miles. That conclusion was reached after using modelling data, public sightings, strandings and historical information on the dolphins' alongshore range.

In response to a question on the risk posed to Maui's dolphins by the trawl fishery, Currey responded that New Zealand had a limited observer program. Although little data is available, there is certainly some risk of bycatch in trawl gear. Maas emphasised that most of the distribution of Maui's dolphins is heavily fished and fishing is completely excluded in only part of the range.

In response to a question about how the interim measures would be expected to bring bycatch closer to the PBR (one dolphin every 10-23 years), Currey emphasised that the great uncertainty surrounding aspects of Maui's dolphin ecology and distribution makes evaluation of the efficacy of management very difficult. Emergency measures could be triggered by further bycatch. However, as discussed by sub-committee member, decision makers balance economic impacts with conservation. Currey indicated that scientific recommendations on how to assess efficacy of management for a population that is so low in numbers would be helpful.

It was suggested that at least some of the same principles apply to Maui's dolphins as apply to vaquitas. Assessment of abundance and trends for a very rare species is exceedingly difficult, and for that reason management measures must be precautionary. The sub-committee acknowledged that good knowledge of distribution is important for defining habitat that needs protection.

As it developed its recommendations, the sense of the sub-committee was that if any fisheries with the potential for bycatch were to remain active within the range of Maui's dolphins, 100% observer coverage would be expected to maximise the chance of identifying any bycatch and thus provide information that could be used to trigger immediate further area closures.

In conclusion, the sub-Committee stated its **extreme concern** about the survival of Maui's dolphin given the evidence of population decline, contraction of range and low current abundance. The sub-Committee **agreed** that the human-caused death of even one dolphin in such a small population would increase the extinction risk for this subspecies.

The sub-Committee therefore **recommended** that rather than seeking further scientific evidence, the highest priority should be given to immediate management actions that will lead to the elimination of bycatch of Maui's dolphins. This includes full closures of any fisheries within the range of Maui's dolphins that are known to pose a risk of bycatch of small cetaceans.

The sub-Committee **commends** the New Zealand Government on its initial and interim measures to protect Maui's dolphins. However, the sub-Committee **emphasises** that the critically endangered status of this sub-species and the inherent and irresolvable uncertainty surrounding information on small populations require the immediate implementation of precautionary measures. Ensuring full protection of Maui's dolphins in all areas throughout their habitat, together with an ample buffer zone, would minimise the risk of bycatch and maximise the chances of population increase.

5.3 Irrawaddy dolphin

SC/65a/SM05 presented work on the Irrawaddy dolphin, *Orcaella brevirostris*. All freshwater sub-populations of this species are considered critically endangered, including those inhabiting the Mekong River in Cambodia and Laos. In Laos, dolphins historically ranged in a number of tributaries in the Sekong River Sub-basin, and in the mainstream of the river around a trans-boundary deep pool on the Laos-Cambodia border. Dolphins now appear to be extirpated from the Sekong sub-basin, and only six individuals remain in the trans-boundary pool. Despite efforts at protection on both sides of the border, the continuing use of gillnets, explosives and electric fishing gears as well as the proposed Don Sahong dam will very likely cause the extirpation of dolphins. Conservation measures are urgently needed and will require coordinated action across the trans-boundary area from both Laos and Cambodia. The author proposes a number of recommendations:

(a) immediate banning of gillnets from all parts of the trans-boundary pool throughout the year;
(b) concerted effort to end illegal fishing and the use of explosives in the area;
(c) trans-boundary efforts to regulate boat traffic transiting the deep pool;
(d) commitment not to build the Don Sahong dam; and
(e) secure funding to support conservation efforts at the site, including effective enforcement of the above recommendations.

The sub-committee **agreed** that the situation in Laos was of serious concern and that without urgent intervention in the trans-boundary pool and the surrounding area as recommended in SC/65a/SM05, the remaining dolphins will not persist for much longer.

Porter reported that individuals from six populations of Irrawaddy dolphins (*Orcaella brevirostris*) in Malaysia, India and Bangladesh had developed cutaneous nodules. Disease prevalence ranged from 2.2% to 13.9% with the two most affected populations inhabiting the most polluted of the six areas. In India, prevalence was significantly higher in 2009-11 than in 2004-06. The emergence of this disease in multiple populations of *O. brevirostris* is of concern given the possible link to degraded environmental conditions and the vulnerability of this species to other threat factors.

The sub-committee **acknowledged** Porter and colleagues for bringing this information to the meeting and **encouraged** further investigation in collaboration with health experts and biologists working in these (and other) regions.

5.4 Atlantic humpback dolphin

SC/65a/SM16rev provided an update on an IWC funded project for the Atlantic humpback dolphin (*Sousa teuszii*). The update focused on project activities in Congo, with brief mention of work conducted in Gabon. Initial analyses were limited to beach-based data collected in 2012 in Conkouati Douli National Park (CDNP) in Congo and assessment of acoustic detections recorded on CPODs. Occupancy within CDNP was estimated as 0.83 (95% CI=0.03-0.99). Beach based sightings data were analysed using point transect distance sampling (Thomas *et al.*, 2010). SC/65a/SM16rev indicated that the method has some potential for coastal humpback dolphins. Average encounter rates were 0.023 and 0.021 for humpback and bottlenose dolphins respectively. Estimates of overall abundance (348, 95% CI 234-518, CV=19.74) were considered high by the authors, likely due to issues with distance estimation and unresolved issues with the use of effort data. Acoustic monitoring using CPODs indicated the dolphins' preference for particular sites within CDNP. The results also suggest that when dolphins are present in CDNP, they tend to spend longer there than at the other sites. The project hopes to complete two years of monitoring and further work will try to link acoustic detection rates with abundance (Kyhn *et al.*, 2012). The number of reported bycatches (n=3) has declined since 2012 but it is unclear if this reflects a true decline in the number of catches or a change in the frequency of reports. GIS analyses suggest there is some relationship between fishing effort and the risk of bycatch and some consideration will be given to the application of pingers on nets (Dawson *et al.*, 2013) in areas of greatest risk.

The project will continue for the foreseeable future with funding secured from a variety of sources (foundations, private donors and industry sources) to help support project activities for at least 18 more months. This includes sufficient funding to support boat based patrols by park enforcement officials in order to free CDNP of illegal trawlers. The associated effects of these trawlers were discussed in Collins (2012).

In discussion Collins noted that the project will use newly repaired boats to engage in photo-identification studies and line-transect survey work. There was discussion of the value of working with a local mining company which is committed to reducing the long-term environmental impact of its operations. This company has already modified a jetty project and re-located a proposed breakwater to reduce coastal impacts. Williams noted that the challenges of surveying this coastal *Sousa* population are similar to those encountered in surveying freshwater cetacean populations which exhibit strong density gradients out from the riverbank. He suggested that when detectability is confounded by a density gradient one can conduct parallel survey lines at different distances or generate two different sources of information. For example in addition to shore-based surveys one could place C-pods out at a gradient away from shore to get a density gradient and remove it from the detection function. He suggested cross-referencing of coastal survey methods with freshwater methods (see Item 8.8). He also noted that if survey results are good enough to know that bycatch is clearly exceeding PBR, further refinement is not necessary before taking management action. Collins agreed that in this case bycatch is exceeding PBR and that survey methods can demonstrate this as long as consistent methodologies are used over time. Rojas-Bracho also noted that CPODs can be used to detect population trends. Fishermen are not particularly inclined to work to reduce bycatch, some sell the meat, but dolphins can cause serious damage to nets (and up to US$300 replacement costs). All recognise the dolphins are protected as a Congolese Annex I species and that fines for catching them are on par with those for elephants and chimpanzees.

5.5 Indo-Pacific humpback dolphin

Smith *et al.* (2013) provided an update on their IWC Small Cetacean Fund funded project on Indo-Pacific humpback dolphins. Goals of this project were to determine the population identity for animals in the northern Bay of Bengal, Bangladesh and to contribute to the resolution of taxonomy within the genus *Sousa*. In the winter seasons of 2011/12 and 2012/13, during almost 4,000km of search effort in the Bay of Bengal offshore of the Sundarbans mangrove forest, Bangladesh, 72 sightings were made of Indo-Pacific humpback dolphins. During 56 of these sightings, effort was made to collect skin samples using a cross-bow biopsy collection system. Despite taking 440 shots, only 14 skin samples were obtained during six sightings. In addition, a single sample was collected from a humpback dolphin stranding in southern Bangladesh. The average distance to the dolphins for successful shots was estimated to be 21.4m (range=15-30). The reasons for the limited success in obtaining samples include:

(1) boat avoidance behaviour, seemingly common for this species as discussed in the sub-committee;
(2) the erratic surfacing patterns of the dolphins and the inability to track them underwater in the turbid waters of the Bay of Bengal;
(3) the long time for the biopsy dart to reach the targeted dolphin at long distances which meant that the target animal was often submerged before the dart reached it; and
(4) the lack of manoeuvrability of the research vessel in relation to the erratic surfacing behaviour of the dolphins.

Permits are currently being organised to export the samples to be analysed at the American Museum of Natural History. These samples are from a very interesting part of the range of Indo-Pacific humpback dolphins and analysis will be particularly relevant for completing the project's goals and contribute vital scientific information needed for the conservation management of humpback dolphins in Bangladesh.

Wang (2013) reported on progress on the Photo-identification Monitoring of the Eastern Taiwan Strait Population of Indo-Pacific Humpback Dolphins (*Sousa chinensis*). Twelve photo-identification surveys were conducted from June 7 to July 22 2012. Surveys were carried out primarily within the main distribution of the eastern Taiwan Strait population of Indo-Pacific humpback dolphins from as far south as Taisi (Yunlin County) and north to Tongshiao (Miaoli County). In addition, three surveys were conducted in waters much further south (to Luzhugou, Tainan County) to encompass almost the entire known distribution of this population. About 1,495km of waters were surveyed in more than 106 hours. In total, 42 sightings were recorded, all of the eastern Taiwan Strait population, and a cumulative total of 186 dolphins were observed. At least 60 different recognisable individuals were photographed. With the exception of one possible 'new' individual (a young dolphin that obtained new scars and spotting of the body and dorsal fin), all were in a catalogue that has been maintained by the *FormosaCetus* Research and Conservation Group since 2002. During this study at least three individuals were observed to be carrying fishing equipment or bearing new injuries that likely resulted from entanglement in fishing gear. Entanglement in fishing gear has been identified as one of the five main threats to this population. With potentially thousands of fishermen capable of using gillnets along western Taiwan and many operating within the habitat of the eastern Taiwan Strait population of Indo-Pacific humpback dolphins, nets are likely the most serious, immediate and direct threat to these dolphins. The incidence of new injuries and entangled animals appears to be increasing (since 2007) but more data is needed to support this observation.

Rosenbaum provided an update on the IWC Small Cetacean Fund work led by Salvatore Cerchio entitled *Ecology, Status, Fisheries Interactions and Conservation of Coastal Indo-Pacific Humpback and Bottlenose Dolphins on the West Coast of Madagascar*. The activities conducted during Year 2 of the three-year project can be divided into three major components. First, in the northwest region, boat-based field surveys to define priority habitat and assess conservation status of cetaceans including coastal dolphins were completed around Nosy Iranja and Nosy Be between November and December 2012. During 31 days on the water, 250 hours of surveys were conducted on a total of 2,909km of track line. Around Nosy Iranja, nine species of cetaceans were sighted in 33 groups (two mysticete and seven odontocete species). Preliminary results suggest that this region has a large and diverse cetacean community, representing an extension of important habitat for coastal dolphins. This new information has already been factored into the Ankivonjy MPA boundary considerations. In Nosy Be, surveys added a sixth year of effort and fourth season of substantial data collection on coastal dolphins of this region. Second, in the Northwest region, interview surveys of fishers in the island of Nosy Iranja and associated coastline were completed in October 2012, aimed at assessing marine mammal bycatch and hunting. A total of 53 interviews were conducted with 93 fishers in 10 villages around the region. Incidental bycatch was reported in all 10 villages, involving dugong, *Tursiops* sp. and *Stenella* sp. No fishers reported hunting of coastal dolphins, but hunting of dugong was reported in seven of the 10 villages. These results demonstrate the differences in the level and targets of directed hunting of cetaceans between the northwest and southwest communities in Madagascar. Lastly, in the Southwest region, community engagement work to reduce dolphin hunting and bycatch in villages on the coast north of Toliara was conducted throughout the year. A series of community outreach activities and workshops resulted in the creation of four new community-led associations for the conservation of marine mammals.

In the coming year, efforts will focus on integrating data from the boat surveys and interviews into the respective larger datasets in the northwest regions. Work in the southwest will continue with repeated visits to the Befandefa/Andovadoaka region to further the action plan on marine mammal conservation developed by those communities; this will include formalisation of the new associations described above, starting the process of local DINA (traditional laws) development, and expanding awareness raising efforts.

5.6 Harbour porpoise

SC/65a/SM21 reported on a ship board double-platform line-transect survey conducted in the Kattegat, the Belt Seas and the Western Baltic to assess harbour porpoise (*Phocoena phocoena*) abundance in the so called 'GAP area' between the North Sea and the Baltic Proper. A total of 826km of track lines were surveyed on effort in good conditions (sea state ≤ 2 Beaufort) between 2 and 21 July 2012 and 169 observations were made by the primary observers, comprising a total of 230 porpoises. 57 observations were identified as duplicates by the tracker observers and were used to correct for availability and perception bias of the primary detections. Using Mark-Recapture Distance Sampling analysis, a model using the half normal key function and including sightability as the only covariate was produced to estimate density and abundance of harbour porpoise within the 51,511km^2 survey area. *G*(0) was estimated at 0.571 (±0.074; CV=0.130). The abundance of harbour porpoises within the survey area was estimated at 40,475 animals (95% CI: 25,614-65,041, CV=0.235) with an associated density of 0.786 animals/km^2 (95% CI: 0.498-1.242, CV=0.235) and an average group size of 1.488 animals. The density estimate lies well in range with estimates obtained during previous surveys covering parts of the survey area, SCANS and SCANS II (Hammond *et al.*, 2002; Hammond *et al.*, 2013). However, high stranding numbers and regular bycatch make further monitoring of the GAP area population necessary.

The research effort was **welcomed** by the sub-committee. It was noted that large areas of the northern part of the study region were not surveyed due to unfavourable weather conditions. However no great differences in detection rates were evident between areas. The GAP plan identifies key areas for porpoises and focuses conservation measures on SACs for porpoises. While porpoise encounter rates during this survey agree in general with proposed areas, only spatial assessment of the data (to be conducted in the near future) will be able to verify areas of high density and enable to discuss population boundaries within the GAP area as proposed by Teilmann *et al.* (2011).

SC/65a/SM25 reported on the National Programme in Mauritania, entitled 'Biodiversité, Gaz, Pétrole' (BGP), which is executing an integrated marine and coastal biomonitoring scheme. This includes the monitoring of beaches for stranded cetaceans four times per year. Biometric data as well as stomach contents and blubber and/or liver samples are being collected for later analysis. Three surveys have been completed between November 2012 and May 2013, finding high numbers of stranded carcasses of harbour porpoises *Phocoena phocoena* and other species. Distributional, morphological and mtDNA data strongly suggest that the northwest African population of harbour porpoises is distributionally disjunct and reproductively isolated from the Iberian and other European populations of the species (Van Waerebeek and Perrin, 2007). No abundance estimates are available but the population is believed to be small. Of ten individuals for which the cause of death could be established (from a total of 27 examined) all had severe cutmarks and all but one were lacking tailstocks, flukes or dorsal fins. Such signs were indicative of bycatch and the authors considered bycatch as the principal, if not only, cause of death in these individuals. The authors considered it important that the cetacean strandings in Mauritania be studied in detail in the near future to assess its potential impact on population levels, in particular of harbour porpoises.

SC/65a/SM20 provided an uncorrected abundance estimate for harbour porpoises in northern Spanish waters that are considered part of the separate Iberian Peninsula Management Unit (MU) for this species in the NE Atlantic (ICES, 2013). The estimate of 683 animals (CV=0.63, 95% CI: 345-951, *n*=40) was based on sightings recorded by nine different organisations in the area during 2003-11 and does not take into account availability, perception and responsive movement biases. This species typically is inconspicuous and tends to avoid vessels so the estimate is likely negatively biased. SC/65a/SM20 also presented a bycatch estimate of harbour porpoises based on strandings data. The authors highlighted the need for unbiased estimates of both abundance and bycatch for the Iberian Peninsula MU in order to provide reliable advice for conservation and management actions.

The sub-committee agreed with the authors on the need for unbiased estimates of both abundance and total bycatch for the Iberian Peninsula population and **strongly encouraged** Portuguese and Spanish authorities to promote collaborative research projects towards this end.

5.7 Solomon Islands update on both live-capture (*T. aduncus*) and drive fisheries

Baker presented Oremus *et al.* (2013), a final report to the Government of the Solomon Islands on small boat surveys, photo-identification and genetic sampling to assess the population status of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*), a species subject to live capture for international trade. Since the beginning of the trade in 2003, a total of 108 *T. aduncus* have been exported from the Solomon Islands and the Government had established an export quota of 50 dolphins/year, but there is now an official ban on exports.

The report confirmed preliminary results presented previously in Oremus *et al.* (2012a) and included revisions addressing some of the comments offered by the sub-committee last year. In brief, genetic samples were collected to confirm the species identity and genetic diversity of the *T. aduncus* in the Solomon Islands, and these samples were analysed within the context of other species and regional populations of 'bottlenose dolphins'. Photo-identification records were collected during 62 small boat surveys around four islands (Guadalcanal, Florida, Santa Isabel and Malaita) conducted during November 2009, November 2010 and July 2011. The extent of the surveys ranged from 22% of the coastline for Santa Isabel to 100% of Florida Island. Closed population, capture-recapture models provided estimates of total combined abundance ranging from n=750 to 1,120, depending on the model. Using these estimates, the Potential Biological Removal (PBR) was calculated as an indicator of the sustainability of past catches and the current export quota.

Overall, the assessment of population status and sustainability of removals indicate that to prevent decline and ensure the persistence of local dolphin populations, no more than one dolphin every five years should be captured from the areas of north-western Guadalcanal and Florida Islands, while no more than one dolphin every two and half years should be captured from the areas of southern Santa Isabel and western Malaita. Oremus *et al.* (2013) noted that the PBR is far below the previous government export quota of 50 dolphins/year. When putting past removals into perspective with the current abundance estimates, it is likely that a large portion of the resident population around Guadalcanal has been removed by the live-capture operations.

Therefore, the sustainability of live-captures (and any associated mortality during capture) of Indo-Pacific bottlenose dolphins in the Solomon Islands remains of great concern and the sub-committee emphasised the importance of verifying the actual number of all removals including both live and dead dolphins. Since 2003, more than 100 Indo-Pacific bottlenose dolphins have been shipped from the Solomon Islands to display facilities around the world. Although the ban on exports is believed to remain in place, press reports from the Solomon Islands indicate continued interest in these dolphins, especially on the part of aquariums in China. The sub-committee **noted** that the new survey results presented by Oremus *et al.* (2013) reinforce previously expressed concerns regarding the sustainability of live-capture removals from this small island-associated population of *T. aduncus*.

Genetic results presented by Oremus *et al.* (2013) also have implications for the husbandry of captive animals, particularly if other species of dolphins are allowed to hybridise with dolphins from the Solomons or if there is inbreeding among related individuals unknowingly collected from the same social groups. The sub-committee **endorsed** the recommendation of Oremus *et al.* (2013) calling for development of a 'DNA register', i.e. genetic samples of all dolphins captured should be collected systematically and archived to allow verification of their origin and legitimacy. The export destinations of the last 100 dolphins captured is known and Rose indicated that it should be possible to identify destinations for all captures since 2003.

The sub-committee was also reminded of the previous surveys by RH *Defran* that involved the collection of individual identification photographs that could be compared to the catalogue reported by Oremus *et al.* (2013). The subcommittee encouraged *Defran* to work with Oremus in a collaborative comparison of their respective photo-id catalogues in order to produce a synthesis of sighting information.

The sub-committee thanked the authors for this report and **commended** the Government of the Solomon Islands and the Ministry of Fisheries and Marine Resources for the substantial funding provided to conduct the surveys.

SC/65a/SM08 described efforts to document the numbers and species of dolphins killed recently in the traditional drive hunts on the island of Malaita in early 2013. Although the Solomon Islands have a long history of exploiting dolphins, only the village of Fanalei on Malaita has pursued the hunt on a regular basis over the last decade or so, usually taking a few hundred to over a thousand dolphins annually (primarily pantropical spotted and spinner dolphins). In 2010, the community agreed to stop hunting under the terms of memorandum-of-understanding with Earth Island Institute, a non-governmental organisation. However, in early 2013 media reports indicated that villagers from Fanalei had resumed hunting, killing as many as 900 dolphins in a couple of events. With the assistance of the Ministry of Fisheries and Marine Resources and through a memorandum-of-understanding between the South Pacific Whale Research Consortium and the Solomon Islands Government, two of the authors (Oremus and Leqata) travelled to Malaita in March 2013 to document the hunt by conducting interviews with community hunters, elders and representatives and collecting genetic samples from recent hunts. Evidence of hunting was found in the form of numerous teeth held by the villagers, cooked meat in the kitchens, and carcasses at the dumping area. Samples of teeth, bones, meat or skin (n=45) were collected to confirm species identity using molecular tools (analyses in progress). Accurate records for the 2013 hunts as well as for some of the previous years were provided by one of the hunters. They showed that three species had been caught so far this year. The largest catches were of pantropical spotted dolphins with over 1,500 individuals killed in seven hunting events (range: 54 to 700+ per event). The other two species were the spinner dolphin (159 killed in three events) and, presumably, the common bottlenose dolphin (15 killed in one event). It is likely that the Fanalei community (and maybe other villages) will continue hunting as the demand for dolphin teeth, used in traditional dowry necklaces, is still high. Although villagers are protective of their traditions, they indicated in interviews that they were aware of the potential for depletion of dolphins as a resource and seemed willing to support future monitoring and scientific research.

In discussion, participants noted that the large catches demonstrate that dolphins, and in particular spotted dolphins, are present at least sporadically in very large groups. As the Solomon Islands are at the centre of an extensive archipelago, the history of large catches on Malaita might be indicative of a 'basin effect' where depleted areas attract animals from elsewhere. Additionally or alternatively, the continued large catches could reflect to some extent changes in fishing power (e.g. improved vessels and other equipment) and the ability of the drive hunt to cover a broader geographical area than it did in the past. However, it was also noted that the vessels used in the drive hunt are not powered and this calls into question whether the area covered by the hunt would have increased with time.

In addition, specimens of teeth and bone collected by Dawbin (1966) in the Solomons in the 1960s and curated by the Sydney Museum could be used to compare past and modern genetic diversity. Perrin had examined these skulls and identified them as pantropical spotted dolphins. The subcommittee **encouraged** the Sydney Museum to grant the authors of SC/65a/SM08 access to these specimens.

The sub-committee thanked the authors for conducting this important work and bringing it to the meeting. It also acknowledged the Solomon Islands Ministry of Fisheries and Marine Resources for facilitating the work and the funding provided by the IWC Voluntary Fund. The work considerably improves knowledge of one of the largest drive hunts known. The sub-committee also expressed concern regarding the potential depletion of local populations given the scale of the recent (and historical) catches, noting that populations would have to be very large to sustain catches of this magnitude on an annual basis.

The sub-committee **endorsed the recommendations** of SC/65a/SM08 encouraging the Solomon Islands Ministry of Fisheries and Ministry of Environment to:

(1) collect information on all future hunts and, if possible, provide some verification of species and numbers through independent observers or photographs;
(2) collect genetic samples (e.g. skin, meat, teeth) from each hunt, to confirm species identification and monitor changes in diversity and population identity over time;
(3) support further surveys of waters around Malaita (and other islands, if possible) to estimate the abundance of small cetaceans; and
(4) these actions would provide information needed to assess the potential impact of the traditional drive hunting on local populations of dolphins and a basis for advice on management policies. The sub-committee recognised that implementing these recommendations and any subsequent management policies would likely require the financial and technical assistance of intergovernmental agencies, non-governmental organisation or other interested parties.

In recognition of the large numbers of dolphins taken in the recent and past drive hunt, the sub-committee **agreed** with the authors' concern about potential depletion of the local populations. To better assess this risk and to offer any management advice, the sub-committee also **agreed** that there is an urgent need for estimates of the abundance of small cetaceans around Malaita and, if possible the Solomon Islands as a whole. In this context, the sub-committee recalled the extensive programme of aerial surveys for cetaceans and other megafauna in the South Pacific being undertaken by French Government. These are providing invaluable and reliable baseline estimates of abundance for previously unsurveyed or little surveyed areas. It noted that this programme is planning to survey the New Caledonia area in 2014. Despite the short timeframe, the sub-committee recognised the great potential conservation value that would result if it was possible to extend the surveyed area to include the Solomon Islands. The sub-committee therefore **recommended** that the Secretariat forward a letter on behalf of the Committee expressing its great appreciation for the current survey programme, explaining the benefits of extending the 2014 survey to the Solomon Islands and respectfully requesting them to consider this if at all possible.

Baker offered to contact the other authors of SC/65a/SM08 (Oremus and Leqata) and facilitate communication with the Solomon Islands government through its existing Memorandum of Understanding with the South Pacific Whale Research Consortium.

5.8 Boto and tucuxi

Brazil has been implementing the National Action Plan for the Conservation of Aquatic Mammals and Small Cetaceans which was approved in 2010. This Plan was prepared with the participation of over 32 experts who identified threats to seven species of small cetaceans and established 107 measures for their conservation. Recalling the recommendations of last year's meeting regarding the illegal capture and use of botos (*Inia geoffrenis*) and tucuxis (*Sotalia fluviatilis*) for fishing within Brazilian territory, the Brazilian Government has been taking steps to counteract this activity through enforcement actions (in the past two years, three operations have been carried out). Researchers and students are working in the Amazon basin, seeking to improve knowledge of the two dolphin species as well as carrying out educational outreach on dolphin conservation. The ICMBio-MMA office in Belém, Pará State, reports that it does not have any information about the use of botos as bait in the piracatinga fishery, and researchers in that area also report that such activity does not seem to be occurring there. Further investigation into the extent of catfish trade has shown that it is limited to border areas in the western Brazilian Amazon, in Amazonas State. New measures are being discussed to ban this practice.

The sub-committee **commended** Brazil for its National Action Plan for the Conservation of Aquatic Mammals and Small Cetaceans, and **welcomed** the report on implementation relative to *Inia* and *Sotalia*. At the same time the sub-committee recalled the SC/64 recommendations and **reiterated its recommendation** that an international scientific workshop be organised involving scientists and managers from the range states, with the goal of addressing research and conservation priorities, standardising methodologies and planning long-term strategies.

SC/65a/SM17 reported on the distribution of the botos in the Amazon delta. Despite being the subject of intensive ecological studies over the last decade in many parts of their Amazon and Orinoco river range, there is little recent or historical information on these dolphins' distribution and ecology in the Amazon delta, including the south Amazon river channel, Marajó bay and the Belém area, Pará State, and Northern Brazil. Since November 2005, intensive surveys along the coast of Pará were conducted to search for live or stranded aquatic mammals. Two areas were selected for regular surveys: the east coast of Marajó Island and Maiandeua Island. Additional surveys covered several other locations, such as the northeast coast of Marajó Island and Curuçá, in the east coast of Pará state, which lacked any previous aquatic mammal surveys and collections. Through this study, several new records of *I. geoffrensis* have been confirmed and additional biological material has been collected from carcasses detected and recovered during beach surveys. This material has been deposited in the mammal collection of Museu Paraense Emílio Goeldi. To investigate genetic variation in Amazon River dolphins and make inferences about possible subspecies of *I. geoffrensis* for the east coast of Marajó Island and Curuçá Bay, analyses of the control region and cytochrome *b* were conducted. Results suggest that one specimen from the east coast of Pará state represents an isolated geographic form of boto, genetically distinct from other known subspecies. This study points to the regular and widespread presence of *I. geoffrensis* in Marajó Bay and the surrounding coastline of Marajó Island extending to the east coast of Pará state.

The sub-committee thanked the authors for this new information. The haplotype data suggest that newly sampled animals may be even more divergent than the recently recognised species *Inia boliviensis.* However results are preliminary and more samples are undergoing analysis. The distribution of these dolphins was of some interest as they appear to be spatially separated from groups sighted near Belém. These dolphins are unusual in that they occupy brackish (marine) habitats although given the scale of estuaries (~160km in width) and associated mangroves it was hard to assess how far from the coast they occurred and their distribution may be linked to fresh water outflows. They are hard to sight during surveys which would be problematic for any proposed biopsy effort, although *Inia* sighted in Camará port are very approachable and can be seen foraging around fishing nets.

Iriarte and Marmontel (2013) reported that interactions of botos (*Inia geoffrensis*) and tucuxis (*Sotalia fluviatilis*) with fishing activities are common in the western Brazilian Amazon, but the prevalence of incidental and intentional catches is not known. This article describes incidental mortality events and intentional killing of both dolphin species and the opportunistic use of carcasses as bait. Twenty-five interaction events were recorded and a total of 11 necropsies were performed. Four individuals (two *Inia* and two *Sotalia*) bore evidence of physical violence before death, and one of each species died in abandoned gillnets. Two intentional killings of incidentally entangled botos for bait to be used in the piracatinga (*Calophysus macropterus*) fishery were reported by fishermen, while three carcasses (two *Inia* and one *Sotalia*) with gillnet marks were also observed being use for piracatinga bait. At least six of the entanglement events involving tucuxis occurred in fishing gear used for tambaqui (*Colossoma macropomum*) and pirapitinga (*Piaractus brachypomus*), two of the most important commercial fish species in the Amazon Basin.

Williams drew attention to Williams *et al.* (2012) which presented density estimates for *Inia* and *Sotalia* from the Colombian Amazon. In discussions, 'some members drew attention to the existence of both older and more recent abundance estimates for the study area and suggested that a three-way comparison of these with the abundance estimates derived from the current study would be of great value' (IWC, 2013, p.297). In response to that recommendation, Williams and the other authors of Williams *et al.* (2012), with the addition of Jeff Moore to the team, conducted analyses to infer trends. Two alternative GLM-based approaches were used to account for differences among surveys in terms of timing with respect to high, low and transitional water season and plausible values of $g(0)$ for the earliest survey. The first method used bootstrap analysis and treated the true abundances as fixed quantities; the second used a Bayesian approach in which abundances were treated as random quantities. Conditional on the full range of process variance considered to be reasonable, the authors estimated an 87% chance that *Inia* is declining and an 80% chance that *Sotalia* is stable or increasing. Williams requested feedback on any published or unpublished information on movement rates of *Inia* and *Sotalia* that could be used to assess whether the analyses considered the full range of plausible values for seasonal variation in density.

Two other developments emerged from this exercise. First, as reported at SC/64, the University of St Andrews has a scholarship open to a Brazilian student to expand this work to earn a PhD in statistics[4]. Members of the sub-committee were encouraged to advertise this opportunity to students in Brazil who are interested in quantitative methods in conservation biology.

Second, Williams, Moore and Reeves have raised funds to build a 'rapid assessment toolkit' to provide equipment, open-access software and technical advice to guide low-cost, small-boat surveys to estimate abundance of small cetaceans in regions where bycatch is thought to be a threat, but where abundance data are lacking. The toolkit will be developed and field-tested in Canada in 2013, with an aim to have it ready for use in priority regions in early 2014.

The sub-committee expressed its appreciation to Williams for following through with the work suggested at SC/64 and looks forward to receiving an update on progress with the toolkit project.

6. TAKES OF SMALL CETACEANS

6.1 New information on takes

Funahashi provided the sub-committee with a translation of the records of directed catches and associated quotas for small cetaceans from 1997-2011 obtained from the Japanese National Research Institute of Far Seas Fisheries website (Appendix 4).

The sub-committee also received from the Secretariat the summary of catches of small cetaceans in 2012 extracted from this year's national Progress Reports (see Appendix 4). The sub-committee agreed to further explore, intersessionally, more specific terms of reference for evaluating direct take data, including the idea of developing case studies or other analyses from this information.

The sub-committee thanked Funahashi and the Secretariat for their work in compiling this information for the Scientific Committee each year and reiterated the importance of having complete and accurate catch information, encouraging all countries to submit appropriately qualified and annotated catch data.

SC/65a/SM12 presented information on small cetaceans targeted by direct hunts in Japan. It noted that in 2012 there was an increase in the hunting season for Baird's beaked whales in some areas (Fisheries Research Agency, 2012). With respect to drive hunts of other species in Taiji, the number of live captures has increased in the last decade whilst the number of animals killed has gradually declined. The increase in live captures has been accompanied by an increase in exports.

Catch limits for all species were established in 1993 and remained largely constant until 2007. Since then catch limits for most species have been reduced, with the exception of Baird's beaked whale, Pacific white-sided dolphin and northern form short-finned pilot whale which have remained constant. The catch limit for false killer whales has increased. A recent assessment indicated that for all species assessed, catch limits were above sustainable levels (Funahashi and Baker, 2011), with those of striped and spotted dolphins and false killer whales particularly high, exceeding calculated PBR values by a factor of more than five.

For all species reviewed, with the exception of Baird's beaked whale, Risso's dolphin and the Pacific white-sided dolphin (which was only recently added to the quota scheme), catches have declined and have not filled the reduced quotas. For example catches of striped dolphins declined from an average of 7,663 per year in the 1960s to 3,883 per year in the 1980s despite an expansion in the geographic range of hunts over this period (Kishiro and Kasuya, 1993). In the 1990s and 2000s striped dolphin catches have further declined to an average of 562 per year. For this species, it is thought that by the 1990s the drive hunt had depleted coastal stocks to less than 10% of the post-World War II level (Kasuya, 1999). Despite the recent declines in catch levels, for all species assessed except Pacific white-sided dolphin

[4]*http://www.st-andrews.ac.uk/scholarships/brazil/biodiversity/#assessing-the-status-of-south-american-river-dolph.*

and false killer whale (where very few have been caught in recent years), available evidence indicates that average catches for 2006-10 exceed sustainable levels (Funahashi and Baker, 2011). Although there is little data available on age or reproductive status of catches of any species, changes in catch composition of three species are indicative of over-exploitation. This includes the northern-form of the short-finned pilot whale (IWC, 1987), striped dolphin (IWC, 1993b; 1998; Kasuya, 1999) and spotted dolphin (Kasuya, 1985). There is no recent data on trends in reproductive status and age of catches for any of the species targeted by these hunts.

Reported data indicate that recent catches continue to exceed sustainable levels, and there are likely additional undocumented deaths and sub-lethal impacts. Struck and lost and bycatch rates are not available for any of the species, while the effects of hunt-induced disturbance and social disruption may further reduce survival and reproductive success and impede population recovery (Wade *et al.*, 2012). There is a lack of information on these aspects and they have not been considered when setting catch limits.

Published assessments of the abundance of targeted populations of all species are now more than ten years old and exceed the maximum period for which a population estimate should be considered reliable (Moore and Merrick, 2011). Given the indications of population decline in some species (IWC, 1992; 1993a; 1993b; 1994; 1998; Kasuya, 1985; 1999), the long history of intensive exploitation, the lack of information on changes in catch composition and that catch limits and catches remain above sustainable levels, SC/65a/SM12 concluded that there is an urgent need to suspend catches of species taken in direct hunts in Japan and conduct up to date assessments of the exploited populations.

Regarding the species besides pilot whales and Dall's porpoises (see earlier) that are subject to direct exploitation in Japan (specifically common bottlenose dolphins, striped dolphins [which apparently experienced a collapse of the coastal population], spotted dolphins, Risso's dolphins, false killer whales and Pacific white-sided dolphins) the sub-committee is **concerned** that catch limits exceed sustainable levels and that abundance estimates of all species are now more than ten years old, particularly given the indications of population decline in a number of the species (IWC, 1992; 1993a; 1993b; 1994; 1998; Kasuya, 1985; 1999). The sub-committee therefore **re-iterates** its previous concerns (IWC, 1992; 1993a; 1993b; 1994; 1998) and **recommends** that:

- up-to-date assessments of these exploited populations be undertaken, including studies of population structure and life-history;
- up-to-date data on struck and lost rates, bycatch rates, directed hunting effort, stock identity and reproductive status and age composition of catches be collected and made available; and
- catch limits take into account struck and lost and bycatch rates and be based on up-to-date population assessments, and be sustainable with allowance for population recovery.

6.2 Follow up on the Workshop on 'poorly documented hunts of small cetaceans for food, bait or cash'

Ritter presented a proposal for a symposium followed by a workshop on the growing and emerging problem of poorly documented hunts of small cetaceans for food, bait or cash (sometimes referred to as the 'marine bushmeat' problem). A provisional agenda was provided that included an open symposium and a two day workshop (Appendix 5). The scope was limited to Africa, Madagascar and SE Asia. It was agreed that a steering committee consisting of members of this sub-committee as well as individuals with a wider range of expertise would be established by September 2013.

The timing and location of the proposed event was discussed at length. Options considered included a pre-meeting prior to the next Scientific Committee meeting as well as a stand-alone event that the IWC would co-sponsor. A central location was generally preferred as it would provide more opportunities to raise the profile of the issue and allow involvement of more stakeholders who would likely be able to help address this problem in regions of concern. It was also suggested that the symposium could be shared online thus making it accessible to a wide audience.

Ritter also proposed the following way forward, which includes a timeline.

The Workshop steering group shall focus its initial work on:

- appointing new members to be included in steering group (September 2013). New members shall be experts working in the areas the workshop focuses on;
- producing a final draft budget (September 2013), including costs for the venue and for (French) interpretation;
- determining additional expertise to be invited to the workshop (October 2013);
- identifying a definitive venue (December 2013); and
- liaising with international organisations dealing with bushmeat and emerging infectious diseases (e.g. Eco Health Alliance (US) and others).

The steering group shall at the same time start finding funds from NGOs and other organisations.

The steering group shall at the same time start finding funds from NGOs and other organisations. The outcomes of the work on the above bullet points shall be referred to the co-Convenors of the small cetaceans sub-committee and the Head of Science.

6.3 Significant direct and incidental catches of small cetaceans: an update

Donovan drew the sub-committee's attention to the Scientific Committee's 'Report on Significant Direct and Incidental Catches of Small Cetaceans' that was prepared for the United Nations Conference on Environment and Development (UNCED) in 1992 (IWC, 1992). Donovan suggested that there was a need for a single, up-to-date, authoritative reference on this topic and that the IWC Scientific Committee was the appropriate group for producing such a document. He noted that there is a global concern and the topic is of interest to many Member States and that the task would be well within the remit of this sub-committee.

Views of participants concerning this proposal were mixed. Some saw considerable value in such a new review although determining its scale and scope would be important. There are numerous levels of potential focus, ranging from regions to species to specific issues (for instance particular fisheries or types of fisheries). The 1992 review was less complex, very focused and had a limited scope. If a revision were to be attempted, a significant planning effort would be required in order to ensure that the effort was useful, with the right degree of detail. It could serve to generate some more interest in small cetaceans, as well as help identify new priority topics for the subcommittee. Some other members expressed concern that the time and effort required on the part of some individual scientists to contribute to the review could take away from other processes under way to review and prioritise information on significant takes of small cetaceans.

The sub-committee **agreed** to consider this proposal in more detail intersessionally.

7. UPDATE ON PROPOSED JOINT WORKSHOP ON MONODONTIDS

In 2012 the Scientific Committee set up a Steering Group under Bjørge (Acquarone, Donovan, Ferguson, Reeves, Suydam) to plan for a global review of monodontids (IWC, 2013, p.296). The terms of reference were as follows.

(1) Continue planning for a joint Workshop on monodontids with NAMMCO SC, the Canada-Greenland Joint Commission on Narwhal and Beluga, the Alaska Beluga Whale Committee, and others.
(2) Prepare a proposal for global review with a Workshop to be held in the autumn of 2013.
(3) Facilitate exchange of data between the involved groups.

After consultation with NAMMCO, the deadline of autumn 2013 was considered unrealistic. However, the NAMMCO Secretariat, with the Scientific Committee as co-sponsor, has indicated it can convene a global review workshop back-to-back with the joint meeting of the NAMMCO SC Working Group on Belugas and Narwhals and the Canada-Greenland Joint Commission on Narwhal and Beluga, to be held in Copenhagen in the second half of 2014 (or first half of 2015). Experts from all range states (Greenland, Canada, USA, Russia, Norway) should be invited and a list of possible participants in the workshop has been developed. NAMMCO has indicated that it is prepared to cover part of the costs for invited participants and funding for this workshop will be sought from the IWC. Suydam noted that with the workshop and funding coming together, other interested organisations would help support participant travel. In response to a question on participation of observers, Bjørge noted that he was not familiar with NAMMCO procedures but that observer participation should be possible.

The sub-committee **welcomed** this report and thanked the NAMMCO Secretariat for its willingness to host the meeting and help fund invited participants. Bjørge and Fortuna (the SM Convener) will work with the Secretariat to ensure that the request for IWC funding of this Workshop is considered in a timely manner. The Steering Group will continue to advance the Workshop intersessionally and will report back at next year's meeting.

8. OTHER INFORMATION ON SMALL CETACEANS

The aim of SC/65a/SM10 was to provide a context for interpreting stranding data on small cetaceans and other marine vertebrates that are likely to float after death. Spatiotemporal patterns in strandings follow a complex function of abundance and mortality, drift conditions and carcass buoyancy, as well as discovery and reporting rates. Of these confounding factors, drift is the one that would introduce more noise into the stranding data series as it is mostly driven by wind and tidal currents. The general principle of the proposed interpretation framework can be described in a few main steps. Firstly, one has to determine a prior small cetacean distribution, either theoretical or based on available knowledge. Then, by using a deterministic drift model over a given period of time and across a given study area, it is possible to: (1) determine stranding probability at any location in the study area; and (2) generate a predicted stranding data set. Conversely, the observed stranding data set for the same area and period can be used to generate an inferred distribution of dead animals at sea, by using the same drift model backwards. In the end, stranding anomalies are defined as the difference between observed and predicted strandings, whereas anomalies in dead cetacean distribution are defined as the difference between the inferred and the prior distributions. When the prior distribution is set uniformly, anomalies reflect patterns in density and mortality combined, whereas when the prior distribution is based on the knowledge of the actual distribution, anomalies reflect mortality alone. Concrete examples of the interpretation framework were given in Peltier *et al.* (2013) that deals with stranding anomalies of harbor porpoises in the North Sea, the Channel and the Bay of Biscay and Peltier *et al.* (2014) that presents stranding and distribution anomalies of common dolphins in the Channel and Bay of Biscay.

The sub-committee thanked the authors for the paper and acknowledged that this type of approach can provide valuable information for interpreting stranding data. However, it also noted that this approach cannot be used as a stand-alone monitoring method for bycatch, distribution or abundance.

SC/65a/SM28 provided information on a beaked whale stranded in 2012 at Michoacan, Mexico. The animal was identified based on its body coloration as *Mesoplodon* sp. A. DNA was extracted from powder from a vertebral bone. A fragment of the mitochondrial DNA control region and two of the cytochrome *b* were sequenced and tested with BLAST and DNA-Surveillance for molecular identification. With both tests, the sequence was identified as lesser beaked whale (*Mesoplodon peruvianus*). These results confirm that organisms with the coloration pattern referred as *Mesoplodon* sp. A, belong to *M. peruvianus*.

SC/65a/SM04 reported on a study of dolphins along the central Caribbean coast of Costa Rica. The objectives were to investigate the presence and distribution of cetaceans and to determine if port activities are likely to have impacts on them. Surveys were carried out between May and September 2012, covering six 6km long transects perpendicular to the coast, three in the northern portion of the Central Caribbean Coast region and the other three in the port area and its surroundings. The only cetacean species observed were common bottlenose dolphins (*Tursiops truncatus*) and Atlantic spotted dolphins (*Stenella frontalis*). All sightings were in the northern transects, outside the port area. Bottlenose dolphins accounted for most of the sightings (71.4%), while there was only one sighting of spotted dolphins (14.3%) and one of a mixed group of both species. The mixed-group sighting was considered interesting in such a coastal situation since both species are known to form mixed groups but usually in open oceanic waters. Acoustic recordings in the Bay of Moín and environs were interpreted by the authors of SC/65a/SM04 as indicating high potential for disturbance and therefore were seen as a possible explanation for the absence of dolphin sightings in that area during the study.

SC/65a/SM09 summarised the results of small-boat surveys in the Marquesas Islands, funded by the Ministry of the Environment of French Polynesia as part of a larger regional effort to better document cetacean diversity and abundance throughout the five archipelagos of the territory (the Marquesas, Tuamotus, Society, Gambier and Austral Islands). Intensive photo-id and biopsy sampling surveys were conducted from 31 March to 26 April 2012 at six islands: Hiva Oa, Tahuata, Mohotani, Ua Huka, Ua Pou and

Nuku Hiva. Overall, the Marquesas were found to have a high diversity and abundance of cetaceans for such a remote island group surrounded by oligotrophic waters. In total, 99 groups of seven species were encountered and photographed and/or biopsy sampled: spinner dolphin, pantropical spotted dolphin, common bottlenose dolphin, Risso's dolphin, short-finned pilot whale, melon-headed whale and dwarf sperm whale. No rough-toothed dolphins were observed during the surveys despite the fact that they are the second most frequently encountered species in the Society Islands to the south according to previous aerial surveys (Project REMMOA; Laran *et al.*, 2012). Observations of local site fidelity of melon-headed whales were especially noteworthy. They were found in very near-shore waters during the morning, apparently resting and socialising during the morning. Also noted were mixed-species schools of spotted dolphins/spinner dolphins and spinner dolphins/melon-headed whales, as well as overlap between insular and apparently pelagic populations of spinner dolphins. In one offshore encounter, a pod of spinner dolphins exhibited 'alarm' (rapid fleeing) in response to the approach of the small boat. The authors attributed the alarm behaviour to previous experience with tuna purse-seine fisheries and noted that this had never been exhibited by spinner dolphins in the Society Islands.

A total of 232 biopsies were obtained from 52 spinner dolphins at five islands, 61 spotted dolphins at five islands, 111 melon-headed whales at four islands and eight pilot whales at three islands. Analyses of these samples are underway and will contribute to the larger collaborative study of genetic connectivity and isolation among insular communities of dolphins throughout Oceania.

Ridoux noted the potential for comparison of results from the small-boat surveys and the aerial surveys conducted in the Marquesas as part of Project REMMOA. Baker agreed that there was such potential and explained that results from REMMOA had been used to help design the offshore component of the small-boat surveys.

The sub-committee expressed its appreciation for this contribution and for the support of the surveys by the Ministry of Environment (French Polynesia).

SC/65a/SM27 described a mass stranding event (MSE) of short-beaked common dolphins, *Delphinus delphis*. About 20-30 dolphins mass stranded at about 08:00 on 5 March 2012 on a sandy beach at Arraial do Cabo on the south-eastern end of Cabo Frio, Rio de Janeiro State, Brazil (22°57'56'S, 42°01'80'W). In a video, the school of *Delphinus* can be seen swimming straight onto the beach. As soon as the dolphins were on the beach, tourists started to return them back to the sea. It was assumed that all of the dolphins were returned to the water and survived as no dead *Delphinus* were found or reported from the area after the MSE, nor were any dead *Delphinus* reported dead in the Cabo Frio region in the weeks following it. After attempting unsuccessfully to identify a source of disturbance to the dolphins, the authors proposed that these pelagic dolphins had been acoustically trapped or restricted by some sound at the mouth of Enseada da Prainha. The actual MSE was probably induced by some additional acoustic event which caused them to panic/stampede and swim toward the beach and strand. From this experience the authors provided recommendations for investigating future MSE's in Brazil or elsewhere:

(1) gather as much data as possible about the stranding as soon as possible; include any video of the event, including the geography of the area where the MSE occurred; and
(2) gather as much data as possible about any human-related acoustic activities around the time of the MSE, including seismic surveys, hydroacoustic surveys (e.g. bottom mapping), vessels moving back and forth for any reason in the area of the MSE and aerial traffic like helicopters.

Bjørge *et al.* (2013) present bycatch estimates for harbour porpoises incidentally taken in two coastal gillnet fisheries in Norway. Using data collected during 2006-08 from a monitored segment (18 vessels) of the Norwegian coastal fleet (vessels<15m) of gillnetters targeting monkfish and cod, they used general additive models (GAMs) to derive bycatch rates. These bycatch rates were then applied to fishery catch data on the target species to estimate the total number of porpoise taken by the coastal gillnet fisheries. The best models estimated about 6,900 porpoises per year with CV of about 0.3. To reduce harbour porpoise bycatches, the authors recommend that large mesh nets associated with the monkfish fishery to be prohibited at depths less than 50m. They also recommend experiments using Acoustic Deterrent Devices (pingers) on nets set deeper than 50m. If these devices prove successful in reducing porpoise bycatch, they propose that pingers should be implemented in the Norwegian coastal gillnet fisheries for cod and monkfish.

SC/65a/SH25 presented the results of a conference of the Southern Ocean Research Partnership (SORP) that was held immediately on 31 May-2 June 2013. One of the aims was to develop and update the existing project plans and discuss new research proposals (refer to Annex 1 of SC/65a/SH25 for details of these plans). One of the six project plans – *Distribution, abundance, migration patterns and foraging ecology of killer whales in the Antarctic and adjacent waters,* led by Robert Pitman and John Durban of NOAA's Southwest Fisheries Science Center in La Jolla, California – is relevant to this sub-committee. The aims of the project are, through collaboration, to:

(1) compile a killer whale sightings database from land-based observations, research cruises and platforms of opportunity to produce a detailed distribution map of the different killer whale types in Antarctic and adjacent waters, highlighting areas of concentration;
(2) organise photo-id catalogues for selected areas (e.g. Ross Sea, Antarctic Peninsula, the sub-Antarctic islands Crozet, Kerguelen and Marion) to be used for estimating the size of local populations;
(3) collect biopsies to support further phylogenetic studies of Antarctic and sub-Antarctic killer whales, as well as for comparative studies of food habits (stable isotopes/fatty acids) and contaminant loads;
(4) deploy satellite tags to study local and seasonal movements and migratory destinations (if any) of killer whales and also investigate killer whale-habitat relationships;
(5) conduct focal follows to observe foraging habits and prey preferences of the different killer whale types in the region;
(6) make acoustic recordings of the different types of killer whales in Antarctica and the sub-Antarctic for comparative purposes; and
(7) quantify body size differences between groups of killer whales using laser-paired photogrammetry.

The project plan discusses data analyses, data collection, archiving and sharing, and the use of platforms of opportunity to collect data, in particular from research and tourist vessels. The estimated budget is £538,000 GBP, much of which is to cover the cost of the 180 tags required to meet the objectives.

SC/65a/SM19 summarised the results of small vessel surveys of dolphins and whales in the coastal and near shore waters of the Independent State of Samoa (formerly Western Samoa) conducted in collaboration with the Ministry of Natural Resources and the Environment and co-funded by Pew Foundation and IFAW. These surveys were part of a larger collaborative project to describe the degree of genetic isolation or connectively among communities of dolphins around islands of Oceania. Unlike the large, nomadic herds of dolphins found in the open oceans, these island communities often number less than a few hundred individuals and show a strong attachment to specific islands. In adapting to island habitats, some of these communities have become genetically isolated from each other, and from the larger founder populations in the open ocean (Andrews *et al.*, 2010; Oremus *et al.*, 2007; 2012b). To describe this 'pattern of dolphins', members of the South Pacific Whale Research Consortium are collecting genetic samples from dolphins near islands throughout Oceania, to reconstruct the genetic relationships among individuals and communities and relate these to seascape features. The collaborative study will also include analysis of samples collected in the remote Marquesas Islands of French Polynesia, as described in SC/65a/SM09.

The two main islands of Samoa, Upolu and Savai'i, were included in this larger study because of their central location in the South Pacific and potentially importance for facilitating genetic connectivity across the region. The surveys were conducted over 8 days in August 2012, completing a circumnavigation of both islands, a distance of over 1,000km. There were 14 encounters with cetaceans, including humpback whales and 5 species of small cetaceans: spinner dolphins, short-finned pilot whales, common bottlenose dolphins, rough-toothed dolphins and unidentified beaked whales (probably Cuvier's beaked whale). Biopsy samples were collected from spinner dolphins (n=15), short-finned pilot whales (n=6), and common bottlenose dolphins (n=2). For an initial description of seascape influences on the Samoan spinner dolphins, the report included an initial comparison of the mtDNA haplotypes to previously published samples (n=426) from American Samoa, the Society Islands, the Marquesas and the main islands of Hawai'i. Results confirmed the strong differentiation between spinner dolphins from Hawaii and the islands of the South Pacific (F_{ST}=0.221 and φ_{ST}=0.291, p<0.001) and significant differences among island communities within archipelagoes, apparently related to both distances and seascape features. These patterns could be useful in understanding how large marine protected areas will benefit island communities of dolphins. The surveys and genetic samples contribute to previous efforts in Samoa (Olavarria *et al.*, 2004) and nearby American Samoa (Johnston *et al.*, 2008) and to the larger description of isolation and connectivity among dolphins in the Pacific (Andrews *et al.*, 2010; Oremus *et al.*, 2007; 2012b).

SC/65a/IA13 presented information on cetacean sighting surveys in Gabon coastal waters and in the Gulf of Guinea (Côte d'Ivoire, Ghana, Togo and Benin). They were carried out by the Centre National des Sciences Halieutiques of Boussoura (CNSHB) under the auspices of COMHAFAT, with the collaboration of some African fisheries institutions and fisheries research centers such as the Direction General des Pêches in Gabon, the CRO of Abidjan in Côte d'Ivoire, the IMROP of Nouadhibou in Mauritania, the CRODT of Dakar in Senegal, the Direction des Pêches of Cotonou in Benin, the MFRD of Tema in Ghana, the SSRHO IRAD of Limbe in Cameroon and the CIPA of Bissau in Guinea Bissau. The study areas were set for the first survey in Gabon EEZ and the second one in the Gulf of Guinea. Shallow waters, less than 50m and oil fields were excluded from the study area for navigational safety. The research vessel, the *General Lansana Conte* from Guinea (198 tons), follows the lines at 8 to 10 knots. A researcher from each of the seven African countries (Mauritania, Senegal, Ghana, Benin, Togo, Gabon and Cameroon) participated in the survey.

In the area of coastal waters of Gabon, six survey blocks were placed, three offshore and three coastal and zigzag track lines of 878n.miles were set. A 10-day survey period was set in September a season thought to be suitable for cetacean sighting survey in the waters off Gabon. In the area of the Gulf of Guinea, seven survey blocks were placed and zigzag track lines of 1,200n.mile length were set. The starting point of the lines is set off Abidjan, Ivory Coast and the end of the lines is set off Cotonou, in Benin. A 15-day survey period was set from 23 March to 6 April, 2013.

During the cetacean sighting survey, in the coastal waters of Gabon, 232.1n.miles were searched. A total of 49 schools were encountered, seven of which of small cetaceans including pantropical spotted dolphin (*Stenella attenuata*), Atlantic spotted dolphin (*Stenella frontalis*) and bottlenose dolphin (*Tursiops truncatus*).

During the sighting survey in the Gulf of Guinea, 36 schools were sighted. Thirty-five schools were of small cetaceans including bottlenose dolphin (*Tursiops truncatus*), rough-toothed dolphin (*Steno bredanensis*), Risso's dolphin (*Grampus griseus*), pantropical spotted dolphin (*Stenella attenuata*), Atlantic spotted dolphin (*Stenella frontalis*), pygmy killer whale (*Feresa attenuata*), common dolphin (*Delphinus delphis*) and short-finned pilot whale (*Globicephala macrorhynchus*). Further surveys are planned in the region.

9. WORK PLAN

Participants discussed possible elements of the sub-committee's work plan for SC/65b. Regarding previously identified priority topics it was agreed that *Tursiops* systematics should be dropped. The review of Southern Hemisphere ziphiids remains a priority that should be taken up at a time when the Scientific Committee meets somewhere in the region.

Three new priority topics were proposed for SC/65b: a review of results and future of the Voluntary Fund for Small Cetacean Conservation Research, a review of small cetaceans in the eastern Mediterranean and Red Seas, and consideration of small cetaceans in highly polluted environments.

For the review of the research fund, Principal Investigators from a subset of projects could be invited as IPs to present the findings of their research and discuss its conservation relevance. This would guide discussions of the effectiveness and further development of the fund.

Anticipating that the next meeting is likely to be held in Europe, it was suggested that review of small cetaceans in the eastern Mediterranean and Red Seas should be the priority topic at SC/65b.

After discussion it was agreed that small cetaceans of the Mediterranean and Red Seas would be the priority topic and that the agenda would include substantial opportunity for presentation and discussion of the projects funded by the Voluntary Fund. The idea of small cetaceans in highly polluted environments could be considered at some time in the future as a possible priority topic.

10. ADOPTION OF REPORT

The Report was adopted at 22:11 on 11 June 2013.

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Appendix 1

AGENDA

1. Convenor's opening remarks
2. Election of Chair
3. Appointment of rapporteurs
4. Adoption of agenda
5. Review of available documents
6. Review current status of selected populations of small cetaceans in East Asian waters (China [including Taiwan], Korea, Japan and Russia [beluga only])
   - 6.1 Narrow-ridged finless porpoise (*Neophocaena asiaeorientalis*)
     - 6.1.1 Yangtze finless porpoise (*N. a. asiaeorientalis*)
     - 6.1.2 East Asian finless porpoise (*N. a. sunameri*)
   - 6.2 Populations of *Tursiops aduncus* in Korean and Japanese waters
   - 6.3 New data on northern form of the short-finned pilot whale (*Globicephala macrorhynchus*) in Japan
   - 6.4 Dall's porpoise (*Phocoenoides dalli*)
   - 6.5 Belugas from the Okhotsk Sea
7. Report on the Voluntary Fund for Small Cetacean Conservation Research
   - 7.1 Update on the 2011 awarded projects
   - 7.2 Update on the 2013 selection process
8. Progress on previous recommendations
   - 8.1 Vaquita
   - 8.2 Hector's dolphin
     - 8.2.1 Maui's dolphin
   - 8.3 Irrawaddy dolphin
   - 8.4 Atlantic humpback dolphin
   - 8.5 Indo-Pacific humpback dolphin
   - 8.6 Harbour porpoise
   - 8.7 Solomon Islands update on both live-capture (*T. aduncus*) and drive fisheries
9. Takes of small cetaceans
   - 9.1 New information on takes
   - 9.2 Follow up on the workshop on 'poorly documented hunts of small cetaceans for food, bait or cash'
   - 9.3 Significant direct and incidental catches of small cetaceans: an update
10. Update on proposed joint workshop on monodontids
11. Other information on small cetaceans
12. Any other business
13. Work plan
14. Adoption of Report

Appendix 2

ABUNDANCE ESTIMATES EVALUATED BY THE SUB-COMMITTEE

Population	Area	Category	Evaluation extent	Year	Method	Corrected	Estimate and approx. 95% CI or equivalent	IWC reference	Original reference	Comments
Beluga										
Okhotsk Sea	W Okhotsk Sea	3*	3*	2010	Aerial survey visual counts and photographs	A (see comment)	9,560	SC/65a/SM23	Glazov *et al.* (2012); Chelintsev and Shpak, unpub.	Availability bias was assumed to be 50% based on literature values
Okhotsk Sea	NE Okhotsk Sea	3*	3*	2010	Aerial survey visual counts and photographs	A (see comment)	2,666	SC/65a/SM23	Glazov *et al.* (2012); Chelintsev and Shpak, unpub.	Availability bias was assumed to be 50% based on literature values
Harbour porpoise										
W Baltic, Belt Sea/ Kattegat	W Baltic, Belt Sea/ Kattegat	1	2	2012	Distance sampling line transect shipboard surveys	A+P	40,475 (95% CI: 25,614-65,041)	SC/65a/SM21	Not published yet	-

*The estimation method has not been evaluated in detail.

Broad overview summary for Commission and public.

Species	Ocean	Region	Year	Estimate	Approximate 95% confidence intervals
Beluga	North Pacific	Okhotsk Sea	2010	12,226	N/A
Harbour porpoise	North Atlantic	Western Baltic, Belt Sea and Kattegat	2012	40,475	25,614-65,041

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Appendix 3

2013 ESTIMATE OF ABUNDANCE FOR THE VAQUITA (*PHOCOENA SINUS*)

Armando Jaramillo-Legorreta, Tim Gerrodette, Arne Bjørge, Robert L. Brownell, Greg Donovan, Randall Reeves, Peter O. Thomas, Jorge Urbán-R. and Lorenzo Rojas-Bracho.

INTRODUCTION

The vaquita (*Phocoena sinus*) is among the world's most critically endangered cetaceans. Its range is restricted to the northern Gulf of California, Mexico. The principal threat to the species is bycatch in gillnets used by artisanal fishers (Rojas-Bracho *et al.*, 2006; Rojas-Bracho and Taylor, 1999). The most recent estimate of abundance based on a 2008 line-transect survey was 245 animals (95% CI 68-884), a 57% decline since the previous survey in 1997 (Gerrodette *et al.*, 2011). When combined with previous surveys, acoustic detections and bycatch estimates in a population model, 2008 abundance was estimated to be slightly lower (214 animals) but with much higher precision (95% CI 135-326) (Gerrodette and Rojas-Bracho, 2011).

Alternative gear to catch shrimp with no vaquita bycatch has been developed by the Mexican Institute of Fisheries. On June 6, 2013, the Mexican government modified national regulations for shrimp fishing to specify that this new gear will be phased in over a three-year period. In addition, efforts are underway to develop vaquita-safe gear for finfish fisheries in the area (CIRVA, 2012).

The Mexican Ministry of Environment and Natural Resources (SEMARNAT) and the National Commission for Natural Protected Areas (CONANP) have requested an estimate of current (2013) vaquita abundance to support the public policy and applicable legal instruments for vaquita recovery.

Estimation framework

AD Model Builder (Fournier *et al.*, 2012) was used to set up the model and estimate parameters under a Bayesian MCMC approach. Inference was based on 200,000 samples of the posterior distributions of the model parameters.

Available data

Two estimates of abundance, based on surveys specifically designed for vaquitas, were available for the years 1997 (Jaramillo-Legorreta *et al.*, 1999) and 2008 (Gerrodette *et al.*, 2011).

Numbers of currently active fishing boats were taken from an Environmental Impact Assessment that was required for fishing inside the buffer zone of the Biosphere Reserve of the Upper Gulf of California and Colorado River Delta (CEDO, 2013a; 2013b). The total number of vessels removed from the fishery since 2006 under the conservation action plan of PACE-Vaquita was taken from the PACE Reports of the National Commission for Natural Protected Areas (Dulce María Ávila, CONANP, pers. comm., 3 January 2012).

Acoustic encounter rates for the years 2011 and 2012 were estimated from data collected under the Acoustic Monitoring Scheme for Vaquita (SC/65a/SM13). Acoustic encounter rates were assumed to be proportional to abundance.

Model

Parameters

- *N97*, abundance in 1997.
- *Rate9708*, annual rate of decrease of the population between 1997 and 2008.
- *Frac*, fraction of reduction of the artisanal fleet since 2007.
- *qA*, factor to convert acoustic encounter rate to abundance.
- *r*, dispersion parameter of the negative binomial distribution.

Derived parameters

- *Rate0813*, annual rate of decrease of the population since 2008.
- *N08, N09, …, N13*, abundance for years 2008 to 2013.
- *lambda11, lambda12*, daily acoustic encounter rates for 2011 and 2012.

Prior distributions

- For *N97*, a lognormal with average 567 and standard error 394 (Jaramillo-Legorreta *et al.*, 1999).
- For *Rate9708*, a normal with average 0.0734, calculated from point estimates of abundance for 1997 (567) and 2008 (245). A CV of 30% was assumed.
- For *Frac*, a normal with average 0.39741, calculated from a supposed minimum of one third of the fleet and a maximum of 0.4615. This last figure came from a known number of 755 active boats and a known number of 647 boats that have already been taken out of the fishery. This maximum assumed that the entire fleet was known (i.e. no illegal boats were fishing). The average (0.39741) was then the midpoint between supposed maximum illegality and no illegality. A CV of 30% was assumed.
- For *qA*, a normal with average 0.0035. This was calculated from a projection of population abundance to 2011 and 2012 on the assumption that there was no change in the decrease rate between 1997 and 2008. *qA* was calculated as *lambda/N*, average acoustic encounter rate divided by abundance. The average (0.0035) was the midpoint of this calculation for acoustic data from 2011 and 2012. A CV of 30% was assumed.
- For *r*, a uniform prior distribution between 0.01 and 5.0.

Likelihood

- The abundance estimate for 2008 (Gerrodette *et al.*, 2011) was assumed to have a lognormal distribution with average 245 and standard error 179.
- The acoustic encounter rate data for 2011 and 2012 was assumed to have a negative binomial distribution with mean parameter *lambda* (as explained above) and dispersion parameter *r*.

Procedure

- Values of *N97*, *Rate9708, Frac, qA* and *r* were sampled from their prior distributions.
- *N08* was calculated as: $N08=N97 * (1 - Rate9798)^{11}$.
- *Rate0813* was calculated as: $Rate0813 = Rate9798 * (1 - Frac)$.
- Abundances after 2008 were calculated as: $N_{xx} = N_{xx-1} * (1 - Rate0813)$.
- Likelihood for 2008 abundance was calculated from *N08*.
- *Lambda* was calculated as: $lambda_{xx} = N_{xx} * qA$ for 2011 and 2012.
- Likelihood for encounter rate was calculated from *lambda* values.

	N97	Rate9708	Frac	Qa	N08	Rate0813	N11	N12	N13	Lambda11	Lambda12	*r*
Mean	584	0.92957	0.39639	0.00335	250	0.95750	221	212	204	0.68321	0.65407	0.16310
Median	559	0.92861	0.39691	0.00331	236	0.95707	206	197	189	0.68256	0.65333	0.16289
2.5%	240	0.87152	0.33337	0.00171	155	0.92192	132	124	116	0.62604	0.59872	0.14807
97.5%	1,022	0.99063	0.45541	0.00521	426	0.99435	394	385	377	0.74447	0.71392	0.17922

Note: rates of decrease (9708 and 0813) were modeled as 1-rate. Hence, a larger number in table means reduction of the rate.

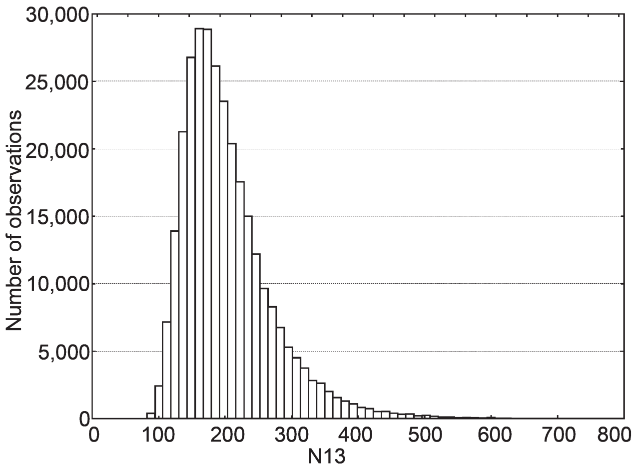
Results

The estimate of vaquita abundance in 2013, given available data, is about 189 individuals (median of the posterior distribution) with a 95% CI 116-377 (0.025 and 0.975 percentiles of the posterior distribution). Summaries of posterior distributions for all parameters are presented in the text table above.

The median posterior estimate of 2008 abundance of 236 agrees well with the original estimate of 245. Mean daily acoustic encounter rates for 2011 and 2012 are respectively 0.693 and 0.645 (SC/65a/SM13). Hence, both *lambda* posterior estimates also show a reasonable fit.

CONCLUSIONS

It is reasonable to conclude that the vaquita population has continued to decline, and that current abundance is between 150 and 200 individuals, as inferred from inspection of the posterior distribution of *N13* shown in the figure below.



The best current estimate of vaquita abundance is about 189 individuals. As has been stated by CIRVA and the Scientific Committee of the International Whaling Commission, the only reliable approach for saving the species is to eliminate vaquita bycatch by removing entangling gear from areas where the animals occur. This is also in accordance with the agreements reached by the Advisory Commission of the Presidency of Mexico for the Recovery of the Vaquita.

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Appendix 4

BYCATCH OF SMALL CETACEANS FROM NATIONAL PROGRESS REPORTS

Data files are available on request from the Secretariat (*secretariat@iwc.int*).

Table 1

Bycatch of small cetaceans.

			Males				Females				Unknown												
Data year	Species	Large Area	Dead	Seriously injured	Injured	Unknown	Dead	Seriously injured	Injured	Unknown	Dead	Seriously injured	Injured	Unknown	RMP *Small Area*	Targeted species	Gear	How observed	Contacts	References	Comments	Local area	Local taxonomy
Australia																							
2012	Unid. small cetacean	Southern Ocean: Great Australian Bight	0	0	0	0	0	0	0	0	3	0	0	0	Unknown or N/A	Shark	[GNS] gillnets and entangling gear: set gillnets (anchored)	Fisherman	Clayton McCloud		*n*=1 on 14/01/12 at -37.29, 139.44 *n*=2 on 07/05/12 at -37.38, 140.06		
2012	Unid. small cetacean	Southern Ocean: Bass Strait	0	0	0	0	1	0	0	1	3	0	0	0	Unknown or N/A	Shark/ demersal scalefish	[GNS] gillnets and entangling gear: set gillnets (anchored) [OTB] trawls: beam trawl	Fisherman	Clayton McCloud		*n*=1 on 18/05/12 at -38.15, 148.52 *n*=1 on 26/06/12 at -37.59, 148.05 *n*=2 on 28/10/12 at -39.42, 144.10 *n*=1 on 16/11/12 at -40.05, 145.03		
2012	Common dolphin	Southern Ocean: Great Australian Bight	3	0	0	0	1	0	0	0	5	0	0	0	Unknown or N/A	Shark	[GNS] gillnets and entangling gear: set gillnets (anchored)	Fisherman	Clayton McCloud		*n*=1 on 15/01/12 at -33.52, 135.05 *n*=1 on 02/02/12 at -32.26, 133.33 *n*=1 on 02/07/12 at -33.47, 134.56 *n*=1 on 06/10/12 at -35.22, 136.40 *n*=1 on 17/10/12 at -35.23, 135.49 *n*=1 on 06/11/12 at -33.22, 134.29 *n*=1 on 27/11/12 at -33.32, 134.19 *n*=1 on 02/12/12 at -33.34, 134.32 *n*=1 on 13/12/12 at -33.22, 134.30		
2012	Common dolphin	Southern Ocean: Bass Strait	0	0	0	0	0	0	0	0	2	0	0	0	Unknown or N/A	Shark	[GNS] gillnets and entangling gear: set gillnets (anchored)	Fisherman	Clayton McCloud		*n*=1 on 03/7/12 at -38.18, 141.0 *n*=1 on 14/7/12 at -37.49, 149.11		
2012	Common dolphin	Indian Ocean: Timor Sea	0	0	0	0	0	0	0	0	2	0	0	0	Unknown or N/A	Prawns	[TM] trawls: shrimp trawls (not specified)	Fisherman	Clayton McCloud		*n*=1 on 10/09/12 at -13.67, 127.20 *n*=1 on 26/10/12 at -10.87, 132.38		
2012	Common bottlenose dolphin	Pacific Ocean: Tasman Sea	1	0	0	0	0	0	0	0	0	0	0	0	Unknown or N/A	Salmanoid aquaculture	[FWR] traps: barriers, fences, weirs, etc.	-	Rachael Alderman		Date: 25/01/12	Bruny Island, Tasmania	
2012	Common dolphin	Pacific Ocean: Tasman Sea	2	0	0	0	0	0	0	0	0	0	0	0	Unknown or N/A	Salmanoid aquaculture	[FWR] traps: barriers, fences, weirs, etc.	-	Rachael Alderman		Dates: 15/02/12, 26/02/12	Dover/ Police Point, Tas.	
2012	Common dolphin	Pacific Ocean: Coral Sea	6	0	0	0	2	0	0	0	0	0	0	0	Unknown or N/A	TWW	[NSC] shark control nets	Observer or inspector	Qld. Dept. of Agriculture, Fisheries and Forestry				
2012	Spinner dolphin	Pacific Ocean: Coral Sea	0	0	0	0	0	0	0	0	1	0	0	0	Unknown or N/A	TWW	[NSC] shark control nets	Observer or inspector	As above				
2012	Indo-Pacific humpback dolphin	Pacific Ocean: Coral Sea	0	0	0	0	0	0	0	0	1	0	0	1	Unknown or N/A	TWW	-	Observer or inspector	Qld Dept. of National Parks Recreation Sport and Racing				
2012	Common bottlenose dolphin	Pacific Ocean: Coral Sea	0	0	0	0	0	0	0	0	1	0	0	0	Unknown or N/A	Mackerel, sharks	[GN] gillnets and entangling gear - gillnets (not specified)	Fisherman					
2012	Common dolphin	Pacific Ocean: Tasman Sea	0	0	0	0	0	0	0	0	1	0	0	0	Unknown or N/A	Sharks	[NSC] shark control nets	Fisherman	Geoff Ross		Date: 16/04/12	Queenscliff	
2012	Common dolphin	Southern Ocean: Great Australian Bight	0	0	0	0	7	0	0	0	0	0	0	0	Unknown or N/A	SA sardine fishery/ unknown	[PS1] surrounding nets - 1-boat operated purse seines; [PS2] surrounding nets - 2-boat operated purse seines	Fisherman	Catherine Kemper		1 on 11/04/12 at 34°27'S, 136°15'E 2 on 12/04/12 at 34°40'S, 136°27'E 1 on 26/04/12 at 34°17'S, 136°22'E 1 on 10/06/12 at 33°02'35"S, 137°34'46"E 1 on 01/08/12 at 33°05'S, 137°32'E 1 on 23/11/12 at 35°27'17"S, 137°05'39"E		
2012	Indo-Pacific bottlenose dolphin	Southern Ocean: Great Australian Bight	1	0	0	0	7	0	0	2	0	0	0	1	Unknown or N/A	Kingfish aquaculture/ unknown	[NK] gear not known or not specified	Fisherman	Catherine Kemper		F: on 22/01/03 at 34°55'30"S, 137°21'30"E M: on 070/9/12 at 34°42'48"S, 135°54'18"E Unk: on 21/10/12 at 33°32'20"S, 137°35'35"E		

Data year	Species	Large Area	Males Dead	Males Seriously injured	Males Injured	Males Unknown	Females Dead	Females Seriously injured	Females Injured	Females Unknown	Unknown Dead	Unknown Seriously injured	Unknown Injured	Unknown Unknown	RMP *Small Area*	Targeted species	Gear	How observed	Contacts	References	Comments	Local area	Local taxonomy
Belgium																							
2012	Harbour porpoise	Atlantic Ocean: North Sea	5	0	0	0	9	0	0	0	1	0	0	0	Unknown or N/A	Flatfish and gadoids	[MIS] miscellaneous gear [GN] gillnets and entangling gear: gillnets (not specified)	Scientist Fisherman Public	Jan Haelters		The diet of harbour porpoises bycaught or washed ashore in Belgium, and relationship with relevant data from the strandings database. The total number of washed ashore (dead) harbour porpoises in 2012 was 97. Detailed data are not available yet, but at least 15 harbour porpoises had died due to bycatch in fishing gear. A large proportion of the stranded animals were in a condition not allowing to draw conclusions about the cause of death. Recreational set net fisheries on the beach were the source of part of the bycatch.	Belgian national waters	
Brazil																							
2012	Guiana dolphin	Atlantic Ocean: south	0	0	0	0	0	0	0	0	19	0	0	0	Unknown or N/A	*Mugil* sp., *Centropomus* sp., *Cynosciym* sp., *Anchoa* sp., micropogomias	[GN] gillnets and entangling gear: gillnets (not specified)	Scientist Fisherman	Aquasis; MAQUA - Universidade do Estado do Rio de Janeiro PCCB-UERN			Brazilian coast	
2012	Francis-cana	Atlantic Ocean: south	2	0	0	0	2	0	0	0	3	0	0	0	Unknown or N/A		[GN] gillnets and entangling gear: gillnets (not specified)	Scientist Fisherman	Museu de Zoologia Morgana Cirimbelli Gaidzinskiâ UNESC Projeto Bio-Pesca, SP				
Italy																							
2012	Risso's dolphin	Atlantic Ocean: Medi-terranean Sea	1	1	0	0	0	0	0	0	0	0	0	0	Unknown or N/A		[LLS] hooks and lines: set longlines	Scientist	Gaspare Buffa			Castel-lammare del Golfo, Sicily	
2012	Common bottlenose dolphin	Mediterranean Sea	0	0	0	0	2	0	0	0	0	0	0	0	Unknown or N/A		[PTM] midwater trawls: pair trawls	Scientist	Gaspare Buffa, Giuseppa Buscaino			Cape Gran-itola, W Sicily	
2012	Common bottlenose dolphin	Mediterranean Sea	0	0	0	0	2	0	0	0	2	0	0	0	Unknown or N/A		[NK] gear not known or not specified	Scientist Public					
2012	Striped dolphin	Mediterranean Sea	1	0	0	0	1	0	0	0	0	0	0	0	Unknown or N/A		[NK] gear not known or not specified	Scientist Public					
2012	Unid. small cetacean	Mediterranean Sea	1	0	0	0	0	0	0	0	0	0	0	0	Unknown or N/A		[NK] gear not known or not specified	Scientist Public					
2011	Common bottlenose dolphin	Mediterranean Sea	1	0	0	0	1	0	0	0	0	0	0	0	Unknown or N/A		[NK] gear not known or not specified	Scientist					
2011	Striped dolphin	Mediterranean Sea	2	0	0	0	1	0	0	0	0	0	0	0	Unknown or N/A		[NK] gear not known or not specified	Scientist Public					
2012	Common bottlenose dolphin	Atlantic Ocean: Adriatic Sea	1	0	0	0	0	0	0	0	0	0	0	0	Unknown or N/A	Anchovies	[PTM] midwater trawls: pair trawls	Scientist	Caterina Fortuna			GFCM GSA 17	Tusiope
2011	Common bottlenose dolphin	Adriatic Sea	2	0	0	0	0	0	0	0	1	0	0	0	Unknown or N/A	Anchovies	[PTM] midwater trawls: pair trawls	Scientist	Caterina Fortuna			GFCM GSA 17	Tursiope
2011	Common bottlenose dolphin	Atlantic Ocean: Tyrrhenian Sea	2	0	0	0	0	0	0	0	0	0	0	0	Unknown or N/A		[NK] gear not known or not specified; [GN] gillnets and entangling gear: gillnets (not specified)	Scientist	Bruno Diaz Lopez		2 calves (one entangled in gillnet and one in a line of a marine fin fish farm)	NE Sardinia	
2012	Common bottlenose dolphin	Tyrrhenian Sea	3	0	0	0	0	0	0	0	0	0	0	0	Unknown or N/A		[NSC] shark control nets; [NK] gear not known or not specified	Scientist	Bruno Diaz Lopez	Bottlenose dolphins and aquaculture: interaction and site fidelity on the NE coast of Sardinia	2 calves and one adult (dead carcases in a marine fin fish farm, 2 entangled in anti-predator nets of the fish farm)	NE Sardinia	

			Males				Females				Unknown												
Data year	Species	Large Area	Dead	Seriously injured	Injured	Unknown	Dead	Seriously injured	Injured	Unknown	Dead	Seriously injured	Injured	Unknown	RMP *Small Area*	Targeted species	Gear	How observed	Contacts	References	Comments	Local area	Local taxonomy
Republic of Korea																							
2012	Pacific white-sided dolphin	Pacific Ocean; Sea of Japan/ East Sea	14	0	0	0	7	0	0	0	7	0	0	0	Unknown or N/A		[LL] hooks and lines - longlines (not specified); [FIX] traps: traps (not specified); [GN] gillnets and entangling gear: gillnets (not specified); [TBB] trawls: bottom trawls	Fisherman					
2012	Short-finned pilot whale	Pacific Ocean; Sea of Japan/ East Sea	0	0	0	0	1	0	0	0	0	0	0	0	Unknown or N/A		[GN] gillnets and entangling gear: gillnets (not specified)	Fisherman					
2012	Harbour porpoise	Pacific Ocean; Sea of Japan/ East Sea	2	0	0	0	3	0	0	0	5	0	0	0	Unknown or N/A		[FIX] traps: traps (not specified); [FYK] traps: fyke nets; [GN] gillnets and entangling gear: gillnets (not specified)	Fisherman					
2012	Common bottlenose dolphin	Pacific Ocean; Sea of Japan/ East Sea	0	0	0	0	2	0	0	0	0	0	0	0	Unknown or N/A		[TBB] trawls: bottom trawls	Fisherman					
2012	Common bottlenose dolphin	Pacific Ocean; Yellow Sea	0	0	0	0	0	0	0	0	1	0	0	0	Unknown or N/A		[LL] hooks and lines: longlines (not specified)	Fisherman					
2012	Risso's dolphin	Pacific Ocean; Yellow Sea	0	0	0	0	0	0	0	0	1	0	0	0	Unknown or N/A		[FSN] traps: stow nets	Fisherman					
2012	Long-beaked common dolphin	Pacific Ocean; Sea of Japan/ East Sea	118	0	0	0	66	0	0	0	145	0	0	0	Unknown or N/A		[NK] gear not known or not specified; [FIX] traps: traps (not specified); [FYK] traps: fyke nets; [FPO] traps: pots; [GN] gillnets and entangling gear: gillnets (not specified)	Fisherman					
2012	Finless porpoise	Pacific Ocean; Yellow Sea	2	0	0	0	1	0	0	0	2050	0	0	0	Unknown or N/A		[NK] gear not known or not specified; [FSN] traps: stow nets; [GN] gillnets and entangling gear: gillnets (not specified)	Fisherman					
2012	Finless porpoise	Pacific Ocean; Sea of Japan/ East Sea	2	0	0	0	8	0	0	0	128	0	0	0	Unknown or N/A		[NK] gear not known or not specified; [FIX] traps: traps (not specified); [FSN] traps: stow nets; [FYK] traps :fyke nets; [GN] gillnets and entangling gear: gillnets (not specified); [TBB] trawls: bottom trawls	Fisherman					
New Zealand																							
2013	Common dolphin	Pacific Ocean: NZ	8	0	0	0	5	0	0	0	0	0	1	0	ES	Jack mackarel	[TM] midwater trawls: midwater trawls (not specified)	Observer or inspector					
2013	Long/short-finned pilot whale	Pacific Ocean: NZ	1	0	0	0	3	0	0	0	0	0	0	0	ES	Jack mackarel	[TM] midwater trawls: midwater trawls (not specified)	Observer or inspector					
2013	Maui's dolphin	Pacific Ocean: NZ	0	0	0	0	1	0	0	0	0	0	0	0	ES	Jack mackarel	[GNS] gillnets and entangling gear: set gillnets (anchored)	Fisherman					
2013	Hector's dolphin	Pacific Ocean: NZ	0	0	0	0	1	0	0	0	1	0	0	0	ES	Jack mackarel	[GNS] gillnets and entangling gear: set gillnets (anchored)	Fisherman; observer or inspector					

Data year	Species	Large Area	Males: Dead	Males: Seriously injured	Males: Injured	Males: Unknown	Females: Dead	Females: Seriously injured	Females: Injured	Females: Unknown	Unknown: Dead	Unknown: Seriously injured	Unknown: Injured	Unknown: Unknown	RMP *Small Area*	Targeted species	Gear	How observed	Contacts	References	Comments	Local area	Local taxonomy
Spain																							
2012	Common dolphin	Atlantic Ocean: north	0	0	0	0	2	0	0	0	0	0	0	0	Unknown or N/A		[OTB] trawls: beam trawl	Scientist Fisherman	CEMMA Jesas Santamarina Fernandez	Servizo Para O Segue-mento E Monitorizaciã Poboacional Dos Cetâceos E O Desen-volvemento Da Rede De Asistencia Aos Vara-mentos De Mamiferos E Reptiles Marinos En Galicia (Exp. 25/2012cn). Memoria Anual 2012		Galicia	
2012	Common bottlenose dolphin	Atlantic Ocean: north	0	0	0	0	1	0	0	0	0	0	0	0	Unknown or N/A			Scientist Fisherman	CEMMA Jesas Santamarina Fernandez	Servizo Para O Segue-mento E Monitorizaciã Poboacional Dos Cetâceos E O Desen-volvemento Da Rede De Asistencia Aos Vara-mentos De Mamiferos E Reptiles Marinos En Galicia (Exp. 25/2012cn). Memoria Anual 2012		Galicia	
2012	Common dolphin	Atlantic Ocean - Alboran Sea	0	0	0	0	1	0	0	0	0	0	0	0	Unknown or N/A		[GN] gillnets and entangling gear: gillnets (not specified)	Scientist					
2012	Common dolphin	Atlantic Ocean: north	1	0	0	0	1	0	0	0	0	0	0	0	Unknown or N/A		[GN] gillnets and entangling gear: gillnets (not specified)	Scientist				Gulf of Cadiz	
2012	Common bottlenose dolphin	Atlantic Ocean: north	0	0	0	0	1	0	0	0	0	0	0	0	Unknown or N/A		[NK] gear not known or not specified; [GN] gillnets and entang-ling gear: gillnets (not specified)	Scientist				Gulf of Cadiz	
UK																							
2013	Harbour porpoise	Atlantic Ocean: north	6	0	0	0	6	0	0	0	0	0	0	0	Unknown or N/A		[NK] gear not known or not specified	Scientist	Andrew Brownlow; Nick Davison; Robert Deaville		All cases diagnosed at necropsy of stranded animals		
2013	Common dolphin	Atlantic Ocean: north	4	0	0	0	1	0	0	0	0	0	0	0	Unknown or N/A		[NK] gear not known or not specified	Scientist	Robert Deaville		All diagnosed during necropsy of stranded animals		
USA																							
2010	Killer whale	Pacific Ocean: Bering Sea	0	0	0	0	0	0	0	0	1	0	0	0	ES		[TX] midwater trawls: other trawls (not specified)	Observer or inspector	Jeff Breiwick				
2012	Pygmy sperm whale	Atlantic Ocean: Gulf of Mexico	0	0	0	0	0	0	0	0	1	0	0	0	Unknown or N/A	Tuna/ swordfish	[LL] hooks and lines: longlines (not specified)	Observer or inspector	Lance Garrison				
2012	Long/short-finned pilot whale	Atlantic Ocean: north	0	0	0	0	0	0	0	0	0	3	0	0	Unknown or N/A	Tuna/ swordfish	[LX] hooks and lines: hooks and lines (not specified)	Observer or inspector	Lance Garrison				
2010	Atlantic white-sided dolphin	Atlantic Ocean: north	0	0	0	0	0	0	0	0	16	1	0	0	Unknown or N/A		[GNS] gillnets and entangling gear: set gillnets (anchored) [TBB] trawls: bottom trawls	Observer or inspector	Marjorie Rossman				
2010	Common dolphin	Atlantic Ocean: north	0	0	0	0	0	0	0	0	46	2	0	0	Unknown or N/A		[GNS] gillnets and entangling gear: set gillnets (anchored); [TBB] trawls: bottom trawls; [OT] midwater trawls: otter trawls (not specified)	Observer or inspector	Marjorie Rossman				
2010	Harbour porpoise	Atlantic Ocean: north	0	0	0	0	0	0	0	0	68	0	0	0	Unknown or N/A		[GNS] gillnets and entangling gear: set gillnets (anchored)	Observer or inspector	Marjorie Rossman				
2010	Common bottlenose dolphin	Atlantic Ocean - north	0	0	0	0	0	0	0	0	6	0	0	0	Unknown or N/A		[TBB] trawls: bottom trawls	Observer or inspector	Marjorie Rossman				
2010	Risso's dolphin	Atlantic Ocean: north	0	0	0	0	0	0	0	0	16	0	0	0	Unknown or N/A		[TBB] trawls: bottom trawls	Observer or inspector	Marjorie Rossman				
2010	Long/short-finned pilot whale	Atlantic Ocean: north	0	0	0	0	0	0	0	0	17	0	0	0	Unknown or N/A		[GNS] gillnets and entangling gear: set gillnets (anchored); [TBB] trawls: bottom trawls	Observer or inspector	Marjorie Rossman				

Data year	Species	Large Area	Males: Dead	Males: Seriously injured	Males: Injured	Males: Unknown	Females: Dead	Females: Seriously injured	Females: Injured	Females: Unknown	Unknown: Dead	Unknown: Seriously injured	Unknown: Injured	Unknown: Unknown	RMP *Small Area*	Targeted species	Gear	How observed	Contacts	References	Comments	Local area	Local taxonomy
USA cont.																							
2010	Unid. small cetacean	Atlantic Ocean: north	0	0	0	0	0	0	0	0	2	0	0	0	Unknown or N/A		[GNS] gillnets and entangling gear :set gillnets (anchored); [TM] midwater trawls: midwater trawls (not specified)	Observer or inspector	Marjorie Rossman				
2010	Atlantic spotted dolphin	Pacific Ocean: north	0	0	0	0	0	0	0	0	0	0	1	0	Unknown or N/A		[MIS] misc-ellaneous gear		Dera Look	Assistant Marine Mammal Response Coordinator	Animal reported off lighthouse by PWF vessel. No response mounted. Entanglement did not appear life threatening. 20.7219333333333 -156.971783333333	Lighthouse, Lanai	

Table 2

Directed catches of small cetaceans.

Data year	Species	Large Area	Females	Total landed	Struck and lost	RMP *Small Area*	Type of catch	Contacts	References	Comments	Local area	Local taxonomy
USA									-			
2012	White whale	Arctic Ocean - Beaufort Sea	0	92	0	Unknown or N/A	Aboriginal	Kathy Frost	-			
2012	White whale	Arctic Ocean - Chukchi Sea	0	52	0	Unknown or N/A	Aboriginal	Kathy Frost	-			
2012	White whale	Arctic Ocean - Bering Sea	0	201	0	Unknown or N/A	Aboriginal	Kathy Frost	-	E Bering=169; Kuskokwim=8; Bristol Bay=24.	E Bering, Kuskokwim, Bristol Bay	

Table 3

Ship strikes of small cetaceans.

Data year	Species	Large Area	Males: Dead	Males: Seriously injured	Males: Injured	Males: Unknown	Females: Dead	Females: Seriously injured	Females: Injured	Females: Unknown	Unknown: Dead	Unknown: Seriously injured	Unknown: Injured	Unknown: Unknown	RMP *Small Area*	Submitted to ship strikes	Contacts	References	Comments	Local area	Local taxonomy
Australia																					
2012	Pygmy sperm whale	Southern Ocean - Great Australian Bight	1	0	0	0	0	0	0	0	0	0	0	0	Unknown or N/A	Unknown	Catherine Kemper		Date: 15/10/12. Vessel type: unknown. Speed: unknown.	32km north of Streaky Bay, SA.	
Belgium																					
2012	Harbour porpoise	Atlantic Ocean - north	0	0	0	0	0	0	0	0	0	0	0	0	Unknown or N/A	No	Jan Haelters	References 1. -3.	Note 1.	Belgian national waters	
New Zealand																					
2013	Common bottlenose dolphin	Pacific Ocean; NZ	0	0	0	0	0	0	0	0	0	1	0	0	ES	Unknown	Karen Stockin				
Spain																					
2012	Common bottlenose dolphin	Atlantic Ocean; Mediterra-nean Sea	1	0	0	0	1	0	0	0	0	0	0	0	Unknown or N/A	No	Juan Antonio Raga; Juan Jimenez		2 independent cases of standings with clear signs of interaction with boats (fishing?): deep cuts, missing fins, or broken mandibles.		
2012	Striped dolphin		1	0	0	0	0	0	0	0	0	0	0	0					1 stranding with clear signs of interaction with boats (fishing?): broken mandible.		
UK																					
2013	Harbour porpoise	Atlantic Ocean - north	7	0	0	0	1	0	0	0	0	0	0	0	Unknown or N/A	No	Andrew Brownlow; Nick Davison; Robert Deaville		Ship strike cases, diagnosed at necropsy of stranded animals. Will be uploaded to ship strike database within fortnight.		

			Males				Females				Unknown										
Data year	Species	Large Area	Dead	Seriously injured	Injured	Unknown	Dead	Seriously injured	Injured	Unknown	Dead	Seriously injured	Injured	Unknown	RMP *Small Area*	Submitted to ship strikes	Contacts	References	Comments	Local area	Local taxonomy
USA																					
2011	Common bottlenose dolphin	Atlantic Ocean - north	1	0	0	0	2	0	0	0	1	0	0	0	Unknown or N/A	Unknown	Mendy Garron				
2011	Common bottlenose dolphin	Atlantic Ocean; Gulf of Mexico	2	0	1	0	1	0	0	0	0	0	0	0	Unknown or N/A	Unknown	Mendy Garron				

References 1.-3. Differentiating between underwater construction noise of monopile and jacket foundation wind turbines: a case study from the Belgian part of the North Sea. 2. Offshore windfarms in the Belgian part of the North Sea: heading for an understanding of environmental impacts. 3. The effect of pile driving on harbour porpoises in Belgian waters.

Note 1: Anthropogenic noise: to assess the impact of pile driving for the construction of the C-Power offshore wind farm (Thorntonbank, Belgian waters) on the spatial and temporal distribution of harbour porpoises, passive acoustic monitoring (PAM) was combined with aerial surveys. At the end of March 2011, just before construction activities started, aerial surveys yielded an estimate of on average 2.5 harbour porpoises/km² in Belgian waters. Density estimates in mid April 2011, after the start of the construction (piling) activities, had fallen to 1.3 animals/km². Although a decreasing density in Belgian waters towards the end of April should be considered as normal (*cf.* seasonal migration), changes in the spatial distribution between pre-and post-piling suggested harbour porpoise disturbance. PAM showed a clear fine-scale match between acoustic harbour porpoise detections and piling activities. Immediately upon the start of piling activities, harbour porpoise detections at a few km from the piling site fell to virtually zero. After the cessation of piling it took hours to days before new detections were made at this location. Aerial surveys allowed quantifying the distance over which an apparent impact occurred at around 22km, with a repopulation of part of the area observed after one day with no piling. These results are available at *www.mumm.ac.be*, and were presented at different meetings: ICES Annual Science Conference, Bergen, Norway, 17-21 September 2012; the Offshore Wind and Ecology Congress (OWEZ), Amsterdam, 11-12 October 2012; the symposium 'Protecting the Dutch whale - crossing boundaries', Amsterdam, 18 October 2012. Further studies are planned of the impact of the piling for another wind farm starting in spring 2013. The impact of military activities on the marine environment, including on marine mammals, was discussed. Reference: Degraer, S., Courtens, W., Derweduwen, J., Haelters, J., Hostens, K., Stienen, E. and Vandendriessche S. 2011. Discussienota structureel overleg Dienst Marien Milieu Defensie. Eindrapport in opdracht van de Federale Overheidsdienst Volksgezondheid, Veiligheid van de Voedselketen en Leefmilieu, Directoraat-generaal Leefmilieu. Brussels, Belgium. 51pp.

Table 4

Direct takes of small cetaceans in Japan by type of fishery and Prefecture of departure port, 1997 to 2011. Complied by Naoko Funahashi.

	Prefecture	Quota 2005/2006	Quota 2007/2008	Quota 2009/2010	Quota 2011/**201**	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	**2011**
Baird's beaked whale																				
SW	Hokkaido	14	14	14	14	1	2	10	10	10	10	10	10	14	12	14	13	14	14	**30**
SW	Miyagi+Chib	52	52	52	52	26/27	26/26	26/26	26/26	26/26	26/26	26/26	26/26	26/26	25/26	27/26	25/26	27/26	26/26	**5/26**
Short-fin pilot whale (northern form)																				
SW	Miyagi	36	36	36	36	50	35	60	50	47	47	42	13	22	7	-	-	-	-	**-**
Short-fin pilot whale (southern form)																				
SW	Chiba+Wakayama	36	36	36	36	5/22	3/46	13/31	7/49	4/36	1/35	-/27	-/29	1/24	-/10	-/16	-/20	-/22	-/10	**-/-**
D	Wakayama	300	277/254	230/207	184/**161**	204	84	211	109	210	55	55	62	40(2)	198(8)	243(5)	99(1)	219(1)	-	**74(6)**
H	Okinawa	100	92/85	77/69	61/**53**	66	61	79	89	92	38	36	72	90	56	79	62	54	34	**46**
Risso's dolphin																				
SW	Wakayama	20	20/	-	-	20	20	12	20	17	12	19	7	8	7	20				
D	Wakayama	300	295/290	285/280	275/**270**	60	157	250	367	350	220	186	437	340	232	312(8)	216(8)	336(8)	271(10)	**273(17)**
H	Wakayama	250	246/242	238/234	230/**226**	148	265	227	119	107	154	168	60	46	105	185	122	94	126	**104**
False killer whale																				
SW	Wakayama		-/20	20	20											-	-	-	-	**-**
D	Shizuoka		10	10	10				-	-	-	-	-	-	-	-	-	-	-	**-**
D	Wakayama	40	70	70	70	25	37	-	-	18	7	12	-	-	30(24)	-	-	-	-	**17(10)**
H	Okinawa	10	20	20	20	3	8	5	8	8	-	4	3	1	5	4	5	1	-	**3**
Striped dolphin																				
D	Shizuoka	70	63/56	49/42	35/**28**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
D	Wakayama	450	450	450	450	545	376	520	235	418	565	382	554	397(2)	479	384	535(5)	321	458(2)	**406(8)**
H	Chiba	80	72/64	56/48	40/**32**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
H	Wakayama	100	100	100	100	57	73	76	65	66	77	68	83	60	36	86	65	98	100	**96**

Cont.

	Prefecture	Quota 2005/2006	Quota 2007/2008	Quota 2009/2010	Quota 2011/**201**	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	**2011**
Bottlenose dolphin																				
D	Shizuoka	75	71/67	63/59	55/**51**	-	-	71	-	-	-	-	9	-	-	-	-	-	-	**-**
D	Wakayama	890	842/795	747/700	652/**604**	234	143	511	1,271	195	688	105	475	285(36)	285(80)	300(77)	297(57)	352(98)	395(168)	**76(25)**
H	Wakayama	100	95/89	84/79	73/**68**	57	95	68	79	44	38	52	43	66	75	97	93	77	38	**40**
H	Okinawa	10	9	8	7	8	7	8	8	8	3	7	10	10	12	4	1	4	1	**3**
Spotted dolphin																				
D	Shizuoka	455	409/365	318/272	227/**181**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
D	Wakayama	400	400	400	400	-	397	-	27	-	400	102	-	-	400(13)	-	329(6)	-	125(16)	**106(2)**
H	Wakayama	70	70	70	70	23	63	38	12	10	18	30	2	13	5	16	-	3	7	**2**
White-sided dolphin																				
D	Shizuoka		36	36	36											-	-	-	-	-
D	Wakayama		134	134	134											-	21(16)	14(13)	27(17)	**24(21)**
H	Iwate		154	154	154											-	-	-	-	**-**
H	Wakayama		36	36	36											-	-	7	-	**-**
Dall's porpoise (Dalli type)																				
H	Hokkaido	1,500	1,451/1,399	1,348/1,296	1,244/**1,192**	999	994	670	1,203	1,413	1,328	1,655	647	1,240	719	841	467	308	116	**-**
H	Aomori	20	18/16	14/12	10/8	2	-	-	-	-	-	-	-	-	-	-	-	-	-	**-**
H	Iwate	7,200	6,969/6,721	6,472/6,225	5,975/**5,726**	7,433	4,116	5,632	6,106	6,960	6,057	6,427	3,796	5,394	3,312	2,975	1,947	1,362	1,140	**89**
H	Miyagi	280	269/260	250/241	231/**221**	99	193	77	204	57	229	226	171	246	181	254	180	103	-	**-**
Dall's porpoise (Truei type)																				
H	Hokkaido	100	98/95	92/89	86/**83**	31	69	57	69	100	89	84	66	51	44	44	66	-	2	**-**
H	Iwate	8,300	8,054/7,805	7,557/7,108	6,860/**6,611**	9,976	6,013	8,371	8,589	8,120	8,243	7,325	9,109	7,733	7,758	7,243	4,566	7,767	3,532	**1,855**
H	Miyagi	20	16	215	214	-	-	-	-	-	3	3	-	-	-	-	-	-	129	**8**
Rough toothed dolphin																				
H	Okinawa		-	-		-	-	1	-	-	-	-	-	-	-					
Killer whale																				
H	Okinawa		-	-		1	-	-	-	-	-	-	-	-	-					

Key: (N) shows number sold alive from all catches, including research use. SW = Small-type whaling. D = drive fishery. H = hand-harpoon fishery.

Note: It was found out that there are mistakes on the types of Dall's porpoise recorded from the hand harpoon hunting in Miyagi Prefecture statistics in the past, and the Prefecture concerned is investigating now. It is planned that statistics will be corrected after the investigation is completed, retroactively to the past. (Japan Progrep. SM/2010J).

Sources: Small Cetacean Fisheries and Resource Study (in Japanese), Fisheries Research Agency: *http://kokushi.job.affrc.go.jp/H19/H19/H19_45.pdf*; *http://kokushi.job.affrc.go.jp/H20/H20_45.pdf*; *http://kokushi.job.affrc.go.jp/H21/H21_45.pdf* ; *http://kokushi.job.affrc.go.jp/H22/H22_45.pdf* ; *http://kokushi.job.affrc.go.jp/H23/H23_45.pdf*; *http://kokushi.job.affrc.go.jp/H24/H24_45.pdf* : Iwasaki, T. 2012. Progress report on small cetacean research April 2010 to March 2011, with statistical data for the calendar year 2010. Japan Fisheries Agency: *http://www.jfa.maff.go.jp/j/whale/w_document/pdf/120516_progress_report.pdf*.

Appendix 5

PROPOSAL FOR A SYMPOSIUM AND WORKSHOP ON THE ISSUE OF ‘MARINE BUSHMEAT’: CHANGING PATTERNS OF SMALL CETACEAN EXPLOITATION: THE EMERGING THREAT OF ‘MARINE BUSHMEAT’

Baker, Brownell, Cerchio, Reeves, Ritter, Scheidat, Simmonds

BACKGROUND

Bycatch of small cetaceans in some artisanal and small scale commercial fisheries has evolved into non-targeted catch that is consumed and, further, into directed catch in a number of less developed regions around the world. The resulting takes can be large and are almost certainly unsustainable in many instances although the exploited populations have not been assessed to determine catch levels that they could support. These emerging situations are a cause of great concern for affected cetacean populations.

The subject of ‘poorly documented hunts of small cetaceans for food, bait or cash’ (IWC, 2013); often called ‘marine bushmeat’) had been suggested at IWC/62 as a future priority topic, and accordingly an intersessional correspondence group was set up during IWC/63. After IWC/63, the Group’s work focused on further defining the scope of the issue, identifying researchers/groups working in this field and compiling a provisional list of cases worldwide. During SC/64, a steering group was formed to plan for an IWC Workshop on the issue. It is now proposed to hold a one day open symposium followed by a two day Workshop in 2014, and the current state of the planning is summarised below.

THE EVENT

The issue has been made a standing item on the agenda of the small cetaceans sub-committee as a sub-item under the agenda item ‘Takes of small cetaceans’. We now envision a meeting of experts, as a pre-meeting event at IWC SC/65b. Key researchers from different areas around the world (see draft list of participants below) should be invited, and the meeting should be organised to build up on similar meetings/sessions already held during previous conferences, workshops etc.

Objectives

Objectives for the event and for future research include the following:
- case studies: detailed analyses of the situations in Africa, Madagascar, Southeast Asia and Sri Lanka, where bycatch is evolving (or has evolved) into human consumption and directed takes;
- identifying driving forces behind increasing use of cetacean meat;
- development of management strategies for addressing the issue, including e.g. capacity building, education, and improved monitoring to address threats to local populations; and
- identifying emerging diseases in cetaceans and the threat of transmission to humans and domestic animals (zoonoses).

Organisation

Salvatore Cerchio (working in Madagascar with Wildlife Conservation Society, WCS) was identified as the Convenor of the Steering Group. Other members of the Steering Group are Baker, Brownell, Reeves, Ritter, Scheidat and Simmonds.

The event will consist of a one day open symposium (by registration) followed by a two day Workshop prior to the next Scientific Committee meeting in 2014.

DRAFT PARTICIPANT LIST

The following experts were identified as potential invited participants. A total of around 40 participants is envisaged.

Isidore Ayissi	Cameroon
Scott Baker	USA
Robert Baldwin	Oman
Idriss Bamy	Guinea-Bissau
Sarah Baulch	UK
Gill Braulik	Tanzania
Robert Brownell	USA
Salvatore Cerchio	Madagascar
Tim Collins	Gabon, Congo, Angola
Greg Donovan	IWC
Josea Dossou-Bodjrenou	Benin
Anouk Ilangakoon	Sri Lanka
Aristide Kamla	Cameroon
Jeremy Kiszka	France/Comores
Jeff Moore	USA
Putu Liza Mustika	Indonesia
Patrick Ofori Danson	Ghana
Marc Oremus	New Caledonia
Chris Parsons	UK/USA
Bill Perrin	USA
Louisa Ponnampalam	Malaysia
Lindsay Porter	Hong Kong
Andrew Read	USA
Randall Reeves	Canada
Fabian Ritter	Belgium
Martin Robards	USA
Howard Rosenbaum	USA
Gabriel Segniagbeto	Togo
Mark Simmonds	UK
Brian Smith	Bangladesh
Michael Uwagbae	Nigeria
Koen van Waerebeek	Peru

Other expertise to be identified:

- Zoonoses;
- terrestrial bushmeat; and
- socio-economic drivers.

DRAFT AGENDA

Day 1: Symposium

Overview

- Types (e.g. hunts, non-directed and 'directed' bycatch).
- Assessment methods (e.g. direct observations, interview surveys, market surveys).
- Threats to cetacean populations.
- Threat of zoonosis.
- Drivers.

Case studies

- Africa (e.g. Republic of Congo, Cameroon, Ghana, Togo).
- Southeast Asia (e.g. Indonesia).
- Sri Lanka.
- Madagascar.

What can be done?

- Conservation
- Management options

Conclusion and discussion

Days 2 and 3: Workshop

(i) Introductions and background to the Workshop
(ii) Appointment of chair and rapporteurs and other meeting arrangements
(iii) Review of Agenda
(iv) Reporting/reviewing plans and procedures

1. Background
   1.1 Use of the term 'marine bushmeat'
   1.2 Definition of scope
2. Driving forces
   2.1 Overfishing (local artisanal *vs* foreign industrial etc.)
   2.2 Subsistence/poverty/human demographic change and growth
   2.3 Economics
      2.3.1 (Expanding) markets for small cetacean meat (primary and secondary consumption)
      2.3.2 Other (expanding) markets for small cetacean meat and products
3. Impacts on cetacean populations
   3.1 Removal rates
   3.2 Review of what is known of relevant population sizes and statuses
   3.3 Other related issues, including stress and injury
   3.4 Cumulative effects/synergies with other known threats
4. Threat of zoonosis
   4.1 Potential disease transfer to humans
   4.2 Potential disease transfer to domestic animals
5. Management options
   5.1 Existing legislation and regulation
   5.2 Management/conservation objectives
   5.3 Monitoring options
   5.4 Capacity building (education, local management)
   5.5 Co-operation with other international bodies/agreements
   5.6 Alternative livelihoods
6. Knowledge gaps and research needs
   6.1 Identifying research needs to investigate impacts on small cetaceans
   6.2 Identifying research needs to inform mitigation and management
   6.3 Summary, action points and conclusions

Draft budget for 'Marine Bushmeat' conference

Draft budget for 'marine bushmeat' conference.

Item	Flight	Other travel	No. nights	Hotel (£100/d)	Per diem £55/d	Sub-total per person	Sub-total
IP costs	£700	£100	3	£300	£165	1,265x40	£50,600
Coffee breaks (£10/day/person)							£1,200
Total							**£51,800**

REFERENCE

International Whaling Commission. 2013. Report of the Scientific Committee. Annex L. Report of the Sub-Committee on Small Cetaceans. *J. Cetacean Res. Manage. (Suppl.)* 14:273-317.

Annex M

Report of the Sub-Committee on Whalewatching

Members: Urbán (Chair), Carlson (co-Chair), An, Back, Childerhouse, Chilvers, Chung, Currey, Funahashi, Gallego, Galletti, Heyliger, Holm, Hung, Iñíguez, Kato, Kaufman, Kim, Luna, Márquez, Marzari, Moon, Nelson, New, Parsons, Perkins, Robbins, Rodríguez, Rojas-Bracho, Rose, Ritter, Santos, Scheidat, Schweizer, Simmonds, Stachowitsch, Williams, Willson.

1. OPENING REMARKS

Urbán welcomed members of the sub-committee and noted the priority items identified by the Scientific Committee:

(1) assess the impacts of whalewatching on cetaceans (methods and results of changes in behaviour and movement patterns; methods and results of physiological changes to individuals; and methods and results of demographic and distributional changes); and
(2) review whalewatching in the Republic of Korea.

In addition, the following items were identified:

(1) review reports from Intersessional Working Groups: large-scale whalewatching experiment (LaWE) steering group; LaWE budget development group; swim-with-whale operations; in-water interactions; and guiding principles development;
(2) review scientific aspects of the Commission's Five-Year Strategic Plan for Whalewatching;
(3) receive a report of the IWC whalewatch operator's workshop in Brisbane;
(4) consider information from platforms of opportunity of potential value to the Scientific Committee;
(5) review whalewatching guidelines and regulations;
(6) review collision risks to cetaceans from whalewatching vessel;
(7) update information on swim-with-whale operations;
(8) provide information on the emerging whalewatching industry in Oman;
(9) assess whalewatching carrying capacity; and
(10) discuss input to the IWC Conservation Management Plans.

2. ELECTION OF CHAIR AND APPOINTMENT OF RAPPORTEURS

Urbán was elected Chair, Carlson was elected Co-chair, and Rose was appointed rapporteur.

3. ADOPTION OF AGENDA

The adopted Agenda is given as Appendix 1.

4. REVIEW OF AVAILABLE DOCUMENTS

The documents available to the sub-committee were identified as: SC/65a/WW01, SC/65a/WW03-05, SC/65a/SH25, SC/65a/SM15, Denkinger *et al.* (2013), Neilson *et al.* (2012) and Parsons (2012).

5. ASSESS THE IMPACTS OF WHALEWATCHING ON CETACEANS

At SC/56, the sub-committee noted that much research on whalewatching was published each year of direct relevance to the work of the sub-committee. The sub-committee agreed that a summary report or digest of published whalewatching research, for information without discussion, would be useful, particularly in highlighting new or useful methodologies of interest to the sub-committee. Parsons was asked to collate the material for presentation on an annual basis. SC/65a/WW01 summarised four papers addressing the impacts of whalewatching on cetaceans.

Peters *et al.* (2013) documented the effects of swim-with-dolphin tourism on the behaviour of the little studied burrunan dolphin (*Tursiops australis*) in south Australia. Transitions in dolphin group behaviour were analysed using first-order Markov chains. Activity budgets were compared: (a) before vessel/swimmer encounters; (b) during encounters; and (c) after encounters. Feeding activity significantly increased after encounters and milling activity increased during encounters. Group cohesion did not significantly fluctuate, but large groups were more likely to approach swimmers than vessels and the reverse response was true for small groups. The behavioural budgets of dolphins failed to return to pre-encounter levels, indicating that this single swim-with-dolphin vessel had an impact on the dolphins' behaviour. The authors concluded that the increase in milling behaviour during encounters could compromise feeding, socialising and resting behaviour and, in turn, have longer term consequences for the fitness of the population.

Tourism in Kaikoura, New Zealand, has experienced rapid growth since its onset in the 1980s. Tourists here have the opportunity to 'watch' or 'swim with' the local population of dusky dolphins (*Lagenorhynchus obscurus*). Lundquist *et al.* (2012) tried to estimate the potential impact that this tourism may have on these dolphins, to ensure timely and effective management. Markov chain models were used to determine whether dolphin behaviour changed due to the presence of tourism vessels. In the presence of a vessel, milling increased in all seasons apart from autumn, whilst resting and traveling decreased. Responses of dolphins to vessels were also dependent on time of day, with resting behaviour decreasing, whilst traveling increased, in the afternoon. The authors expressed concerns that behavioural changes may translate to reduced fitness due to the interruption of critical behaviours.

Dans *et al.* (2012) also used Markov chain analysis to investigate changes in behavioural budget of dusky dolphins in Golfo Nuevo, Patagonia, Argentina. Over 100,000 people visit the area to watch southern right whales (*Eubalaena australis*), but in 1997 commercial dolphin watching also began in the area. The authors tried to determine which changes in dolphin behaviour would have the biggest effect on the dolphins' feeding budget and the time it would take before the dolphins would return to feeding after disturbance. They stated that '[o]*ur most important finding was that feeding time budget* [sic] *was modified when boats interfered* [sic] *with the transition from feeding to traveling and from traveling to feeding*' (p. 714). It took on average 10 minutes for the dolphins to return to feeding. The authors noted that dolphin-watching operators frequently approached traveling dolphins more closely in order to encourage them to leap out of the water. The authors suggested that local whalewatching guidelines should have a maximum time for close (<50m) approaches.

The southern resident population of killer whales (*Orcinus orca*) (SRKW) on the west coast of the USA and Canada was listed as endangered in 2003 (Canada) and 2005 (USA). Ayres *et al.* (2013) collected data on thyroid (T3) and glucocorticoid (GC) hormone levels from the faeces of killer whales to assess whether the SRKW population has declined due to shortage of Chinook salmon (*Oncorhynchus tshawytscha*) (the SRKW's main prey in summer) or due to an increase in vessel traffic around the cetaceans, which reduces their ability to forage and increases psychological stress. Faecal hormones levels were compared to temporal changes in Chinook salmon and vessel traffic across a three-year period. The pairing of the GC and T3 markers provides an insight into both the psychological and nutritional stress experienced by SRKWs; i.e. GC level will increase with both nutritional and psychological stress, whereas T3 hormone level will drop in response to nutritional stress (it does not alter with psychological stress). The hormone level analysis supported the inadequate prey hypothesis and not the vessel traffic impact hypothesis.

The sub-committee noted that hormone analysis, using faecal and blow sampling, was a potentially valuable methodology for examining impacts of whalewatching and could be transferable to other cetacean populations to investigate and evaluate these impacts. Urbán reported that faecal samples are being collected from blue whales (*Balaenoptera musculus*) in Mexico to determine reproductive status of females, but stress hormone levels could be measured as well. A study of right whales (Rolland *et al.*, 2012) has utilised blow sampling to measure GC hormone levels as a measure of stress due to shipping. Robbins reported that both blow and faecal sampling is on-going with humpback whales (*Megaptera novaeangliae*) off the north Atlantic coast of the USA and stress in relation to the presence of whalewatching vessels could be studied, but she noted that it is very difficult to collect humpback faecal samples. The faeces sink quickly, making collection even when directly on top of the defecating whale difficult. Others noted the difficulty of blow sampling with dolphins and that the close approaches required may induce stress, but sampling bow-riding dolphins might be possible. This method is being tested in Commerson's dolphins (*Cephalorhynchus commersonii*) in Argentina and Iñiguez said he would report on progress at SC/65b.

Clearly the efficacy of these methods would be species-specific; in addition, some groups of animals, such as 'curious' whales, might be easier to sample (and show less stress related to the actual collection). Certain examples of this – curious humpback whales in Hervey Bay, Australia, and dwarf minke whales on the Great Barrier Reef – might provide baseline data, but some members urged caution about sampling 'curious' whales, as they may not be representative of the larger population. It was suggested that a third methodology to measure stress responses is tagging, with tags that can monitor heart rates (a metric used to measure stress in captive cetaceans, (e.g. Lyamin *et al.*, 2011). The impact of research vessels (for all these sampling methods) can be significant and a good experimental design is needed to control for this.

Measuring stress with the various methods above show great potential in the study of whalewatching impacts and it was suggested that the sub-committee could work with the Standing Working Group on Environmental Concerns to hold a joint workshop on stress responses related to vessel presence and shipping noise. It was noted that blow sampling is still a developing methodology, whereas faecal sampling is more advanced. It also was noted that in some areas where whalewatching impacts are of interest, faecal sampling is not possible, such as eastern north Pacific gray whales (*Eschrichtius robustus*), which are on their breeding grounds when targeted by whalewatching and are therefore neither feeding nor defecating; however, blow sampling in this population would be relatively easy. The sub-committee invites papers to be submitted next year on the use of faecal and blow sampling to measure stress hormones in relation to whalewatching, as well as in relation to other stressors where the methodology could be applied to whalewatching.

New provided a brief update on the mathematical models for the behavioural, social and spatial interactions of bottlenose dolphins first described in New *et al.* (2012). Questions had been raised regarding the incorporation of ecological and geographical features, as well as the model's ability to account for the behaviour of different vessel types. The model was adapted to incorporate these features, and has the potential to be used to assess the relative impact of different vessel types, as well as their cumulative effects.

The sub-committee thanked New for this update. The effect of habituation/tolerance on analyses of impacts was emphasised; the continued presence of some animals does not mean there is no impact. Also, for high-intensity noise sources, there may be complicated zones of impact (e.g. interference can cause sound troughs/shadows). Animals near a sound source may be in sound shadows – again, their presence close to a sound source does not necessarily mean there is no impact (Parsons, 2012). One member also noted that sound can propagate vertically rather than horizontally and may affect prey at depth. Lower intensity shipping noise might be easier to model. Also, it was noted that animals may avoid noise vertically rather than horizontally and that animals may be attracted to vessels. New responded that the model is an individual-based model, so it can be modified to assess risk-attracted animals, for example, differently from risk-averse animals. The model also simplifies situations deliberately because of complications of sound propagation. Whalewatching studies can offer empirical data to ground-truth the model's assumptions and New noted that the model is being tested in Doubtful Sound and Moray Firth. Site specific issues need to be factored in (some areas are less complex acoustically than others) and it may be best to model worst-case scenarios for management purposes.

6. REVIEW WHALEWATCHING IN THE REPUBLIC OF KOREA

Jangsaengpo in Ulsan was a landing station for commercial whaling from the late 19th century to 1986. In 2009, the municipal government started a whalewatching program to satisfy a growing demand to experience wild animals. A retired research vessel (about 300 gross tonnes) was refitted for whalewatching and launched in April 2009. The season was April to October and the number of days of operation each season ranged from 72 to 96 days. The encounter rate was very low in 2009 and 2011, but relatively high in 2010 and 2012. The most frequently encountered species was long-beaked common dolphins (*Delphinus capensis*) 58,500 individuals were seen in 42 sightings. Forty-seven common minke whales (*B. acutorostrata)*, 1,900 Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), a mixed group of false killer whales (*Pseudorca crassidens*) and common bottlenose dolphins (*T. truncatus*), and three finless porpoises (*Neophocaena phocaenoides*) also were encountered. Tourism numbers increased from 3,512 in 2009 to 8,738 in 2012 and it is expected to be 20,000 in 2013 as there is now a new vessel (550 gross tonnes).

Local government and tourism companies on Jeju Island investigated the possibility of operating dolphin-watching excursions around the island. There is a small, resident population of *T. aduncus* in these waters (see Annex L, Item 6.2). However, the Ministry of Oceans and Fisheries advised these entities not to develop boat-based dolphin-watching due to the small size of the bottlenose dolphin population, which was designated a protected species in 2012.

The sub-committee thanked An for this review. It was noted that some Korean researchers and non-governmental organisations (Song, 2013) considered Jeju an excellent location to establish a dolphin-watching industry. However, work presented to the sub-committee on small cetaceans (see Annex L, Item 6.2) clarified that the Jeju dolphin population is small and resident. Given this, the local government has decided to pursue land-based dolphin-watching only and to prohibit boat-based dolphin watching for the time being. The sub-committee **commended** the Jeju authorities and the Ministry of Oceans and Fisheries for this precautionary approach. It **recommended** that research be continued on the bottlenose dolphin population of Jeju, to provide strong baseline information prior to boat-based dolphin-watching ever beginning here.

Song (2013) also identified Pohang and the Yellow Sea coast as two other possible locations to develop whalewatching. An felt the Yellow Sea was not suitable for cetacean watching, as only finless porpoises and minke whales were observed there and transit time to their core sighting area was 3-4 hours. However, there are spotted seals nearer to shore, so pinniped (and other marine wildlife) viewing could develop. He felt Pohang was in fact the best location for whalewatching, as there were many sightings of several species of cetaceans, but unlike Ulsan, there is no infrastructure.

In response, it was noted that the Yellow Sea location appeared to be much like Scotland, which had a robust whalewatching industry. Regarding Pohang, lack of infrastructure could be an attraction to ecotourists and therefore should not rule out this location for whalewatching. Nevertheless, several members urged a precautionary approach to whalewatching management in Korea, given the early stages of its development. It was noted that there is no code of conduct for whalewatching in Korea, as there is at present only one vessel and it is operated by local government. Guidelines are being developed and the sub-committee referred An to the Commission's guiding principles and the compendium of whalewatching guidelines and regulations.

It was noted that Ulsan, given the early stages of its whalewatching development, may be a suitable location for a study under the Modelling and Assessment of Whalewatching Impacts project (see Item 7.1).

7. REVIEW REPORTS FROM INTERSESSIONAL WORKING GROUPS

7.1 Large-scale Whalewatching Experiment (LaWE) Steering Group

There was no intersessional communication or formal update on LaWE submitted to SC/65a. Consequently the sub-committee **agreed** to re-evaluate the project.

The primary objectives of LaWE were to assess the population-level impacts of whalewatching and determine the effectiveness of suggested mitigation measures in avoiding any potential negative effects of the activity. These objectives remain relevant to the work of the sub-committee; it is important that research addressing these objectives continues.

The sub-committee **agreed** to establish a new intersessional working group, with New as Convenor, tasked with developing a revised work plan to move forward with this project, now named the Modelling and Assessment of Whalewatching Impacts (MAWI), which will seek to build on what was learned in LaWE (see Table 1). In time for SC/65b, the group, using the 5-Year Strategic Plan research objectives and actions as guidance, will seek to define the specific research questions and hypotheses that will most benefit understanding of the impact of whalewatching, identify those whalewatching locations that would be suitable and amenable for targeted studies addressing these questions, and summarise the current modelling tools available to analyse the data that will be collected. Once these issues have been addressed, it will be possible to identify a timeline, benchmarks, budgets and any additional resource or support needs.

7.2 LaWE budget development group

This item was not discussed, as there was no intersessional communication with this working group.

7.3 Swim-with-whale operations

At previous meetings, summarised results of a web search on swim-with-whale operations were presented, along with a draft of a questionnaire for swim-with operators, in order to collect more detailed information (Rose *et al.*, 2003; 2005; 2007). The questionnaire was successfully beta-tested in the Dominican Republic in early 2012 (IWC, 2013, p.321). In May 2013, the questionnaire was distributed to operators in two other locations – Tonga and New Caledonia. The first respondent sent in a completed questionnaire on 3 June 2013, from Tonga. The intersessional group will continue (see Table 1) and will present a summary of results from these surveys at SC/65b.

7.4 In-water interactions

Ritter reported that the intersessional group was largely inactive since last year. However, several members of the group were involved in a scientific study conducted in October 2012 off La Gomera (Canary Islands), where in-water interactions with different small cetacean species were examined. During experimental in-water encounters, specific behaviours exhibited by the animals were observed, recorded and videotaped. The intersessional group will continue (see Table 1) and will present results from this study at SC/65b.

7.5 Guiding principles development

SC/65a/WW03 presented the work of the Intersessional Working Group on Guiding Principles Development. The

Table 1

Intersessional Working Groups and related information.

Group	Terms of reference	Membership
Modelling and Assessment of Whalewatching Impacts (MAWI): Steering Group	Define specific research questions and hypotheses that will benefit understanding of the impact of whalewatching, identify those whalewatching locations that would be most suitable and amenable for targeted studies addressing these questions, and summarise the current modelling tools available to analyse the data that will be collected.	New (Convenor), Carlson, Cook, Kaufman, Leaper, Parsons, Ritter, Robbins, Rose, Simmonds.
Background Document for Guiding Principles	Draft a document explaining origin and evolution of guiding principles, i.e. whether they arose from research and/or 'best practice'.	Carlson (Convenor), Kaufman, Ritter, Rose.
Five-Year Strategic Plan Whalewatching Handbook	Develop work plan and collate information for assisting Commission's Standing Working Group on Whalewatching to draft the Whalewatching Handbook.	Rojas-Bracho (Convenor), Carlson, Iñíguez, Kaufman, Luna, Parsons, Ritter.
Swim-with-whale Operations	Assess the extent and potential impact of swim-with-whale operations.	Rose (Convenor), Kaufman, Parsons, Ritter, Sironi.
In-water Interactions	Identify and investigate potentially dangerous recreational interactions between free-ranging cetaceans and people in the water, emphasising the extent of the problem and research on behavioural 'warning indicators'; identify research gaps and summarise information.	Ritter (Convenor), Gero, Parsons, Rose, Scheer, Simmonds, Vermeulen.

draft guiding principles were developed and expanded by the group per Action 1.1 of the Commission's Five-Year Strategic Plan for Whalewatching. The principles include general management considerations and guidelines for cetacean watching and were developed from Annex VI of the Report of the Regional Workshop on Marine Mammal Watching in the Wider Caribbean Region (Anon., 2011) and the General Principles for Whalewatching developed by the Scientific Committee at the 1994 Commission meeting (IWC, 1997). In discussion, it was noted that these guiding principles will guide the development of the Commission's Five-Year Strategic Plan for Whalewatching Handbook, so it is not only a product of the sub-committee, but of the Commission. These guidelines will have wide ramifications and will influence global development of whalewatching.

In discussion it was noted that there are two stages of a whalewatching industry – developing (new) and developed (mature). The guiding principles should be useful to stakeholders at both stages. The guiding principles should also be broad enough to cover target species that range from critically endangered to abundant. The sub-committee **agreed** to develop a 'background document' to annotate the guiding principles, with an explanation of their origin and evolution, as well as definitions of terms and other explanatory background (which might include illustrations of descriptive content). The intersessional working group will work on this document and present a draft at SC/65b (see Table 1).

The lack of resources for training workshops in various countries was also mentioned. In response, it was noted that that Five-Year Strategic Plan for Whalewatching Handbook will contain a resource guide, with contact information for various funding sources. Finally it was suggested that the guiding principles, which will be available on the Commission website, should be prefaced by language clarifying that the guidelines do not supersede local legislation or regulations.

The sub-committee **agreed** to these guiding principles and the final version of the guiding principles is attached as Appendix 2.

8. OTHER ISSUES

8.1 Review scientific aspects of the Commission's Five-Year Strategic Plan for Whalewatching

The sub-committee reviewed elements of the Five-Year Strategic Plan for Whalewatching and the Commission's Whalewatching Handbook relevant to its work. Objective 1, Research, details three action items tasked to the sub-committee.

1.1 Develop (and/or review), pending further comprehensive scientific research and assessment (refer to action 1.3), guiding principles to be followed in whalewatching operations including swim with and provisioning programs to minimise potential adverse impacts.

1.2 Identify data deficient and critically endangered populations likely to be subject to whalewatching. Develop precautionary guidance and advice on additional mitigation measures that may be required for whalewatching operations on such populations.

1.3 Consider an integrated research program (a form of long term experiment) to better understand the potential impacts of whalewatching on the demographic parameters of cetacean populations. Seek to:
- demonstrate a causal relationship between whalewatching exposure and the survival and vital rates of exposed cetacean individuals;
- understand the mechanisms involved in causal effects, if they exist, in order to define a framework for improved management; and
- establish standard methodologies for the conduct of assessments.

Action Item 1.1 is addressed in SC/65a/WW03 and Parsons agreed to collate data for Action Item 1.2 and report to the sub-committee at SC/65b. The sub-committee noted that the MAWI intersessional working group will address action item 1.3, with New as Convenor (see Table 1 and Item 7.1).

8.2 Report of 2013 IWC Whalewatch Operator's Workshop

Carlson reported on the Whalewatch Operator's Workshop held in Brisbane, Australia on 24-25 May 2013. The workshop was funded by the Governments of Australia and the USA. The main objective of the Workshop, attended by over 60 representatives of industry, science and government, was to get input from operators and industry representatives for the web-based Whalewatching Handbook to be posted on the Commission's website, with continued oversight by the Commission's Standing Working Group on Whalewatching and an on-going and iterative monitoring, evaluation and review of the Five-Year Strategic Plan for Whalewatching. In addition, the Workshop sought to help the Commission understand what role it can play in identifying and promoting 'best practises' and responsible whalewatching, what the industry might like to see or have in an online Whalewatching Handbook, actions in the plan that might require further engagement with industry and how to continue to integrate work at the Commission with industry expertise.

The participants, relative to the work of the sub-committee, requested that the Handbook include the development of data collection template(s), case studies (what has and hasn't worked), biological information on species and examples of best practises. It was suggested that the Commission could facilitate feedback to operators and governments on management and science questions associated with research needs, research results (in a useable form), and how operators can best provide input into research priorities.

Furthermore, it was suggested that the Commission encourage countries to implement adaptive management, whether they use regulations or guidelines, and to reference the existing collection of worldwide regulations and guidelines. The participants agreed that the best management regime (e.g. regulations, permitting/licensing, guidelines) depends on regional factors (e.g. species, geography) and that it would be beneficial to have Commission support for regional workshops and networking opportunities.

The sub-committee thanked the organisers and sponsors of this Workshop and Carlson for her report. Sub-committee members who participated noted how valuable it was to receive feedback from operators on the sub-committee's work. In discussion, the sub-committee **agreed** to establish an intersessional working group, with Rojas-Bracho as Convenor, to determine how the sub-committee can best assist and contribute to the Whalewatching Handbook (see Table 1).

8.3 Consider information from platforms of opportunity of potential value to the Scientific Committee

The sub-committee was asked to review a 'citizen science' handout drafted by the Tonga Whalewatching Operators Association. The Association, in co-operation with the South Pacific Whale Research Consortium (SPWRC), is encouraging its passengers to share humpback whale tail fluke photos taken while in Tonga. The handout contains information on photo quality, necessary data related to the photo, and websites for submission of photos.

In discussion, it was noted that for those whalewatching vessels too small to have a dedicated researcher on board, this type of handout could allow 'citizen scientists' to provide data directly to research groups, such as SPWRC and the Antarctic Humpback Whale Catalogue. Additional data fields could be added, such as group size and general behaviour. The simple data form developed at SC/56 (the Data Reporting Scheme) could be revived and made available as a resource through the Commission's website.

It was reported that a robust whalewatching industry exists in the Ballena Marine National Park in Costa Rica. In late 2009 researchers began collecting data from the whalewatching vessels as platforms of opportunity. The success of this work encouraged tour operators to ask for training to collect data on their own. They were trained in the use of data forms and GPS. The first year of data collection by operators has been completed and these data will be compared with data collected by researchers, to determine if there are significant differences in data quality. A paper will be prepared for SC/65b. The sub-committee welcomed this update.

Ritter presented Denkinger *et al.* (2013), which studied cetacean presence and diversity in the Galápagos Marine Reserve. The Galápagos National Park was created in 1959 and the Galápagos Marine Reserve (GMR) in 1986. The GMR is situated within the area of direct influence of the El Niño Southern Oscillation (ENSO) phenomenon and with every El Niño event the marine environment experiences significant changes caused by warming surface waters. Using wildlife viewing vessels as platforms of opportunity, 18 years of data, of occasional sightings reported by trained tour guides as well as from dedicated research cruises, have been collected during El Niño, La Niña, and neutral conditions. A total of 26 cetacean species from six families was reported. Overall, 11 species were considered rare and were seen only once or twice, while 12 species were common, with more than 20 sighting recorded over the study period. The most common species were common bottlenose dolphins (*Tursiops truncatus*), Bryde's whales (*Balaenoptera edeni*), common dolphins (*Delphinus delphis*), killer whales (*Orcinus orca*) and humpback whales (*Megaptera novaeangliae*). A smaller number of species were reported during strong El Niño years, with an increased number of species seen during cooler La Niña conditions. Thus, most species seem to move out of the GMR during El Niño years.

The authors note that sighting data were opportunistically collected and thus only reflect the tourist routes; therefore, sighting data are not directly comparable to data collected with systematic surveys that include larger areas of the GMR. However, it is clear that the Galápagos Islands support a unique and diverse cetacean fauna that can be reliably observed along the established routes for whalewatching vessels. These operations should take into account the conservation status and particular responses of the different species to natural environmental fluctuations like ENSO in order to implement responsible whalewatching.

The sub-committee thanked Ritter for bringing this paper to its attention and invited the submission of primary papers addressing similar issues to SC/65b.

SC/65a/SH25 reported on a meeting of the Southern Ocean Research Partnership (SORP) held immediately preceding SC/65a, on Jeju Island, Republic of Korea, on 31 May-2 June 2013. Forty-seven delegates from 16 countries, including representatives of the Secretariat, attended. The meeting's primary objective was to present the scientific results stemming from the five on-going SORP research projects that have been endorsed by the Commission and produced several papers presented at SC/65a in several sub-committees. Recommendations 4 and 5 of the meeting report were of particular interest to the sub-committee. Recommendation 4 was for the partners in SORP to employ all platforms of opportunity and, where applicable, 'citizen science', to collect data for inclusion in SORP research projects, thereby reducing the logistical constraints of circumpolar coverage and overall expenditure. Platforms of opportunity include, but are not limited to, tourist vessels and operations, polar programmes and their personnel, fishing vessels, other researchers, NGOs and volunteer groups, the general public and the internet.

Recommendation 5 was to store and archive data collected from international, collaborative research efforts such as SORP in open-access, central repositories that have the capacity to handle both primary scientific data and information derived from 'citizen science', e.g. image catalogues. The example of the cetacean sightings portal hosted by the Australian Antarctic Division was offered as an example of a centralised repository that automatically forwards information received to the relevant researchers, catalogues and databases, as well as informing submitters how their data will be used. In discussion it was noted that coordinated efforts are required to harness the potential of platforms of opportunity and ensure the success of this and similar 'citizen science' initiatives.

The sub-committee thanked Bell for presenting the relevant details of SC/65a/SH25. Kaufman noted that the Pacific Whale Foundation has received a grant from the Australian Marine Mammal Centre for developing a crowd sourcing platform for photo-identification of humpback whales. He will present the platform at SC/65b. It was noted that SORP is coordinating with the International Association of Antarctic Tour Operators to solicit data from platforms of opportunity. Cruise ships were identified as excellent outreach platforms, where 'citizen scientists' can be sourced and educated, but also where experienced biologists are often found as naturalist guides, making them a potential source of good-quality data. Several members noted that more outreach is needed to tourism associations and industries to encourage 'citizen science'. 'Citizen science' efforts should be coordinated, because photographs in particular often come from tourists and key matches can come from this source. The Antarctic Humpback Whale Catalogue, with over 1,000 individuals identified from the Antarctic region, and the SORP blue whale project were identified as benefiting from these 'citizen scientists'.

8.4 Review whalewatching guidelines and regulations

SC/65a/WW01 reviewed two studies that addressed compliance with whalewatching guidelines and regulations. Kessler and Harcourt (2013) studied the levels of compliance with regulations by commercial and recreational whalewatching boats off Sydney, Australia. The study focused on approach distance (300m for whales with calves, 100m for other whale groups) and the number of boats around a whale group (three or fewer within 300m of a whale group). The number of vessels within 300m of a whale group ranged from 2 to 12; up to 24 vessels were within 1km. The average number of boats within 300m of a whale group increased during weekends and also increased between 2007 and 2010. Only 37% of vessels abided with the regulation to keep more than 300m away from mothers with calves, but at least 92% stayed farther than 100m from whales, and 96% did not approach whales from directly in front or behind. The number of encounters where more than three vessels were within 300m of whales significantly increased between 2007 and 2010. Non-compliance by recreational vessels could be as high as 40%.

The authors suggested that recreational vessels used commercial whalewatching vessels as a guide to finding whales, and also to guide their behaviour around whale groups.

It was noted that Kessler and Harcourt (2013) was further evidence that recreational vessels around whales could be more of a management concern than dedicated whalewatching vessels. One member commented that at 300m it is difficult to impossible to see a calf and therefore vessels will often violate such an approach limit. Such unrealistic distance limits may even encourage excessive manoeuvring of vessels within 300m of mother-calf pairs, since once a calf is sighted, vessels have to move away.

Another member noted that Hervey Bay was offered as a best-case compliance situation in previous discussions within the sub-committee, which is clearly not the case. He suggested that the Australian Government might want to re-examine the situation in Hervey Bay. A general discussion followed regarding the need for both bottom-up (e.g. tourism associations voluntarily following codes of conduct) and top-down (e.g. regulations enforced by on-water authorities) management of whalewatching, sometimes in the same location.

Chion *et al.* (2013) looked at the effectiveness of a proposed regulation for beluga watching in the Saguenay-Saint Lawrence Marine Park, Quebec, Canada, using an agent-based modelling approach. Simulations were used to investigate three aspects of sustainable management: impact on the whales, economic impact, and tourist satisfaction. The regulations were divided into rules pertaining to speed, boat distance/density and observation time. The results indicated that the proposed new regulation (a limit of no more than 10 vessels within 926m of a whale) would be beneficial to whalewatching, with benefits to both the whales and tourists. The proxy variable, being 'alone with whales' (i.e. limiting boat numbers) was deemed 'beneficial' for tourists, economic viability and the whales themselves, but increased time with whales had a negative impact on the animals, while not affecting tourist satisfaction or economic impact. The overall results of the analysis supported replacing the old regulation with the new regulation.

It was noted that this modelling approach is another technique that could easily be applied to other locations to assess the effectiveness of whalewatching regulations.

Carlson noted that the 2013 Compilation of Worldwide Whalewatching Regulations was almost complete and would be online by August.

8.5 Review of collision risks to cetaceans from whalewatching vessels

SC/65a/WW04 investigated the probability of vessel collisions with humpback whales in the waters of Maui County, Hawaii, USA. Surprise encounters (SE) and near-misses (NM), defined as a group of whales sighted (at abeam and forward angles) within 300m and 80m of a vessel respectively, were used as proxies for probability of whale-vessel strikes. Between February and April 2013, 33 line transect surveys were conducted corresponding to 86.8hrs and 1,058n.miles of survey effort. A total of 361 groups or 723 individuals were recorded, including 191 SE (52.9%) and 12 NM (3.3%). Assessment of SE and NM individuals indicated a maximum of two and five individuals/km^2 for calf and non-calf groups respectively. The rate of SE increased with vessel speed, from 1.5 encounters/hr at 5kn to 4.2 encounters/hr at 20kn. No NM occurred at 5kn. Little variation in the detection of encounters was found under different Douglas Sea State and Beaufort Sea State conditions. Calves were present in 28.3% of SE and 58.3% of NM. This coincides with previous reports that calves may be more susceptible to vessel collisions. Continued research over the next four years will help identify frequency and trends of potential vessel collisions with humpback whales, and contribute to developing a predictive model of vessel strikes for management purposes.

The sub-committee welcomed this work as directly responsive to this agenda item. In discussion, it was noted that risk of vessel collision should be factored into models developed under MAWI. It was also noted that a graduate student is undertaking a scar-based assessment of Gulf of

Maine humpback whales and vessel strikes. The photographic database consists of photographs from whalewatching operations, research organisations and a non-governmental organisation of animals in a well-documented population of humpback whales, many of known age and sex. Progress on the study will be reported at SC/65b and could be useful to developing the model described in SC/65a/WW04. The model to be developed in Hawaii will be compared to data from the Hawaiian reporting network for ship strikes, which also reports 'encounters' (the equivalent of near misses), to see if the model matches the network's reports. The eventual goal is to establish zones of collision predictability.

Ritter presented relevant aspects of Neilson *et al.* (2012), which analysed all reported whale-vessel collisions in Alaska between 1978 and 2011. Of 108 recorded collisions, the vessel type was known in 89. Many types and sizes of vessels collided with whales; however, small recreational vessels (35%, *n*=31) as well as commercial recreational vessels (e.g. charter vessels, tour boats and commercial whalewatching vessels; 35%, *n*=31) were most commonly involved in collisions. When vessel speed was known, 49% of the collisions (*n*=37) occurred at vessel speeds ≥12kn. Maximum speed reported was 35kn.

Several members of the sub-committee noted that recreational vessels that stop to view whales are often more of a factor when considering impacts of whalewatching than dedicated whalewatching vessels. In some areas there are literally hundreds of small recreational vessels, fishing vessels, and high speed ferries in the vicinity of whales, even within marine sanctuary areas. It was suggested that the sub-committee should consider recreational vessels in its future work. The sub-committee invited the submission of papers documenting recreational vessel traffic around whales and their impacts at SC/65b.

8.6 Swim-with-whale operations

In 2000, the Committee considered tourists swimming with whales to be 'highly invasive' (IWC, 2001), which in turn led to some countries banning swim-with-whale programs (Mexico and Spain) or imposing strong regulatory conditions (e.g. USA). SC/65a/WW01 summarised four papers addressing swim-with-whale operations targeting humpback whales, dwarf minke whales and southern right whales across three regions (Argentina, Australia and Tonga).

Curnock *et al.* (2013) explored the effort and spatial distribution of tourists swimming with dwarf minke whales across time on the Great Barrier Reef, Australia. In 2003, authorities capped the number of tour licenses at nine in this area, and two conditions were imposed on license holders: compliance with the code of conduct and completion of a whale sighting sheet. Submitted whale sighting sheets (2003-08; *n*=1,477) and direct observations were used to investigate behavioural changes during encounters with the whales. Tourists swam with whales for a mean duration of 120min in 64% of encounters. The mean number of whales was higher in the presence of swimmers (3.66) than in their absence (2.92). No significant differences in the encounter duration or number of whales present were detected across time; however, the number of encounters increased per season by 91% across the study period and the total contact time with whales increased from 237.4 hours in 2003 to 451.6 hours in 2008.

Kessler and Harcourt (2012) studied the human-whale value transition in Tonga across time and the current impact of humpback whale tourism, using re-sightings of whales during swim-with encounters. The authors monitored humpback whale sightings in reference to water depth and re-sightings of whales during swim-with encounters, using photo-identification. They identified 331 unique individuals during 2006-10, of which there were 26 re-sightings of 22 individuals. Individuals were never re-sighted for more than two years after the first sighting. These results suggest that the whales display low site fidelity and travel regularly into other regions.

Kessler *et al.* (2013) documented humpback whale responses to experimental swim-with-whale encounters in Tonga, to determine whether these posed greater risks than regular whalewatching activities. They tested three 'swim' approaches to whales: (a) a 'quiet' approach with swimmers at surface with minimal splashing; (b) a 'splash' approach with swimmers at the surface with vigorous splashing; and (c) a 'dive' approach – a quiet approach but with swimmers diving whilst whales were in visual range. Responses such as 'avoidance' (whales move away from swimmers or vessel) and changes in surface behaviour were recorded. The 'splash' swim approach resulted in significantly more whale avoidance than 'quiet' and 'dive' swims. The presence of a calf, or the distance that the vessel approached, did not influence whale avoidance. However, close whale approaches led to increased whale activity. These results suggest that swim-with-whale encounters do not cause greater responses than regular whalewatching if swimmers enter and remain in the water quietly with minimal splashing. The authors recommended: (a) conducting additional research to document the impact that tourism may pose to mother-calf associations and parental care; (b) increasing minimum approach distance to 90m (at 90m only 10% of the whale group showed an increase in surface activity) with a slow approach speed; and (c) having swimmers enter the water quietly with minimal to no splash.

Lundquist *et al.* (2013) documented responses by southern right whales (*Eubalaena australis*) in Argentina to simulated swim-with-whale encounters. Theodolite tracking was used before, during and after staged 'swims' from a vessel (swimming with whales is currently illegal in the study region). The variables scored included behaviour (resting, traveling, surface-active or social), whale group composition and orientation. The following behaviours decreased compared with baseline data by the percentage in brackets: resting (11%), social (12%) and surface activity (5%). Mother/calf pairs displayed less resting and social behaviours during a swim encounter whilst travel increased, and these groups were more likely to change direction during a swim encounter. Juvenile whales displayed significantly less social behaviour and higher rates of traveling. After the swim encounter, levels of resting increased and travel decreased. 'Other' groups spent significantly less time resting but no other behaviour altered. The authors concluded that allowing swim-with-whale tourism in the region is not warranted, at least until further research is completed.

The sub-committee thanked Parsons for his review of recent whalewatching publications and invited the submission of similar experimental design research to SC/65b, especially from areas where swim-with-whale encounters either are not allowed or are just starting, so research results can inform management decisions. It was noted that one such area is Hervey Bay, Australia, an important resting area for humpback mother-calf pairs. Currently swimming with whales is not occurring but tour operators there are interested in conducting such encounters, despite the presence of sharks and bad visibility. The sub-committee noted that the growing body of research on swimming with whales suggests strongly that it is an additional stressor to the animals and that the guiding principles (Appendix 2) discourage new swim-with-whale operations. It **recommended** that the guiding principles be applied to any management decisions in Hervey Bay.

It was noted that how swimmers are briefed before entering the water is an important element for reducing impacts during swim-with-whale encounters. The questionnaire developed by the swim-with-whale intersessional group includes a question on pre-encounter briefings and results will be presented at SC/65b. Another option for reducing impacts could be requiring a 'practise' swim before whales are encountered, to instruct swimmers how to behave *in situ*. A discussion followed regarding how research on how tourists react to swim-with-whale encounters might be helpful in informing outreach messages to manage tourist expectations. Many tourists may enjoy whalewatching more from a vessel than in the water and appropriate education could lessen the demand for swimming with whales. In fact, encounters with cetaceans from vessels are often likely to be closer, and hence more 'intense', than in-water encounters (e.g. with bow-riding dolphins). It was noted that tourists are now swimming with river dolphins in Brazil, an area where such before-after research on tourist reactions might be useful.

It was noted that SC/65a/SM26 mentions swim-with-cetacean excursions in Japan and recommends monitoring the situation. The sub-committee invited submissions on this situation at future Committee meetings.

8.7 Emerging whalewatching industry in Oman

Willson presented an update on the emerging whalewatching industry in Oman. He also described an initiative to guide and regulate the industry, as previously recommended by the Committee. The initiative is being directed by the Environment Society of Oman.

The three centres for whalewatching tours are Muscat, Musandam and Salalah. Muscat has both commercial operators and recreational boat users targeting bottlenose, spinner and long-beaked common dolphins, with four new harbours opening in the city within the last three years. Salalah has an emerging dive industry, with an operator promoting opportunistic interactions with cetaceans during dives.

The objectives of the new initiative to educate the industry are to protect whales and habitat from impact whilst raising the industry's 'best practise' standards. Some degree of responsibility and self-regulation is expected, which will result from project activities such as formation of an operator's cooperative; an accreditation scheme; government endorsement of guidelines through licensing; and specific outreach to recreational boat users. Progress has been made with securing support of ministries, developing an inventory of operators, assessing operator performance and drafting a set of whalewatching guidelines. Operator workshops are planned for the 4th quarter of 2013.

The sub-committee thanked Willson for this update, which shows great progress, and invited the continued submission of updates on this emerging situation. It was noted that Brazil, Chile and South Africa established guidelines and regulations after consultation with the Committee and it is encouraging to see Oman follow suit. The inclusion of advice to tourists in the Omani draft guidelines was noted as a novel element that might be encouraged elsewhere. In discussion it was noted that there was good cooperation between researchers and the Omani government, which has been open to suggestions by researchers and non-governmental organisations. The sub-committee encouraged local stakeholders, including non-governmental organisations, to continue their commitment to taking this initiative forward. It was suggested that Oman was a good location to conduct whalewatching carrying capacity research, given the early stages of industry development.

The sub-committee **recommends** that the whalewatching guidelines in Oman consider the growing body of research on swim-with-whale encounters and the guiding principles (see Appendix 2), which discourage this activity.

8.8 Assessing 'whalewatching carrying capacity'

Childerhouse reported on the situation in Kaikoura, New Zealand and whalewatching targeting sperm whales. A moratorium on new commercial whalewatching permits for sperm whales at Kaikoura expired on 1 August 2012. In anticipation of the period ending, the New Zealand Government commissioned a two-year research programme into the impact of commercial whalewatching on sperm whales at Kaikoura. The research was completed in December 2011 (Markowitz *et al.*, 2011). The research identified some statistically significant effects but these were considered to be of minor biological consequence. However, there has been a decline in the abundance of sperm whales over the period since whalewatching started, although the cause of the decline is unknown. The government sought public consultation on the issuing of new permits. All but one submission was supportive of extending the present permit moratorium. Changes to the existing whalewatching permits at Kaikoura are not recommended. While the research and submission process has highlighted a number of 'flags of concerns' regarding whalewatching at Kaikoura that warrant a precautionary approach to increasing whalewatching activity, there are no 'warning bells' that justify changing existing permits. The available science indicates that aircraft operating under the existing regulations have little or no impact on the behaviour of sperm whales. At present there is a three platform rule for the number of planes or boats around a single whale. It has been recommended that planes be removed from the three platform rule and that the issuing of additional aircraft permits be considered for the future. Another 10-year moratorium on the issuing of new whalewatching permits for vessels was recommended and has been implemented. A 10-year period will allow for meaningful monitoring of the effects of whalewatching activity on sperm whales.

In discussion, other plausible hypotheses for the decline were suggested, including changes in prey or prey distribution. Research to address this possibility is planned. It was noted that studies measuring relevant hormone levels in faeces or blows, which can distinguish between psychological and nutritional stress (see Item 5), might be appropriate here; this idea will be passed on to relevant authorities.

8.9 IWC Conservation Management Plans

SC/65a/SCP01 reported that the Commission is implementing three Conservation Management Plans (CMPs): the northwest Pacific gray whale plan; the southeast Pacific southern right whale plan; and the southwest Atlantic right whale plan. The Arabian Sea humpback whale population is also a candidate for a CMP. The Committee has been requested to identify potential candidates for future CMPs. Cetacean species and populations facing specific threats or critical habitat for cetaceans should be prioritised. CMPs are flexible and will be updated at least every year and their results will be submitted to the Scientific and Conservation Committees. CMPs are not meant to replace national or regional management plans, but rather to complement them.

In discussion, it was noted that the southern resident killer whales of the northeast Pacific Ocean meet the criteria for a CMP. It was clarified that species or populations that are data-rich (with known threats) are equally good as CMP candidates as those species or populations with significant data gaps. It was noted that data-rich populations that are known to be targeted by whalewatching are ideal nominees from this sub-committee.

The sub-committee **agreed** to submit the southern resident killer whale population as a candidate population for a CMP to the Commission. It was suggested that the sub-committee liaise with the standing working group on environmental concerns, as noise and pollutants are threats to this population.

9. WORK PLAN

The work plan prioritised major items as listed below.

(1) Assess the impacts of whalewatching on the physiology, behaviour, and fitness of cetaceans (individuals and populations) and their habitats, in order to demonstrate causal relationships between whalewatching exposure and the survival and vital rates of cetaceans; understand mechanisms involved in causal effects, if any; and establish standard methodologies for the conduct of these assessments (see Objective 1 and Action 1.3 of the 5-Year Strategic Plan for Whalewatching).

In addition, the following items were **agreed** for the next meeting.

(2) Review reports from Intersessional Working Groups:
  (i) Modelling and Assessment of Whalewatching Impacts (MAWI) steering group (see Action 1.3 of the Five-Year Strategic Plan for Whalewatching);
  (ii) background document for guiding principles (see Action 1.1);
  (iii) Five-Year Strategic Plan for Whalewatching Handbook (see section on implementation in the Five-Year Strategic Plan for Whalewatching);
  (iv) swim-with-whale operations; and
  (v) in-water interactions.
(3) Review progress on Five-Year Strategic Plan for Whalewatching.
(4) Review whalewatching in the region of the next meeting.
(5) Consider information from platforms of opportunity of potential value to the Scientific Committee.
(6) Review whalewatching guidelines and regulations.
(7) Consider emerging whalewatching industries of concern.

The sub-committee discussed the work plan and set priorities for next year as listed. Terms of reference and members of the Intersessional Working Groups as **agreed** by the sub-committee are listed in Table 1.

In discussion, it was noted that the prey/demography link is thought to be the weakest aspect of any attempt to link short-term behavioural changes to long-term population consequences. It was suggested that the sub-committee liaise with other Committee groups (such as the working groups on ecosystem modelling and environmental concerns) to seek guidance on information linking natural variability in prey availability to cetacean demography. Better understanding of this natural variability will allow us to better quantify anthropogenic factors such as whalewatching, to relate impact studies on individuals to fitness or population level consequences. The sub-committee invites scientists with expertise in linking prey with demography to present papers at SC/65b. This is related to both the work of MAWI (see Item 7.1) and to whalewatching carrying capacity (see Item 8.8).

10. OTHER MATTERS

SC/65a/WW05 reported on results from a survey of whalewatching passengers designed to identify causes of a decline in the number of whalewatchers in Hervey Bay, Australia. One result of the survey showed that the decision to participate in a whalewatching trip was primarily based on being able to support research and conservation efforts. This indicated that tour operators in Hervey Bay would benefit by, among other things, supporting such efforts.

SC/65a/SM15 summarised a genetic analysis of bottlenose dolphins in Bocas Del Toro, Panama, which showed that this small population (~150 dolphins) has a unique haplotype not seen elsewhere in the Caribbean, confirming its genetic isolation and vulnerability. At SC/64 the sub-committee noted that there is a major problem with boat operator compliance with local whalewatching guidelines and 'strongly recommended' that the Panamanian authorities enforce national whalewatching regulations and 'recommended' continued research to monitor this dolphin population and the impacts of dolphin watching (IWC, 2013, p.319). However, enforcement has not happened, and there has recently been a confirmed report of a dolphin watching vessel striking a dolphin. In light of this observed mortality, the sub-committee strongly reiterates its recommendations.

11. ADOPTION OF THE REPORT

The report was adopted at 09:00hrs on 11 June 2013. The sub-committee thanked Urbán and Carlson for their wise guidance during the discussions and Rose for her efficient rapporteuring. It wished Urbán a happy birthday, which fell on the fifth day of the meeting this year.

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Appendix 1

AGENDA

1. Opening remarks
2. Election of Chair and Rapporteurs
3. Adoption of Agenda
4. Review of available documents and information
5. Assess the impacts of whalewatching on cetaceans (methods and results of changes in behaviour and movement patterns; methods and results of physiological changes to individuals; and methods and results of demographic and distributional changes)
6. Review whalewatching in the Republic of Korea
7. Review of intersessional Working Groups
   - 7.1 Large-scale Whalewatching Experiment (LaWE) Steering Group (Convenor: Lusseau)
   - 7.2 LaWE budget development group (Convenor: Kaufman)
   - 7.3 Swim-with-whale operations (Convenor: Rose)
   - 7.4 In-water interactions (Convenor: Ritter)
   - 7.5 Guiding principles development (Convenor: Carlson)
8. Other issues
   - 8.1 Review scientific aspects of the Commission's Five-Year Strategic Plan for Whalewatching
   - 8.2 Report of IWC Whalewatch Operator's Workshop, Brisbane
   - 8.3 Consider information from platforms of opportunity of potential value to the Scientific Committee
   - 8.4 Review of whalewatching guidelines and regulations
   - 8.5 Review of collision risks to cetaceans from whalewatching vessels
   - 8.6 Swim-with-whales operations
   - 8.7 Emerging whalewatching industry in Oman
   - 8.8 Assessing 'whalewatching carrying capacity'
   - 8.9 IWC Conservation Management Plans
9. Work plan
10. Other matters
11. Adoption of the report

Appendix 2

REPORT OF THE INTERSESSIONAL WORKING GROUP ON GUIDING PRINCIPLES DEVELOPMENT

General principles for cetacean watching

The following general principles, general management considerations and guidelines for cetacean watching were developed from Annex VI of the Report of the Regional Workshop on Marine Mammal Watching in the Wider Caribbean Region (Anon., 2011) and the General Principles for Whalewatching developed by the Scientific Committee of the IWC at the 1994 meeting (IWC, 1997). While a number of the identified principles also relate to human safety, guidance on human safety during whalewatching needs to be sourced from the appropriate experts. The main purpose of the attached principles is to mitigate impacts on cetaceans. The overarching principles are to:

(a) ensure the conservation of cetaceans and their habitats;
(b) ensure a precautionary approach to the development and management of cetacean watching;
(c) minimise the impact of viewing activities on cetaceans, other species and the marine environment
(d) provide long-term socio-economic benefits for the livelihood of local communities; and
(e) promote local knowledge, cultural importance and understanding of cetaceans and the marine environment through training, education and dedicated research.

Management considerations

In an effort to minimise the potential risk of adverse impacts of cetacean watching and to ensure the sustainable development of such activities, effective management strategies need to be implemented. Several tools and approaches should be considered.

- National/regional licensing or permitting schemes to regulate:
  - the number, size, type and speed of vessels,
  - standards of operation,
  - capacity building,
  - site specific and species specific requirements,
  - permitted research and access by media,
  - training for operators, and
  - sanctions for non-compliance, such schemes subject to adaptive management (as new information becomes available, regulations change to incorporate this new information).
- National/regional measures to regulate approaches, frequency, length and type of exposure (i.e. codes of conduct) in encounters with marine mammals.
- Development of management provisions through cooperation amongst stakeholders, such as government agencies, non-governmental organisations, and operators wherever appropriate.
- National/regional management measures, to include closed seasons, exclusion zones, speed limits, and 'no approach times', to provide additional protection to habitats, populations, and individuals.
- Assessment of the numbers, distribution and other characteristics of the target cetacean population/s before the implementation of tourism operations to establish the feasibility of the industry and a baseline for monitoring.
- Where cetacean watching operations are evolving, the industry should proceed with caution, moderating activity and adapting management until sufficient information on populations and species is available to guide further development.
- Monitoring compliance with and the effectiveness of management provisions and modifying them as required to reflect new information and circumstances, with the consultation of stakeholders, such as operators and non-governmental organisations.
- Establishment of an enforcement framework to ensure compliance with regulations.
- Scientific and socio-economic research and monitoring, assessment of potential impacts on cetaceans, and collection and sharing of information by all stakeholders, such as scientists, operators, and non-governmental organisations.
- Dissemination of information on best practice and research to improve public awareness, including all stakeholders.
- On-going operator, naturalist and industry training and accreditation programmes on the biology and behaviour of target species, local ecosystems, navigation, culture, best practice of cetacean watching operations, and the management provisions in effect.
- Development of on board research protocols to collect data on sighing effort, sighting data and other relevant documentation (e.g. about injuries, entanglements, highly identifiable individuals, vessel-cetacean interactions, etc.).
- Supporting and empowering communities' participation and ownership of the cetacean watching industry.
- Educational standards for the provision of accurate and informative material to cetacean watching participants, to:
  - develop an informed and environmentally responsible public (locals and tourists);
  - encourage development of realistic expectations during encounters;
  - encourage the provision of naturalist guides on all boats; and
  - encourage public participation in on-board research and education programmes (e.g. docent and intern training, opportunistic data collection, species identification, plankton tows);
  - awareness of species protection measures and enforcement; and
  - ongoing assessment and evaluation of on-board education programmes.

Vessel design and maintenance to minimise the risk of adverse effects on cetaceans, including disturbance from noise:

Cetacean species may respond differently to low and high frequency sounds, relative sound intensity or rapid changes in sound; and their behaviour may not only be species specific but also differ between individuals and/or age classes. Therefore:

- vessels, engines and other equipment should be designed, maintained, and operated during cetacean watching to reduce as far as practicable adverse acoustic and physical impacts on the target species and their environment;

- vessel design and operation should minimise the risk of injury to cetaceans should contact occur; for example, shrouding of propellers can reduce risk of injury; and
- in order to avoid strikes, operators should keep track of cetaceans during an encounter and not engage engines until all cetaceans being watched are on the surface and away from the vessel.

Guidelines for watching cetaceans

Cetacean watching activities can potentially have adverse impacts on cetacean populations, including disruption of important behaviours, displacement from habitat, chronic stress and serious injury. Response behaviours to the presence of vessels will vary between species, between different behavioural states, and possibly between age/sex classes or even individuals. Therefore, water-users, captains and on-board naturalists should:

- be able to distinguish between species;
- be able to distinguish between different behaviours of the same species (e.g. travel, foraging, social);
- be able to distinguish between age and sex classes within a species;
- operate watercraft, and aircraft so as not to disrupt the normal movement or behaviour of cetaceans,
- cease pursuing/watching a cetacean at any sign of disturbance or alarm (e.g. repeated evasive reactions, animals blowing bubbles below the surface); and
- allow marine mammals to determine the nature and duration of the encounter.

Generally, the following recommendations should be considered.

- Do not touch cetaceans.
- Do not feed marine mammals.
- Do not make any loud or sudden noises that are transmittable under water.
- Do not make sudden or repeated changes in direction or speed.
- Do not carry out any activities that might condition cetaceans to approach watercraft.
- Do not throw litter into the water.
- Dedicated observer(s) should be on duty, in addition to the captain of the vessel.
- Do not place a vessel in a position where it will drift into marine mammals.
- Leave boat engine on and idling, or drop sails, when watching cetaceans. They should be able to detect a platform at all times.
- Do not disperse or separate a group of cetaceans.
- Watercraft should not chase, encircle, leap-frog, block the direction of travel of cetaceans or access to the open sea or position itself in the middle of a group.
- If cetaceans approach the watercraft, maintain a constant speed and direction, or slow down gradually, put engines in idle or drop sails.
- If cetaceans approach a vessel to bow-ride or wake-ride, maintain a steady speed and avoid changes in course.
- When departing from cetaceans, determine where the animals are relative to the watercraft to avoid collisions or coming too close to the animals, and increase speed gradually only after confirmation that the animals are outside the no approach zone.
- Watching cetaceans with calves for more than 30 minutes, or three dive sequences with sperm whales, is discouraged.
- Any accidents or collisions with cetaceans should be documented and reported to relevant authorities, and to the IWC ship strike database.

Watercraft

- Watercraft should meet appropriate regional safety standards.
- Certain watercraft should not be used for cetacean watching. These include all motorised personal watercraft (e.g. jet skis and similar crafts), standup paddle-boards, personal sailboats, parasail, kayaks, remotely operated craft, wing in ground effect craft, hovercraft, wind boards, and kite boards. The use of aircraft and helicopters for cetacean watching is discouraged, except in the case of permitted scientific research and media.

Angles and distances of approach

Approach

- The most appropriate method for approaching a cetacean is from the side and slightly to the rear of the animal. Avoid approaches from head on or directly from behind.
- In the case of sperm whales, approach animals from the rear and slightly to the side.

Caution zone

A caution zone is an area in which watercraft should proceed at a no-wake speed (six knots or less). The caution zone is the area within 300m from a whale, and 150m from a dolphin.

- No more than three watercraft should be in the caution zone of a cetacean at a time.
- When there is more than one watercraft in the caution zone, operators should coordinate movements and maintain radio contact.
- Observe cetaceans at a speed not exceeding the speed of the slowest animal.

No approach zone

The no approach zone is the minimum distance to which a watercraft may approach a cetacean. Engines should be in neutral, sails dropped and paddles out of the water.

Watercraft

Minimum approach distances for whales range from 50-250m, minimum approach distances for dolphins range from 30-100m, including the area directly in front of and behind a pod. However, there may be conditions under which it would be recognised that a greater distance would be appropriate e.g. with mother-calf pairs, critically endangered species, and small resident populations.

Aircraft

If permitted as a viewing platform, aircraft should not approach (in height or distance) to within 500m of a cetacean.

Mother and calf pairs

Exercise extreme caution with groups containing calves, which are particularly vulnerable to disturbance and require additional protection. Site-specific restrictions on length of encounter and distance of approach should be considered for groups with calves.

Swimming and diving with cetaceans in the wild

Swimming with cetaceans may increase the potential for disturbance and displacement and puts whales at additional risk. There are existing swim-with-cetacean programmes (commonly known as swim-with programmes) but the further development of these programmes is discouraged. For those countries where swim-with activities are currently being undertaken, it is recommended that the following standards be applied to these operations.

- Scientific studies should be initiated to assess: (a) the associated risk to the safety of the people and the whales participating in swim-with activities; and (b) the current and potential future impacts of these activities on the target species. Any accidents should be documented and reported to relevant authorities.
- Particularly sensitive animals (e.g. mothers with calves) and sensitive habitats (e.g. calving and feeding grounds) should be provided additional protection (refer to Management Considerations)
- Sub-surface swimming >1m should not be allowed, including the use of any underwater breathing apparatus and scooters.
- Underwater flash photography or lighted filming should not be allowed.
- A precautionary, adaptive management approach should be taken when reviewing swim-with operating procedures. Consideration should be given to:
  - regular review of operational standards as credible scientific information on the impacts of swim-with programmes becomes more available;
  - all persons in the water with cetaceans should be accompanied by an appropriately trained naturalist;
  - limiting the number of vessels permitted to undertake swim-with activities in a region;
  - limiting the number of swimmers allowed in the water at any one time;
  - limiting the maximum amount of in-water time allowed, including maximum swim time for each interaction, time required between successive swims with each animal and maximum cumulative interaction time with each animal per day;
  - appropriate drop-off distance for swimmers and minimum swimmer distance from animals;
  - entering the water with cetaceans during behaviourally sensitive (e.g. feeding/foraging) situations should be discouraged;
  - swimming with mothers and calves should be discouraged; and
  - prohibit leap-frogging and limit the number of swimmer drop-offs or attempts.

REFERENCES

Anon. 2011. Report of the Regional Workshop on Marine Mammal Watching in the Wider Caribbean Region, Panama City, Panama, 19-22 October 2011. UNEP Environment Programme. 56pp. [Available at: *http://www.unep.org*].

International Whaling Commission. 1997. Report of the Scientific Committee, Annex Q. Report of the whalewatching working group. *Rep. int. Whal. Commn* 47:250-56.

Annex N

Report of the Working Group on DNA

Members: Pastene (Chair), Cipriano, Gaggiotti, Hoelzel, Kanda, Kato, Luna, Øien, Palsbøll, Pampoulie, Park, Perkins, Skaug, Solvang, Waples.

1. ELECTION OF CHAIR

Pastene convened and chaired the Group.

2. APPOINTMENT OF RAPPORTEURS

Pastene acted as rapporteur.

3. ADOPTION OF AGENDA

The adopted Agenda is given as Appendix 1. Items 5, 6, 7 and 8 of the Agenda are in response to requirements placed on the Scientific Committee by IWC Resolution 1999-8 (IWC, 2000), which called for annual reports on progress in the following areas.

(1) Genetic methods for species, stocks and individual identification.
(2) Collection and archiving of tissue samples from catches and bycatch.
(3) Status of and conditions for access to reference databases of DNA sequences or microsatellite profiles derived from directed catches, bycatch, frozen stockpiles and products impounded or seized because of suspected infractions.

4. REVIEW OF DOCUMENTS

Document SC/65a/SD01 was relevant for the Working Group.

5. PROGRESS ON GENETIC METHODS FOR SPECIES, STOCK AND INDIVIDUAL IDENTIFICATION

SC/65a/SD01 was prepared in response to a recommendation from the Icelandic Scientific Permit Review Workshop to provide a detailed protocol for the genetic analyses to ensure that the genetic data presented to the Workshop followed the IWC guidelines for genetic research (recommendation 12.1.2 (2) in SC/65a/Rep03). SC/65a/SD01 presented a full description of the protocol for the genetic analyses performed and presented in SC/F13/SP17 and SC/F13/SP20, from collection of tissues to extraction of DNA, amplification of genetic markers, and storage of tissues in the Icelandic DNA registry tissue bank, all developed and used during the Icelandic Special Permit Research Programme. The Group **welcomed** this document and **agreed** that it responded appropriately to the recommendation from the Icelandic Scientific Permit Review Workshop.

The Chair suggested that the Icelandic genetic analysis protocol described in SC/65a/SD01 could be included as an appendix to the Group meeting report following the examples of the Japanese and Norwegian protocols in previous years. The Group was informed that the Icelandic document will be updated and that it could be added to the report of the Group meeting the next year.

The Chair **encouraged** the preparation of technical documents on methods for species, stock and identification for discussion at the next year meeting under this agenda item.

6. REVIEW RESULTS OF THE 'AMENDMENTS' OF SEQUENCES DEPOSITED IN GENBANK

During the first round of sequence assessment (IWC, 2009, p.347) some inconsistencies were found but these appear to be due to a lag in the taxonomy recognised by *GenBank* or uncertainty in taxonomic distinctions currently under investigation (e.g. the number of species and appropriate names for recently recognised species of 'Bryde's whales') (IWC, 2013b, p.330). After the assessment some of the inconsistencies were corrected by the original submitters. Further corrections have been hampered by the fact that currently, only the original submitter can alter taxonomy fields in *GenBank*. Last year the Committee **reiterated** its previous suggestion on the addition of a field in *GenBank* where comments on taxonomy updates of the entries can be made. The Committee **agreed** that Cipriano should make a request to *GenBank* and that he should inform the IWC Secretariat and the Convenor of the DNA Testing Group if a more formal request is required (IWC, 2013a, p.64).

Cipriano informed the Group that he had contacted *GenBank* during the intersessional period. A response was received noting that *GenBank* is willing to work with the IWC on this particular problem, and requested that a list of Accession numbers associated with problematic taxonomic designations be provided. This would help *GenBank* to understand the scope of the problem while considering a mechanism to allow taxonomy corrections and notations by request. In preparation for a response to *GenBank,* Cipriano updated the list of Accession numbers involving inconsistencies, which is shown in Appendix 2.

The Group **agreed** that the list should be sent to *GenBank* by Cipriano with a letter explaining the background and the main reasons for the inconsistencies, which include:

(a) species for which the taxonomy is still being worked out (e.g. the 'Brydes whale' species complex);
(b) species that have been recently split into new (or redescribed) species (e.g. the right whales and minke whales); and
(c) subspecies for which the taxonomy is still being investigated (e.g. the blue whales and minke whales).

The Group noted that the list in Appendix 2 includes only baleen whale species and sperm whale and suggested that *GenBank* should be informed that the same taxonomy problem occurs with some small cetacean sequences. The Group also noted that there is no description criteria for official acceptance of all mammalian species but this is left up to particular sources (e.g. the list of species recognised by the Society for Marine Mammalogy, Rice, 1998), and that species names for taxa that have recently undergone taxonomic revision are not being used consistently by all authors.

The DNA Working Group also suggested further discussion by the IWC ad hoc taxonomy group on the issues regarding new species descriptions and taxonomy of baleen whales.

7. PROGRESS ON COLLECTION AND ARCHIVING OF SAMPLES FROM CATCHES AND BYCATCHES

The Committee previously endorsed a new standard format for the updates of national DNA registers to assist with the review of such updates (IWC, 2012, p.53), and the new format worked well last year. This year the update of the DNA registers by Japan, Norway and Iceland were based on this new format.

Kanda reported on the status of the Japanese register (see Appendix 3). The collection of samples is from scientific whaling in the North Pacific (JARPN-JARPN II) and the Antarctic (JARPA-JARPA II), and from bycatches. It includes coverage for 1994-2012 (JARPN-JARPN II), 1987/88-2012/13 (JARPA-JARPA II). In the case of bycatches it includes coverage for 2001-12.

Skaug reported on the status of the Norwegian register (see Appendix 4). The collection of samples of North Atlantic common minke whale is from commercial catches for the period 1994 to 2012.

Pampoulie reported on the status of the Icelandic register (see Appendix 5). The collection of samples is from scientific whaling and from commercial catches. It includes coverage for 2003-07 (scientific whaling) and 2006-12 (commercial catches). Samples are presently in hand for all whales taken in 2003-12.

8. REFERENCE DATABASES AND STANDARDS FOR A DIAGNOSTIC REGISTER OF DNA PROFILES

An update of the Japanese register is shown in Appendix 3. For common minke whales 99.6% of the 2,215 whales sampled by JARPN-JARPN II in 1994-2011 were screened for mtDNA and microsatellites. For animals sampled in 2012 mtDNA analyis of 100% (*n*=182) has been completed, but the microsatellite analysis has not been completed yet. For bycatches, 100% and 97.9% of the 1,324 whales bycaught in 2001-11 were screened for mtDNA and microsatellites, respectively. For animals bycaught in 2012, mtDNA analysis has been completed for 100% (*n*=114), but the microsatellite analysis has not yet been completed.

For Bryde's whales 99.5% and 100% of the 593 whales sampled by JARPN II in 2000-11 were screened for mtDNA and microsatellites, respectively. For animals sampled in 2012, mtDNA analysis has been completed for 100% (*n*=34). In the case of bycatches, 100% of the four whales bycaught in 2001-11 were screened for mtDNA and microsatellites. One Bryde's whale was bycaught in 2012 and the mtDNA genetic analysis was completed.

For sei whales 99.5% and 100% of the 884 whales sampled by JARPN II in 2002-11 were screened for mtDNA and microsatellites, respectively. For animals sampled in 2012, mtDNA analysis has been completed for 100% (*n*=100). The microsatellite analysis has not yet been completed. There was no bycatch of sei whales in 2012.

For sperm whales 92.3% and 100% of the 52 whales sampled by JARPN II in 2000-11 were screened for mtDNA and microsatellites, respectively. The three animal sampled in 2012 were all screened for mtDNA. Microsatellite work has not yet been completed. In the case of bycatches, 100% of the two whales bycaught in 2001-11 were screened for mtDNA and microsatellites. No sperm whales were bycaught in 2012.

For Antarctic minke whales 16.5% and 92.3% of the 6,794 whales sampled by JARPA in 1987/88-2004/05 were screened for mtDNA and microsatellites, respectively. Of the 3,264 whales sampled by JARPA II in 2005/06-2010/11 62.5% and 78.2% were screened for mtDNA and microsatellites, respectively. For animals sampled in 2011/12 (*n*=266) the mtDNA and microsatellite work has not yet been completed. The Group was informed that in the case of the microsatellite analysis of the JARPA II samples, the number of loci was increased to 12.

For Antarctic fin whales the 17 samples collected by JARPA II in 2005/06-2010/11 were screened for mtDNA and microsatellites. The DNA work for the single animal sampled in 2011/12 is ongoing.

For North Pacific humpback whales 100% of the 37 whales bycaught in 2001-11 were screened for mtDNA and microsatellites. For animals bycaught in 2012, mtDNA analysis was completed for 100% (*n*=3). Two North Pacific right whales and three North Pacific fin whales bycaught in 2001-21 were screened for both mtDNA and microsatellite. There was no bycatch of North Pacific right whales in 2012.

For North Pacific fin whales 100% of the three whales bycaught in 2001-11 were screened for mtDNA and microsatellites. There was no bycatch of North Pacific fin whales in 2012.

Almost all samples in the Japanese DNA registry have been sexed.

An update of the Norwegian register is shown in Appendix 4. After discounting for duplicates, missing samples and laboratory problems, 100% of the North Atlantic common minke whales caught in 1997-2011 (*n*=8,278) were screened for mtDNA and microsatellites. Genetic work for 464 whales caught in 2012 is ongoing and will be completed during this year.

An update of the Icelandic registry is shown in Appendix 5. For North Atlantic common minke whales 100% of the 189 whales sampled under scientific permit whaling in 2003-07 were screened for mtDNA and microsatellites. For whales taken by commercial whaling in 2007-10, 5.9% (*n*=186) were completed for both markers. For 2011, 3.5% (*n*=58) were completed for both markers. For 2012, 22.4% (*n*=49) were completed for both markers. Genetic work on the additional samples is ongoing and will be completed during this year.

100% of the fin whales caught by commercial whaling in 2006-10 (*n*=274) were screened for both mtDNA and microsatellites.

The Group **appreciated** the efforts of Japan, Norway and Iceland in compiling and providing this detailed information of their registries in the new format. The Group **agreed** that the information provided in the new format greatly facilitated the annual review.

9. OTHER MATTERS

No other matters were discussed by the Group.

10. WORK PLAN

The terms of reference for the Working Group will remain the same for the next year, unless the Commission requests other information in the interim. Members of the Working Group were encouraged to submit papers relating to these terms of reference and to propose additional agenda items. Results of the 'amendment' work on sequences deposited in *GenBank* will be reported next year. Next year the Working Group will examine the technical information relevant to the TORs of the Group, contained in documents presented to other groups and subcommittees.

11. ADOPTION OF THE REPORT

The report was adopted by consensus.

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Rice, D.W. 1998. *Marine Mammals of the World. Systematics and Distribution*. Special Publication No. 4, The Society for Marine Mammalogy, Allen Press Inc., Lawrence, Kansas. v-ix+231pp.

Appendix 1

AGENDA

1. Election of Chair
2. Appointment of rapporteurs
3. Adoption of the Agenda
4. Review of documents
5. Progress on genetic methods for species, stock and individual identification
6. Review of results of the 'amendments' of sequences deposited in *GenBank*
7. Progress on collection and archiving of tissue samples from catches and bycatches
8. Reference databases and standards for diagnostic DNA registries
9. Other
10. Work plan
11. Adoption of the Report

Appendix 2

UPDATED LIST OF ACCESSION NUMBERS SHOWING INCONSISTENCIES IN GENBANK

Table 1

Updated list of accession numbers showing inconsistencies in *GenBank*.

Acc.#	Locus	bp	Issue (potential notation)	Current *GenBank* name	Source
AF487467	ctrl	399	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487468	ctrl	398	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487469	ctrl	398	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487470	ctrl	397	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487471	ctrl	395	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487472	ctrl	399	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487473	ctrl	395	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487474	ctrl	397	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487475	ctrl	398	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487476	ctrl	398	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487477	ctrl	398	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487478	ctrl	398	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487479	ctrl	397	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487480	ctrl	396	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487481	ctrl	398	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487482	ctrl	397	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487483	ctrl	395	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487484	ctrl	395	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487485	ctrl	395	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487486	ctrl	397	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487487	ctrl	398	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487488	ctrl	395	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487489	ctrl	395	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487490	ctrl	395	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AF487491	ctrl	398	No subspecies distinction	*Balaenoptera acutorostrata*	Andersen *et al.* (2002, unpublished)
AJ226093	ctrl	331	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226094	ctrl	498	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226095	ctrl	356	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226096	ctrl	562	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226097	ctrl	559	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226098	ctrl	215	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226099	ctrl	554	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226100	ctrl	387	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226101	ctrl	344	No subspecies distinction	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226102	ctrl	379	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226103	ctrl	436	No subspecies distinction	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226104	ctrl	367	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226105	ctrl	518	No subspecies distinction	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226106	ctrl	381	No subspecies distinction	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226107	ctrl	398	No subspecies distinction	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226108	ctrl	444	No subspecies distinction	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226109	ctrl	579	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226110	ctrl	559	No subspecies distinction	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226111	ctrl	301	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226112	ctrl	537	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226113	ctrl	553	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226114	ctrl	570	Recognition of new species	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226115	ctrl	538	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226116	ctrl	536	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226117	ctrl	579	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226119	ctrl	562	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226121	ctrl	577	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AJ226122	ctrl	529	Taxonomic change*	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AY230267	ctrl	953	No subspecies distinction	*Balaenoptera acutorostrata*	Mace and Corinne (2003, unpublished)
AY352278	ctrl	385	No subspecies distinction	*Balaenoptera acutorostrata*	McEwing (2003, unpublished)
AY352279	ctrl	385	No subspecies distinction	*Balaenoptera acutorostrata*	McEwing (2003, unpublished)
AY352280	ctrl	388	No subspecies distinction	*Balaenoptera acutorostrata*	McEwing (2003, unpublished)
AY822111	ctrl	406	No subspecies distinction	*Balaenoptera acutorostrata*	Hatch *et al.* (2006)
AY822112	ctrl	407	No subspecies distinction	*Balaenoptera acutorostrata*	Hatch *et al.* (2006)
DQ145040	ctrl	333	No subspecies distinction	*Balaenoptera acutorostrata*	Baker (2005, unpublished)
DQ145048	ctrl	366	No subspecies distinction	*Balaenoptera acutorostrata*	Baker (2005, unpublished)
X72006	ctrl	936	No subspecies distinction	*Balaenoptera acutorostrata*	Árnason *et al.* (1993)
X87773	ctrl	343	No subspecies distinction	*Balaenoptera acutorostrata*	Bakke *et al.* (1995, unpublished)
X87774	ctrl	343	Recognition of new species	*Balaenoptera acutorostrata*	Bakke *et al.* (1995, unpublished)
Y17160	ctrl	551	No subspecies distinction	*Balaenoptera acutorostrata*	Grohmann *et al.* (1998, unpublished)
AB116098	ctrl	937	Taxonomic change*	*Balaenoptera brydei*	Wada *et al.* (2003)
GU085097	ctrl	678	Taxonomy in flux	*Balaenoptera brydei*	Penry *et al.* (2009, unpublished)

Cont.

Acc.#	Locus	bp	Issue (potential notation)	Current *GenBank* name	Source
DQ231170.1	ctrl	457	Taxonomy in flux	*Balaenoptera brydei*	Herath (2007)
DQ340979	ctrl	416	Taxonomy in flux	*Balaenoptera brydei*	Hildebrandt *et al.* (unpublished)
EF068013.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068014.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068015.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068016.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068017.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068018.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068019.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068020.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068021.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068022.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068023.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068024.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068025.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068026.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068027.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068028.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068029.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068030.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068031.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068032.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068033.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068034.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068035.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068036.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068037.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068038.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068039.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068040.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068041.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068042.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068043.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068044.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068045.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068046.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068047.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068048.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068049.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068050.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068051.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068052.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068053.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068054.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068055.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068056.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068057.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068058.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068059.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068060.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068061.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068062.1	ctrl	297	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EF068063.1	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kanda *et al.* (2007)
EU030282	ctrl	852	Taxonomy in flux	*Balaenoptera brydei*	Alves *et al.* (2007, unpublished)
GU085097	ctrl	678	Taxonomy in flux	*Balaenoptera brydei*	Penry *et al.* (2009, unpublished)
JX090150	ctrl	429	Taxonomy in flux	*Balaenoptera brydei*	Kershaw *et al.* (2012, unpublished)
JX090151	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kershaw *et al.* (2012, unpublished)
JX090152	ctrl	299	Taxonomy in flux	*Balaenoptera brydei*	Kershaw *et al.* (2012, unpublished)
AB116099	ctrl	937	Taxonomy in flux	*Balaenoptera edeni*	Wada *et al.* (2003)
AF398372	ctrl	933	Taxonomy in flux	*Balaenoptera edeni*	Yang *et al.* (2001, unpublished)
AY822091	ctrl	405	Taxonomy in flux	*Balaenoptera edeni*	Hatch *et al.* (2006)
AY822092	ctrl	405	Taxonomy in flux	*Balaenoptera edeni*	Hatch *et al.* (2006)
EF057443	ctrl	511	Taxonomy in flux	*Balaenoptera edeni*	Jayasankar *et al.* (2009)
GU085094	ctrl	676	Taxonomy in flux	*Balaenoptera edeni*	Penry *et al.* (2009, unpublished)
GU085095	ctrl	677	Taxonomy in flux	*Balaenoptera edeni*	Penry *et al.* (2009, unpublished)
GU085096	ctrl	676	Taxonomy in flux	*Balaenoptera edeni*	Penry *et al.* (2009, unpublished)
GU085098	ctrl	675	Taxonomy in flux	*Balaenoptera edeni*	Penry *et al.* (2009, unpublished)
GU085099	ctrl	676	Taxonomy in flux	*Balaenoptera edeni*	Penry *et al.* (2009, unpublished)
X72196	ctrl	932	Taxonomy in flux	*Balaenoptera edeni*	Árnason *et al.* (1993)
AY235201	ctrl	504	No subspecies distinction	*Balaenoptera musculus*	Borsa *et al.* (2003, unpublished)
AY390265	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY390266	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY390267	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY390268	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)

Cont.

Acc.#	Locus	bp	Issue (potential notation)	Current *GenBank* name	Source
AY390269	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY390270	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY390271	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY390272	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY390273	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY390274	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY390275	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY390276	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY390277	ctrl	300	Subspecies unclear	*Balaenoptera musculus*	McEwing (2003, unpublished)
AY822087	ctrl	406	No subspecies distinction	*Balaenoptera musculus*	Hatch *et al.* (2006)
AY822088	ctrl	406	No subspecies distinction	*Balaenoptera musculus*	Hatch *et al.* (2006)
DQ145044	ctrl	335	Subspecies unclear	*Balaenoptera musculus*	Baker (2005, unpublished)
AB116095	ctrl	938	Taxonomy in flux	*Balaenoptera omurai*	Wada *et al.* (2003)
AB116096	ctrl	938	Taxonomy in flux	*Balaenoptera omurai*	Wada *et al.* (2003)
AB116097	ctrl	938	Taxonomy in flux	*Balaenoptera omurai*	Wada *et al.* (2003)
AF395044	ctrl	500	Taxonomic change*	*Eubalaena australis*	Malik *et al*. (2000)
AF395045	ctrl	500	Taxonomic change*	*Eubalaena australis*	Malik *et al*. (2000)
AF395046	ctrl	500	Taxonomic change*	*Eubalaena australis*	Malik *et al*. (2000)
AF395047	ctrl	500	Taxonomic change*	*Eubalaena australis*	Malik *et al*. (2000)
AF395048	ctrl	500	Taxonomic change*	*Eubalaena australis*	Malik *et al*. (2000)
AF275349	ctrl	286	Taxonomic change*	*Eubalaena glacialis*	Rosenbaum *et al.* (2000)
AF275350	ctrl	285	Taxonomic change*	*Eubalaena glacialis*	Rosenbaum *et al.* (2000)
AF275351	ctrl	285	Taxonomic change*	*Eubalaena glacialis*	Rosenbaum *et al.* (2000)
AF275352	ctrl	301	Taxonomic change*	*Eubalaena glacialis*	Rosenbaum *et al.* (2000)
AF275353	ctrl	282	Taxonomic change*	*Eubalaena glacialis*	Rosenbaum *et al.* (2000)
AF275354	ctrl	301	Taxonomic change*	*Eubalaena glacialis*	Rosenbaum *et al.* (2000)
AF275355	ctrl	301	Taxonomic change*	*Eubalaena glacialis*	Rosenbaum *et al.* (2000)
AF275356	ctrl	301	Taxonomic change*	*Eubalaena glacialis*	Rosenbaum *et al.* (2000)
AF275357	ctrl	301	Taxonomic change*	*Eubalaena glacialis*	Rosenbaum *et al.* (2000)
AF395039	ctrl	499	Taxonomic change*	*Eubalaena glacialis*	Malik *et al*. (2000)
AF395040	ctrl	500	Taxonomic change*	*Eubalaena glacialis*	Malik *et al*. (2000)
AF395041	ctrl	500	Taxonomic change*	*Eubalaena glacialis*	Malik *et al*. (2000)
AF395042	ctrl	500	Taxonomic change*	*Eubalaena glacialis*	Malik *et al*. (2000)
AF395043	ctrl	500	Taxonomic change*	*Eubalaena glacialis*	Malik *et al*. (2000)
AY395733	ctrl	310	Taxonomic change*	*Eubalaena glacialis*	McEwing (2003, unpublished)
AY395734	ctrl	302	Taxonomic change*	*Eubalaena glacialis*	McEwing (2003, unpublished)
AY821863	ctrl	158	Taxonomic change*	*Eubalaena glacialis*	Rastogi *et al.* (2004)
U96647	ctrl	389	Taxonomic change*	*Eubalaena glacialis*	Rosenbaum *et al.* (1997)
U96648	ctrl	389	Taxonomic change*	*Eubalaena glacialis*	Rosenbaum *et al.* (1997)
X72199	ctrl	919	Taxonomic change*	*Eubalaena glacialis*	Árnason *et al.* (1993)
AF146390.1	cytb	369	Taxonomy in flux	*Balaenoptera edeni*	Yoshida and Kato (1999)
AF146391.1	cytb	369	Taxonomy in flux	*Balaenoptera edeni*	Yoshida and Kato (1999)
AF146392.1	cytb	369	Taxonomy in flux	*Balaenoptera edeni*	Yoshida and Kato (1999)
AF398371.1	cytb	369	Taxonomy in flux	*Balaenoptera edeni*	Yang *et al.* (2001, unpublished)
EF057444.1	cytb	426	Taxonomy in flux	*Balaenoptera edeni*	Jayasankar *et al.* (2009)
JN190947.1	cytb	400	Taxonomy in flux	*Balaenoptera edeni*	Bijukumar *et al.* (2012)
JN190948.1	cytb	421	Taxonomy in flux	*Balaenoptera edeni*	Bijukumar *et al.* (2012)
JN190949.1	cytb	421	Taxonomy in flux	*Balaenoptera edeni*	Bijukumar *et al.* (2012)
X75583.1	cytb	1140	Taxonomy in flux	*Balaenoptera edeni*	Árnason and Gullberg (1994)
EF103940	cytb	565	Taxonomy in flux	*Balaenoptera omurai*	Ma *et al.* (2006, unpublished)
AF304073	cytb	1140	Synonymy	*Physeter catodon*	Cassens *et al.* (2000)
U13142	cytb	424	Synonymy	*Physeter catodon*	Milinkovitch *et al.* (1994)
X75589	cytb	1140	Synonymy	*Physeter catodon*	Árnason and Gullberg (1994)
AJ554054	mtDNA	####	No subspecies distinction	*Balaenoptera acutorostrata*	Árnason *et al.* (2004)
AP006468	mtDNA	####	No subspecies distinction	*Balaenoptera acutorostrata*	Sasaki *et al*. (2005)
NC_005271	mtDNA	####	No subspecies distinction	*Balaenoptera acutorostrata*	Árnason *et al.* (2004)
AB201259	mtDNA	####	Taxonomy in flux	*Balaenoptera brydei*	Sasaki *et al.* (2006)
AP006469.1	mtDNA	####	Taxonomy in flux	*Balaenoptera brydei*	Sasaki *et al.* (2005)
NC_006928.1	mtDNA	####	Taxonomy in flux	*Balaenoptera brydei*	Sasaki *et al.* (2005)
AB201258	mtDNA	####	Taxonomy in flux	*Balaenoptera edeni*	Sasaki *et al.* (2006)
NC_007938	mtDNA	####	Taxonomy in flux	*Balaenoptera edeni*	Sasaki *et al.* (2006)
AB201256	mtDNA	####	Taxonomy in flux	*Balaenoptera omurai*	Sasaki *et al.* (2006)
AB201257	mtDNA	####	Taxonomy in flux	*Balaenoptera omurai*	Sasaki *et al.* (2006)
NC_007937	mtDNA	####	Taxonomy in flux	*Balaenoptera omurai*	Sasaki *et al.* (2006)
AJ277029	mtDNA	####	Synonymy	*Physeter catodon*	Árnason *et al.* (2000)
NC_002503	mtDNA	####	Synonymy	*Physeter catodon*	Árnason *et al.* (2000)

**GenBank* taxonomy field should be updated to reflect new taxonomy.

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Appendix 3

UPDATE OF THE JAPANESE DNA REGISTER FOR LARGE WHALES BY 2012

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The status of the Japanese DNA register for large whales was presented and discussed during the 2005 Scientific Committee meeting (IWC, 2006). The number of genetic samples and the number of individuals analysed and registered were reported. The status report included information of the scientific whaling in the North Pacific (JARPN II) up to 2004, of the scientific whaling in the Antarctic (JARPA) from the austral summer season 1987/88 to 2004/05, and of the bycatches and stranding up to 2005. Update of the Japanese DNA register for large whales under the new format since the last scientific meeting is as follows.

Table 1

Update of the Japanese DNA register for large whales.

Footnote no.	1	2	3	4	5	6	7	8	9	10	11	12
Species/year	Type	No. whales	No. duplicates	No. missing	No. lab problems	No. mtDNA	%mtDNA	No. msat	% msat	Sex analysed	% sexed	Note
NP minke whale												
1994-2011	SP	2,215	0	0	8	2,207	99.6	2207	99.6	2,215	100	
2012	SP	182	0	0	0	182	100	0	0	182	100	
2001-11	BC	1,324	0	26	2	1,324	100	1,296	97.9	1,294	97.7	
2012	BC	114	0	0	0	114	100	0	0	0	0	
NP Bryde's whale												
2000-11	SP	593	0	0	3	590	99.5	593	100	593	100	
2012	SP	34	0	0	0	34	100	0	0	34	100	
2001-11	BC	4	0	0	0	4	100	4	100	4	100	Include two Omura's whale
2012	BC	1	0	0	0	1	100	0	0	0	0	Omura's whale
NP sei whale												
2002-11	SP	884	0	0	4	880	99.5	884	100	884	100	
2012	SP	100	0	0	0	100	100	0	0	100	100	
NP sperm whale												
2000-11	SP	52	0	0	0	48	92.3	51	100	52	100	2009/10 mtDNA not yet analysed
2012	SP	3	0	0	0	3	100	0	0	3	100	Microsatellites not yet analysed
2001-11	BC	2	0	0	0	2	100	2	100	2	100	
2012	BC	0	0	0	0	0	0	0	0	0	0	
Ant. minke whale												
1987/88-2004/05	SP	6,794	0	10	0	1,118	16.5	6,271	92.3	6,794	100	Incl. dwarf; 87/88-88/89 no microsatellites
2005/06-2010/11	SP	3,264	0	549	162	2,040	62.5	2,553	78.2	3,264	100	Some missing since the 3/11 tsunami
2011/12	SP	266	0	0	0	0	0	0	0	266	100	
Ant. fin whale												
2005/06-2010/11	SP	17	0	0	0	17	100	17	100	17	100	
2011/12	SP	1	0	0	0	0	0	0	0	1	100	
NP humpback whale												
2001-11	BC	37	0	0	0	37	100	37	100	37	100	
2012	BC	3	0	0	0	3	100	0	0	0	0	
NP right whale												
2001-11	BC	2	0	1	0	2	100	1	100	1	100	Missing after the 3/11 tsunami before microsatellite analysis
2012	BC	0	0	0	0	0	0	0	0	0	0	
NP fin whale												
2001-11	BC	3	0	0	0	3	100	3	100	3	100	
2012	BC	0	0	0	0	0	0	0	0	0	0	

[1]Key to sample types: SP=special permit catch, C=commercial catch, BC=bycatch, ST=stranding. [2]Number of whales that potentially entered by the previous years and enters (new year) the markets. [3]Number of occurrences (tissues) sample switching on board the vessels as detected by comparison of genetic profiles. [4]Number of individuals for which tissue samples are missing for other reasons than sample switching. [5]Genetic laboratory not able to obtain microsatellite profiles mtDNA haplotypes from tissue samples. [6]Number of samples analysed for mitochondrial control region. [7]% of total samples analysed for mitochondrial control region. [8]Number of samples analysed for microsatellites. [9]% of total samples analysed for microsatellites. [10]Number of samples analysed for sex. [11]% of total samples analysed for sex. [12]Other problems or information.

REFERENCE

International Whaling Commission. 2006. Report of the Working Group on DNA testing. *J. Cetacean Res. Manage. (Suppl.)* 8: 252-258.

Appendix 4

UPDATE OF THE NORWEGIAN DNA REGISTER FOR COMMON MINKE WHALE BY 2012

Hans J. Skaug
Institute of Marine Research

The genetic analysis of the 2012 catches in the lab are not completed yet, so this Appendix does not contain any new information relative to last year's Appendix. The reason for the delay is due to unplanned circumstances in the genetic lab in Bergen.

Table 1

Update of the Norwegian DNA register for minke whales.

Footnote no.	1	2	3	4	5	6	7	8	9	10	11	12
Species/year	Type	No. whales	No. duplicates	No. missing	No. lab problems	No. mtDNA	%mtDNA	No. msat	% msat	Sex analysed	% sexed	Note
NA minke whale												
1997-2011	C	8,278	74	49	2	8,153	100	8,153	100	8,153	100	
2012	C	464										

[1]Key to sample types: SP=special permit catch, C=commercial catch, BC=bycatch, ST=stranding. [2]Number of whales that potentially entered by the previous years and enters (new year) the markets. [3]Number of occurrences (tissues) sample switching on board the vessels as detected by comparison of genetic profiles. [4]Number of individuals for which tissue samples are missing for other reasons than sample switching. [5]Genetic laboratory not able to obtain microsatellite profiles mtDNA haplotypes from tissue samples. [6]Number of samples analysed for mitochondrial control region. [7]% of total samples analysed for mitochondrial control region. [8]Number of samples analysed for microsatellites. [9]% of total samples analysed for microsatellites. [10]Number of samples analysed for sex. [11]% of total samples analysed for sex. [12]Other problems or information.

Appendix 5

UPDATE OF THE ICELANDIC DNA REGISTER BY 2012

Christophe Pampoulie and Gisli A. Víkingsson

Practical arrangements regarding the establishment of the Icelandic DNA register were concluded in 2007. The Marine Research Institute, Reykjavik, is responsible for the establishment and maintenance of the registry that is of the same format as the Norwegian DNA registry. An ORACLE database has now been created and contains all genotyped individuals information as well as tissue collected ID of individuals collected but not genotyped. In parallel, a DNA tissue bank has been achieved and is now fully functional.

Table 1 gives the present status of the registry. Samples from all the common minke whales landed as a part of the Icelandic research program (2003-07) and all commercial North Atlantic fin whales have been genotyped and information stored in the database. Genetic analyses of North Atlantic minke whales taken for commercial purposes from 2007 to 2012 are currently ongoing. All samples from 2007-12 will be genotyped before the end of the year.

Table 1

Update of the Icelandic DNA register.

Footnote no.	1	2	3	4	5	6	7	8	9	10	11	12
Species/year	Type	No. whales	No. duplicates	No. missing	No. lab problems	No. mtDNA	%mtDNA	No. msat	% msat	Sex analysed	% sexed	Note
NA minke whale												
2003-07	SP	189	0	0	0	189	100	189	100	189	100	
2007-10	C	186	0	0	0	11	5.9	11	5.9	11	5.9	
2011	C	58	0	0	0	2	3.5	2	3.5	2	3.5	
2012	C	49	0	0	0	11	22.4	11	22.4	11	22.4	
NA fin whale												
2006-10	C	274	0	0	0	274	100	274	100	274	100	

[1]Key to sample types: SP=special permit catch, C=commercial catch, BC=bycatch, ST=stranding. [2]Number of whales that potentially entered by the previous years and enters (new year) the markets. [3]Number of occurrences (tissues) sample switching on board the vessels as detected by comparison of genetic profiles. [4]Number of individuals for which tissue samples are missing for other reasons than sample switching. [5]Genetic laboratory not able to obtain microsatellite profiles mtDNA haplotypes from tissue samples. [6]Number of samples analysed for mitochondrial control region. [7]% of total samples analysed for mitochondrial control region. [8]Number of samples analysed for microsatellites. [9]% of total samples analysed for microsatellites. [10]Number of samples analysed for sex. [11]% of total samples analysed for sex. [12]Other problems or information.

Annex O

Report of the *Adhoc* Working Group on Progress Reports and the Online Data Portal

Members: Double (Chair; Australia), An (Korea), Bell (Australia), Bjørge (Norway), Chilvers (New Zealand), Donovan (IWC Secretariat), Fortuna (Italy), Hughes (IWC Secretariat), Iñíguez (Argentina), Leaper (UK), Mattila (IWC Secretariat), Marzari (Argentina), Miyashita (Japan), Øien (Norway), Ridoux (France), Ritter (Belgium), Roel (UK), Rojas-Bracho (Mexico), Rowles (USA), Santos (Spain), Scheidat (Netherlands), Stachowitsch (Austria), Víkingsson (Iceland).

Comments and recommendations on the new online National Progress Report Portal

Brendan Miller of the IWC Secretariat was commended for the significant progress in the development of the online Portal and for supporting national coordinators in the submission of data. Working Group (WG) members welcomed that the layout of the Portal is now similar to the layout of the Microsoft Word template used previously to collate data as this is familiar to those who provide data.

Donovan provided a summary of the original intent of National Progress Reports and the changes in scope and content over time (see Donovan *et al.*, 2011; IWC, 1989; 1998; 2012).

The WG agreed that the National Progress Reports were designed to deliver metadata summaries that direct interested parties to the source of the detailed primary data sources. Dedicated databases (e.g. IWC Ship Strike Database, IWC Catch Database) should be used if detailed quantitative information is required. Currently the IWC Secretariat manages two databases pertinent to the metadata captured by Progress Reports - the Individual Catch Database and the Ship Strike Database. The development of an Entanglement Database is being considered.

The WG discussed improvements to the current Portal and suggested the following changes (in priority order).

(1) The data in extracted reports or reported onscreen must be identical to data known to be in the database Portal. Some participants reported inconsistencies. The Portal should save all data entered or provide notification of failures.
(2) National coordinators should to be able to edit all fields in each record before submission to the IWC and should be able to enter data on behalf of another party
(3) Individual users should be able to edit all fields before the record has been submitted to the national coordinator.
(4) The collation of data related to human impacts on cetaceans is the highest priority for Progress Reports and the sections within the Portal should be reordered to reflect this.
(5) The online reports produced by the Portal need to be reformatted ensure the data are presented clearly onscreen and in print form.
(6) It should be possible to create separate records when the ‘Large Area’ and ‘Species’ are the same but the ‘Local area’ differs or when the ‘Large Area’ and ‘Species’ are the same but the source of the information differs.
(7) Section names should be as clear as possible but with definition where needed (avoid terms such as ‘non-anthropogenic mortality’). Ideally state specifically the nature of the data required (bycatch, ship strike, entanglement and so on).

Ongoing modifications to the Portal

Donovan reported that Miller is exploring the options for a ‘country administer tool’ that would avoid the need to create a new user for every large area, species and source. This was welcomed by participants because designated country administrators are often required to enter data on behalf of someone else.

Number of occurrences within records

Participants expressed concern that in many cases the number of occurrences, especially those related to human-induced impacts, could be misleading because the submitted records only capture reported cases. It was agreed that any report from the Portal clearly states that the record represents *the minimum number of occurrences and the true number could be much higher*. To ensure users are fully aware of the quality and limitations of the data a disclaimer must be read and acknowledged before reports can be generated. An intersessional review group will review field and categories within the Portal to ensure data and associated caveats are captured appropriately.

Suggested modifications to fields and categories

Several modifications to fields and categories were suggested by participants and it was agreed that intersessional groups will be established to review the current fields and categories within each section of the Portal – see below for group coordinators and Terms of Reference.

Data outputs

The WG and review groups will encourage sub-committee Conveners to consider the data output and format required for their work so suitable queries can be developed for the Portal.

Ship strike, bycatch, entanglement and other in-depth databases

The National Progress Report Portal is strictly a metadata data collection tool but in future the Scientific Committee may wish to develop more detailed, individual databases for issues such as bycatch and entanglement. The National Progress Report Portal may assist in identifying sources of data for such databases but should not be the method by which such data are collated.

Intersessional work

An intersessional correspondence group composed of the meeting participants will be established to provide advice and test modifications to the Portal. Any comments sent to the Secretariat related to the Portal can be circulated to this group. The group will be encouraged to provide rapid feedback to the Portal developer.

Rowles will explore how the Portal could capture metadata on the ingestion of marine debris as requested by the sub-committee on environmental concerns.

The groups reviewing the field and categories for each section of the online Portal (see below) will liaise with sub-committee Conveners on the design of database queries and report formats.

Terms of reference for the groups reviewing the fields and categories of the Progress Report schema

Members of the intersessional review groups are to:

(1) review existing fields;
(2) determine if the existing fields and categories within fields meet the needs of the Scientific Committee;
(3) suggest edits/new headings/categories/fields to suit identified critical needs (*nb*: it is important to provide strong justification for any amendments and clearly define what is meant by the amendments suggested);
(4) identify how primary sources can be referenced;
(5) ensure back-compatibility with earlier Progress Reports is not affected; and
(6) report back to the intersessional correspondence group for further feedback once their review has been completed.

Review group Conveners and current members are (others will be co-opted)

- Sightings: Bell.
- Natural marking: TBA.
- Telemetry and artificial marking: Double.
- Tissue and biological samples: Rowles.
- Direct catches of large whales: TBA.
- Bycatch and entanglement of large whales: Ritter, Mattila, Leaper, Rojas-Bracho.
- Direct catches of small cetaceans: TBA.
- Bycatch and entanglement of small cetaceans: Fortuna.
- Strandings: Santos, Ridoux, Rowles.

REFERENCES

Donovan, G., Fortuna, C., Gedamke, J., Leaper, R., Perrin, W., Tandy, M. and Jones, J. 2011. Report of the Scientific Committee. Annex P. Online Submission of Progress Report Data and Proposed Changes to the Progress Report Template. *J. Cetacean Res. Manage. (Suppl.)* 12: 347-50.

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International Whaling Commission. 2012. Report of the Scientific Committee. Annex O. Progress Reports. *J. Cetacean Res. Manage. (Suppl.)* 13:307. [Published on the IWC website]

Annex P

Report of the Working Group on Scientific Permits

Members: Bjørge (Convenor), An, Baulch, Bell, Brownell, Butterworth, Childerhouse, Chilvers, Cipriano, De Moor, Donovan, Double, Elvarsson, Funahashi, Gallego, Galletti, Goodman, Gunnlaugsson, Hakamada, Holm, Iñíguez, Jaramillo-Legorreta, Kanaji, Kanda, Kasuya, Kato, Kelly, Kim, D., Kim, H., Kishiro, Kitakado, Kock, Liebschner, Marzari, Matsuoka, Miyashita, Morishita, Murase, Nelson, Øien, Palsbøll, Pampoulie, Park, Pastene, Punt, Roel, Rose, Sakamoto, Scheidat, Simmonds, Tajima, Tamura, Tiedemann, Víkingsson, Wade, Walløe, Waples, Weller, Williams, Yoshida.

1. CONVENORS OPENING REMARKS

Bjørge welcomed meeting participants and reminded them that the main purpose of the Working Group on Special Permits is to discuss the special permit activities and results in light of Commission Resolutions and the Scientific Committee priorities.

2. ELECTION OF CHAIR

Bjørge was elected Chair.

3. APPOINTMENT OF RAPPORTEURS

Weller served as rapporteur.

4. ADOPTION OF AGENDA

The adopted Agenda is provided as Appendix 1.

5. AVAILABLE DOCUMENTS

The following available documents contained information relevant to the working group: SC/65a/SP01, SC/65a/O06-O09, SC/65a/Rep03.

6. REVIEW REPORT OF WORKSHOP FOR ICELANDIC SCIENTIFIC PERMIT WHALING

This agenda item is related to the Icelandic Research Programme that was conducted from 2003-07 and the results were subject to an Expert Panel Review in 2013 (see SC/65a/Rep03). This Review, chaired by Kitakado, took place in Reykjavik in February 2013 and followed the guidelines described in Annex P (IWC, 2013a).

6.1 Panel report

Kitakado presented an overview of SC/65a/Rep03. During this presentation, he recalled that in reaching its conclusions and recommendations, the Panel noted the statement from the proponents that no further Special Permit programme was envisaged by Iceland at present. 'Annex P' provides the Terms of Reference for the Panel. The general overview and conclusions of the Panel on the Icelandic programme were summarised by Kitakado during his presentation and are detailed in SC/65a/Rep03 (published in this volume).

6.1.1 Panel Chair's summary of the panel report

The Panel was chaired by Kitakado and its composition was decided upon by a steering group comprising the past four Scientific Committee chairs and the Head of Science. Difficulties in the availability of proposed candidates meant that participation by scientists who had no connection with the Committee proved very difficult. In the event, the Panel comprised the present Committee Chair and the Head of Science (in accord with the guidelines), two ex-Committee Chairs, one current member of the Committee, one scientist who has not participated in the Committee for several years and two scientists who have never participated. Expertise in all areas of the research programme was available. In addition to the proponents, four observers were present. Thirty papers were submitted by proponents (SC/F13/SP01-30) and three additional papers were submitted by other scientists (SC/F13/O01-03).

The Panel report (SC/65a/Rep03) is divided into sections based on the stated objectives of the programme: abundance; stock structure; biological parameters, feeding ecology; energetics; pollution; parasites and pathology. Each of these contained the proponents' summary of their results followed by an analysis of the results by the Panel including conclusions and specific recommendations. The final section presents the Panel's general overview and conclusions followed by a summary of all of the recommendations divided into short, medium and long-term.

The report is a long and detailed review. What follows here is a short Panel Chair's summary of only the broad conclusions (SC/65a/Rep03); it does not provide a substitute for reading the full report. In reaching its conclusions and recommendations, the Panel noted that no further special permit programme was envisaged by Iceland at present. With respect to consideration of the effect of the catches on stocks, it noted that the level of catches was considerably below the level for the CIC *Small Area* that would have been allowed under the RMP (IWC, 2011, p.64). The Panel emphasised that its task was to provide an objective scientific review of the results of the Icelandic programme; its task was not to provide either a general condemnation or approval of research under special permit. Consideration of that would require examination of some issues way beyond the purview of a scientific panel.

The Panel made a number of general points in addition to its review of individual topics. The first related to the objectives of the programme. The general nature of the objectives of the original proposal and its characterisation as a feasibility/pilot study made it difficult for the Panel to fully review how well the programme could be said to have met its own objectives. It agreed that it is important that any special permit programme provides careful objectives and sub-objectives for which performance can more easily be assessed, as is now the case in the guidelines for proposed permits in IWC (2013b), developed since the Iceland permit was presented in 2003.

The Panel also commented that better information on sampling design and an evaluation of sample size and representativeness at the local and population level was required. While the method used was probably sufficient for a feasibility study, it would not be the case for a full programme.

A common thread throughout the report related to the need for integrated analyses of the individual components of the programme; it regarded such work as essential and this was the subject of several recommendations. Given the objective of multi-species modelling to improve management, this should also include consideration of the results in the context of a modelling framework. The Panel noted that the programme had tried to maximise the information obtained from the whales taken. It stressed the importance of archiving material collected as well as storing analytical results and data in a relational database linked to the tissue archive.

With respect to abundance, the Panel agreed that the Icelandic survey data have improved knowledge about the abundance and distribution of the common minke whale in Icelandic waters both for use in the RMP and for input to potential multispecies modelling. Despite the logistical difficulties, the spring and autumn surveys provided valuable new information, especially in the context of any future multi-species modelling.

With respect to stock structure, the Panel agreed that the data will assist in the Committee's work on this topic. With respect to feasibility component, it was of course already well-known that it is possible to collect samples to better understand stock structure from carcases (as well as from biopsy samples as the proponents' note). It welcomed the efforts to compare genetic data across the North Atlantic but recommended further effort to integrate information regarding stock structure from the variety of genetic and non-genetic sources.

With respect to biological parameters, the Panel recognised the extensive amount of field and laboratory work that had been undertaken and presented. It noted that evaluating the feasibility of collecting information on biological parameters of sufficient precision and accuracy to inform multi-species modelling requires examining the sensitivity of model results to the parameters concerned. As the modelling was not as advanced as had been originally planned, this evaluation cannot yet be conducted. One of the most important feasibility questions relates to the issue of ageing common minke whales and the Panel commended the work to examine a new approach for common minke whales, recognising that further work needs to be undertaken.

With respect to feeding ecology, a primary component of the programme, the Panel acknowledged the large amount of effort undertaken and the generally thorough analyses using a variety of techniques. The temporal changes observed as a result of the extension of the sampling period could be related to climate change or a regime shift in the waters around Iceland and this is an important issue for further research. The general nature of the objectives made evaluation of the success of the feasibility study more complex but the Panel agreed that knowledge of the general feeding ecology of common minke whales around Iceland has been advanced. It also acknowledged the efforts to collect data in such a way as to allow a more systematic than usual examination of the results that can be obtained from lethal and non-lethal methods (see SC/65a/Rep03, table 4). Finally, the Panel strongly recommended that integrated analyses including comparison of the information from each approach be developed and submitted to the Scientific Committee.

With respect to energetics, again the Panel recognised the considerable field, laboratory and analytical effort. These provided valuable insights into aspects of the energetics of common minke whales around Iceland but further effort is required to integrate the various analyses to provide quantitative input to energetics models and multispecies modelling and allow an evaluation of the sensitivity of the results to the inevitable uncertainty.

With respect to modelling, the Panel recognised the practical difficulties explained by the proponents but concluded that this important part of the programme is as yet poorly developed. In particular, a simple preliminary model should have been developed to inform discussions of which are key parameters with respect to obtaining robust results, evaluating how sensitive results are to different levels of uncertainty and determining appropriate sample sizes. This was a major weakness in the programme. However, the Panel welcomed the modelling work presented to the Workshop as a small but valuable initial step toward the programme's overall objective.

With respect to pollutant studies, the Panel acknowledged the considerable field, laboratory and analytical work that had resulted in a number of published papers. It also appreciated the effort made to compare results across the North Atlantic and to examine relationships between concentration levels in different tissues including 'pseudo' biopsy samples. However, it agreed that the objective of assessing health status had not been fully addressed and cautioned against broad assumptions that low levels necessarily indicate no effect. The sample size of the feasibility study was insufficient to properly address any toxic-related cause-effect relationships.

With respect to parasites and pathology, the objective had been to investigate the feasibility of monitoring and evaluating the morbidity of potential pathogens. The Panel recognised the difficulty of conducting full post-mortems of animals and undertaking thorough examination for parasites and pathogens at sea. While the study of the epibiotic macro fauna has resulted in a good baseline for future analyses, overall, the Panel concluded that the approaches adopted in the feasibility study would be insufficient to achieve the objective outlined.

The Panel briefly noted that the Commission had passed several resolutions relevant to research on the ecosystem, contaminants and environmental change. It agreed that many aspects of the programme were relevant to these topics and that the information had been made available to the Scientific Committee.

With respect to the utility of lethal and non-lethal techniques the Panel referred to extensive discussions at the JARPN II review (IWC, 2010) and the SORP conference (Baker *et al.*, 2012). The Panel welcomed the efforts of the programme to provide data to allow a more thorough and quantitative comparison of some lethal and non-lethal techniques than has previously been possible (see recommendation in IWC, 2010). The Panel developed a simple qualitative table to summarise the situation for North Atlantic common minke whales but stressed that is not intended to represent a complete or comprehensive evaluation of lethal or non-lethal techniques, either in general or for this specific programme and drew attention to a number of caveats.

Finally the report provided a summary of its recommendations. Seventeen addressed specific issues that might be termed 'short-term' while twelve addressed 'medium to long-term' issues.

6.2 Response to Panel report

Víkingsson presented an overview of SC/65a/SP01. This paper summarises the response of scientists from the Icelandic programme (IRP) to the report of the Expert Panel (SC/65a/Rep03). The IRP scientists consider that in general the evaluation of the IRP by the Independent Expert Panel was constructive, objective and balanced. For both the main and secondary objectives of the IRP, the Independent Expert Panel acknowledged the quality and scientific relevance of the presented results to the minke whale research. At the same time, the Independent Expert Panel identified those areas where further work was required and provided suggestions and recommendations to improve the output of the research presented at the Review Workshop. The suggestions and recommendations of the Panel range from minor changes and corrections to suggestions of future research. SC/65a/SP01 summarises the response of scientists related to the IRP to the scientific output of the Review Workshop. Points of general nature and some minor questions/suggestions are responded to in that report and/or in revised versions of the documents presented at the Workshop (Table 1). The Panel also made several suggestions for further analyses of existing data, integration of results from different sub-projects and future research.

At the request of the Panel, further documentation of the sampling design was given. From the outset it is important to emphasise that the objective of sampling design was to cover the Icelandic continental shelf area and not to be representative for the Central North Atlantic minke whale stock. Sampling was distributed in relation to relative abundance in nine small areas. The sub-areas used were part of the Bormicon framework for multispecies modelling of Boreal systems. This area division is based on oceanographic and ecological characteristics of the Icelandic continental shelf area. In addition to the nine Bormicon areas, the planned sampling was stratified seasonally into five units. The purpose of such a fine-scale stratification (45 spatio-temporal sampling units in a study with n=200) was primarily to secure distribution of the sampling all around Iceland in this feasibility study and to allow for post-stratification as appropriate for the different sub-projects.

The Panel recommended integration of several of the 30 papers presented to the Workshop, in particular papers concerning feeding ecology and multispecies modelling, energetics and stock structure. As a response, the IRP scientists produced integrated papers on energetics that were submitted to the EM Working Group of the Scientific Committee (SC/65a/O02), and a fully integrated paper on 'stock structure' which was submitted to the SD Working Group (SC/65a/SD02). In addition, several recommendations were taken into account in new papers such as SC/65a/EM01 and Daníelsdóttir and Ohf (2013) for the modelling issues and SC/65a/SD01 for issues concerning DNA quality analyses. In addition revisions were made of 11

Table 1

IRPs summary of scientific recommendations from the IRP Review Workshop and status of progress with reference to Table 2 of SC/65a/SP01. Recommendations refer to section numbers in the Panel Report (SC/65a/Rep03). This revised version summarises a list of new and revised papers submitted to the Committee in response to the Panel's recommendations and the sub-committees in which they were discussed at SC/65a.

Recommendations	Sub-committee	Status of work
Abundance	**RMP**	
12.1.1.1		To be addressed in the near future. Further recommendations may be needed as to the approach to take (before the North Atlantic minke whale *Implementation Review*).
Stock structure	**RMP, SD**	
Short term recommendations		
12.1.2.1		A fully integrated 'stock structure' paper was submitted to the SD sub-committee of the Scientific Committee (SC/65a/SD02).
12.1.2.2		A paper describing the genetic protocols employed during the IRP was submitted to the SD sub-committee of the Scientific Committee (SC/65a/SD01).
12.1.2.3		This has been dealt with in the fully integrated 'stock structure' paper (SC/65a/SD02).
12.1.2.4		This has been partly dealt with in the fully integrated 'stock structure' paper (SC/65a/SD20) and has been discussed in the SD sub-committee during the SC/65a meeting.
12.1.2.5		To be addressed in the near future.
Biological parameters	**EM**	
Short term recommendations		
12.1.3.1		Addressed in SC/F13/SP15rev.
12.1.3.2		Addressed and changes in reproductive status were considered in papers of concern: see SC/F13/SP10rev, SC/F13/SP5rev.
12.1.3.3		To be addressed in the near future.
Feeding ecology	**EM**	
Short term recommendations		
12.1.4.1		To be addressed in the near future.
12.1.4.2		A revised paper on the diet composition was proposed (SC/F13/SP2rev).
12.1.4.3		An update of status and response to specific recommendations is given in SC/65a/EM01 and Daníelsdóttir and Ohf (2013).
Energetics	**EM**	
Short term recommendations		
12.1.5.1		A fully integrated paper has been submitted to the Scientific Committee (SC/65a/O02).
12.1.5.2		The revised paper requested (SC/F13/SP10rev) has been produced.
12.1.5.3		The revised paper requested (SC/F13/SP5rev) has been produced.
Pollution	**E, EM**	
Short term recommendations		
12.1.6.1		Addressed in SC/F13/SP22rev and SC/F13/SP23rev.
12.1.6.2		Addressed in SC/F13/SP23rev.

of the papers presented to the Workshop in accordance with suggestions of the Panel. While agreeing with most of the suggestions, the IRP scientists have not been able to fully respond to all of these within the short period determined by the review process protocol (40 days). However, the IRP plan to conclude most of these before the 2014 meeting of the Scientific Committee with a particular emphasis on those considered relevant for the upcoming RMP *Implementation Review* of North Atlantic minke whales. For example, collaboration has already been established to investigate the isotope ratios in baleen plates. Most of the suggestions from the Independent Review Panel are considered useful and constructive and will contribute to improve the research output of the Icelandic research programme and provide guidance for future research.

In addition to the original objectives of MRI (2003) the programme several additional collaborations/studies were initiated during the project, on brain anatomy, radioactivity, climate change aspects, genetic relatedness methodology, and analysis of additional pollutants.

The guidelines for review of scientific permit programmes call for special considerations of the utility of non-lethal and lethal research techniques. Such considerations constituted a special objective of the Icelandic research programme. The Independent Expert Panel welcomed the efforts of the IRP to provide data to allow a more thorough and quantitative comparison of some lethal and non-lethal techniques than has previously been possible. It agreed that this work is valuable and informative not only for future studies on North Atlantic common minke whales but also for other populations and species.

Regarding potential effects of the catches on the stock, the Panel noted that the level of catches were considerably below the level that would have been allowed under the RMP.

The presentation also highlighted the relevance of the present results to IWC Resolutions and discussions, such as marine mammal fisheries interactions (IWC, 2002), environmental changes and cetaceans (IWC, 1995; 1996b; 1999; 2000). The IRP associated scientists welcomed the recognition by the Panel of the relevance of the research programme to management issues in general and the RMP in particular.

6.3 Discussion

In discussion of these presentations, it was noted that the Expert Panel agreed that 'many aspects of the Icelandic programme were directly relevant' to a number of Commission Resolutions and noted that this information has been made available to the Scientific Committee in papers presented at Annual Meetings, including the present meeting. Some members of the Working Group expressed a different view, stating that the results from the Icelandic programme were 'potentially' relevant to Commission Resolutions. It was further expressed that the Icelandic Programme fell short of meeting the Resolution on Whaling under Special Permit (IWC, 1996a). Some members, having taken account of the Expert Review, expressed some broader critical views of the Icelandic programme and these are provided in Annex P1. A response from the proponents is given in Annex P2.

The composition of the Expert Panel was also raised in discussion, with some members of the Working Group expressing the future need for increased expertise from experts outside of the Scientific Committee. Donovan explained that this was the intention for the Icelandic programme review but the availability and/or interest of outside experts proved challenging.

Finally, while the large numbers of scientific papers stemming from the Icelandic programme were noted, the short time given to review these papers by some of the respective sub-committees was limited. However, some of these papers were presented and thoroughly discussed by RMP, SD, EM and E. Some members of the Working Group suggested that further consideration be given to how to better manage this time allocation issue in the future.

7. REVIEW OF RESULTS FROM ONGOING PERMITS

Bjørge reminded the Working Group that the Scientific Committee has decided not to discuss annual cruise reports between the periodic reviews. Therefore, the cruise reports will be very briefly summarised with time allowed for questions of clarification.

7.1 JARPN II

SC/65a/O03 presented the results of the 2012 JARPN II (Second Phase of the Japanese Whale Research Programme under Special Permit in the Western North Pacific offshore component. The survey was conducted in sub-areas 7, 8 and 9. There were three main research components: whale sampling survey, dedicated sighting survey and whale sighting and prey survey. A total of five research vessels were used: two sighting/sampling vessels (SSVs) (whale sampling survey component), one research base vessel (*Nisshin Maru*: *NM*) (whale sampling survey component), three dedicated sighting vessels (SVs) (dedicated sighting survey component) and one whale sighting and prey survey vessel (SPV) (whale sighting and prey survey component). The whale sampling survey was carried out from 16 May to 3 August 2012. A total of 2,326 n.miles was surveyed in a period of 69 days by the SSVs. A total of 86 common minke whales, 304 sei whales, 86 Bryde's whales, 218 sperm whales, five blue whales, 61 fin whales, 35 humpback whales and two right whales were sighted by the SSVs and *NM*. A total of 74 common minke whales, 100 sei whales, 34 Bryde's whales and three sperm whales were sampled by the SSVs. All whales sampled were examined on board the *NM*. Preliminary results of biological and feeding ecology analyses are presented in this document. The dedicated sighting surveys were carried out from 17 May to 30 June 2012 in sub-area 7, from 20 August to 3 October in the area between 30°N to 40°N and 140°E to 170°E (this area contains sub-areas 7, 8 and 9), and from 14 September to 1 October in sub-area 7. A total of 2,728, 5,292 and 728 n.miles were surveyed during each survey by the SVs, respectively (see details in SC/65a/O04). The whale sighting and prey surveys were carried out from 28 July to 15 August 2012. Surveys were conducted with SSVs and *NM* in a part of sub-areas 8 and 9. The purpose of this survey was to estimate habitat and prey preference of Bryde's whales and habitat preference of sei whales in relation to oceanographic and ecosystem information in those sub-areas in summer. Data obtained during the 2012 JARPN II survey will be used in the elucidation of the role of whales in the marine ecosystem through the study of whale feeding ecology in the western North Pacific.

SC/65a/O06 presented the results of the 2012 JARPN II coastal component off Kushiro, northeastern Japan (middle part of sub-area 7CN). The survey was carried out from 9 September to 28 October 2012, using four small sampling vessels. Sampling of common minke whales was made in coastal waters within 50n.miles of Kushiro port, and animals collected were landed at the JARPN II research station for biological examination. The vessels surveyed 4,843.7 n.miles (464.6 hours), encountered 95 schools (104 animals) of common minke whales, and collected 48 animals. They also obtained sightings of humpback whales (28 schools, 35 animals) and fin whales (two schools, four animals). Average body length of 27 common minke whale males was 6.09m (SD=0.94) and 5.92m (SD=1.32) for 21 females. Six males and four females were sexually mature. Three females were pregnant. Dominant forestomach prey species included walleye pollock (*Theragra chalcogramma*, 45.8%), followed by Japanese sardine (*Sardinops melanostictus*, 31.3%), mackerels (*Scomber japonicus* and *australasicus*, 6.2%), Japanese anchovy (*Engraulis japonicus*, 6.2%), Japanese common squid (*Todarodes pacificus*, 6.2%), krill (*Euphausia pacifica*, 2.1%) and unidentified fish (2.1%). The frequency of whales feeding on Japanese anchovy was much lower in the present survey, in comparison with the previous Kushiro surveys. On the other hand, Japanese sardine and mackerels were first detected from the stomach of common minke whales since the Kushiro survey was started. Japanese sardine was the second dominant species in the present survey. This coincided with an increase in fisheries catch around Kushiro, where Japanese sardine and mackerel catches increased after an interval of around 30 years.

There was a question of clarification regarding the statement on p.2 of SC/65a/O06 regarding how the cruise tracks for the coastal survey off Kushiro were designed to avoid concentrating search effort in one area. The authors explained that search areas and vessel course were determined from weather conditions, whale distribution, and information on fishing ground of coastal fisheries.

SC/65a/O07 presented results of the 2012 JARPN II coastal component off Sanriku (northeastern Japan, corresponding to a part of sub-area 7). The survey was conducted from 12 April to 26 May 2012, using four small-type whaling catcher boats as sampling vessels and one echo sounder trawl survey vessel. Sampling of common minke whales was conducted in coastal waters within 50n.miles of Ayukawa port in the Sanriku district, and all animals collected were landed at the JARPN II research station established in Ayukawa for biological examination. Sampling vessels surveyed 6,488.1n.miles (620.1 hours), and encountered 95 schools (97 individuals) of common minke whales. They also obtained sightings of humpback whales (43 schools, 58 animals) and fin whales (2 schools, 2 animals). A total of 60 common minke whales were sampled. Average body length of 29 males was 5.10m (SD=0.82) and 5.34m (SD=0.97) for 31 females. Two males and three females were sexually mature. Two females were pregnant. Dominant forestomach prey species included Japanese sand lance (*Ammodytes personatus*, 75.0%, juveniles=35.4, adults=39.6%), followed by Japanese anchovy (*Engraulis japonicus*, 14.6%) and krill (*Euphausia pacifica*, 10.4%). Whales feeding on sand lances were collected in Sendai Bay and animals having Japanese anchovy and krill were sampled outside the bay. Information on sighting distribution, biological characteristics, and prey species of whales collected during the 2012 survey was similar to that recorded before the 2011 earthquake and tsunami.

7.2 JARPA II

SC/65a/O09 presented results of the eighth cruise of the JARPA II (Second Phase of the Japanese Whale Research Programme under Special Permit in the Antarctic) survey in the 2012/13 austral summer season. The survey was conducted from 26 January to 14 March 2013 in Areas III east, IV, V west and part of Area V east. Four research vessels were used: three sighting/sampling vessels (SSV) and one research base vessel (*Nisshin Maru: NM*). The SSVs surveyed a total of 2,103.3n.miles in a period of 48 days. Unfortunately, the research activities were interrupted several times by an anti-whaling group, Sea Shepherd (SS), which directed violent sabotage activities against Japanese research vessels. This negatively affected the survey of JARPA II during the whole period. During the research period, 280 Antarctic minke whales, 412 humpback whales, 241 fin whales, six blue whales and five southern right whales were sighted. Ten sperm and 13 southern bottlenose whales were also sighted. Photo-id was conducted on three blue whales, seven humpback whales and one southern right whale. Three skin biopsy samples were collected from humpback whales. Oceanographic surveys were conducted at 55 points using XCTD to investigate vertical sea temperature and salinity profiles. A total of 103 Antarctic minke whales were sampled by the SSVs. All whales sampled were examined on board the research base vessel. The main results of this survey can be summarised as follow:

(1) humpback whales were widely distributed in the research area with a higher density index than that of the Antarctic minke whales in all areas except in the Prydz Bay;
(2) the ice-free extent of the research area was substantially larger than in past seasons;
(3) mature female Antarctic minke whale were observed only in the Prydz Bay; and
(4) all Antarctic minke whales sampled in Area IV east were immature animals.

7.3 Planning for periodic review of results from JARPA II

JARPA II is due for a period review during the next inter-sessional period. According to 'Annex P', the pro-ponents should submit a document expanding the data to be made available to the Workshop one Annual Meeting prior to the Review Workshop. This information is provided in SC/65a/O08.

SC/65a/O08 summarised the data available for the next JARPA II Review Workshop to be held by the Scientific Committee early in 2014. The summary was made for the six first surveys of JARPA II (2005/06-2010/11). The summary of the data followed the guidelines of Annex P:

(a) outline of the data that will be available;
(b) references to data collection and validation protocol;
(c) references to documents and publications of previous analyses; and
(d) contact details.

Data in SC/65a/O08 were summarised into the following sections:

(a) data for abundance estimate for several baleen and toothed whale species;
(b) ecological data;
(c) biological, feeding ecology, pollutant and stock structure data of Antarctic minke whale;
(d) biological, feeding ecology, pollutant and stock structure data of fin whale; and
(e) stock structure data of other species.

Details of these data are shown in Annex P5.

The next step of the review process is that the proponents make data available in electronic form one month after the end of the Annual Meeting. Then the proponents will send a document to the Secretariat describing the analytical methods to be discussed at the Workshop. This will happen nine months prior to the next Annual Meeting; that is the beginning of September. Based on the description of analytical methods, the Chair, Vice Chair and Head of Science, in consultation with the SWG involved in this process, will start to identify experts to participate in the Workshop.

Some members of the Working Group expressed the need to initiate new discussions concerning Annex P, especially in light of the planning for periodic review of results from JARPA II.

8. GENERAL COMMENTS REGARDING SPECIAL PERMIT WHALING

Some members of the Working Group expressed concern that a lack of review and comment outside the periodic reviews under Annex P should not be interpreted as an indication that any of the serious scientific concerns expressed about Special Permit whaling programmes have been addressed. This statement is included as Annex P3. Other members opposed this view and their statement is included as Annex P4.

9. REVIEW OF NEW OR CONTINUING PROPOSALS

There are no new proposals for Special Permit whaling or any changes to JARPA II or JARPN II. Therefore there was no discussion under this agenda item.

10. ADOPTION OF REPORT

The report was adopted at 11:00 on 10 June 2013. The Working Group thanked Bjørge for his chairmanship.

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Appendix 1

AGENDA

1. Election of Chair
2. Appointment of rapporteur
3. Adoption of Agenda
4. Available documents
5. Review report of Workshop for Icelandic Scientific Permit whaling
6. Review of results from ongoing permits
   6.1 JARPN II
   6.2 JARPA II
   6.3 Planning for a periodic review of results from JARPA II beginning September 2013
7. Review of new or continuing proposals
   7.1 JARPA II
   7.2 JARPN II
8. Adoption of Report

ANNEX P1

A CONTRIBUTION TO THE REVIEW OF ICELAND'S PROGRAMME OF WHALING UNDER SPECIAL PERMIT

R. Leaper, B. Roel, W. de la Mare, M. Double, S. Childerhouse and N. Gales

Introduction and background

The intention here is to provide a summary of the views of the authors to contribute to the Scientific Committee's review of Iceland's programme of whaling under special permit.

Paragraph 30 of the Schedule to the *International Convention for the Regulation of Whaling 1946*, specifies the role of the Scientific Committee in reviewing special permits issued by any country. In order to assist the Committee in its review function an Expert Panel (SC/65a/Rep03) has provided its conclusions and advice on Iceland's programme, and this has informed our view.

We examine the programme as a whole by comparing the presented outcomes with the programme's objectives, taking into account comments arising in the Scientific Committee addressing the original Icelandic proposal, the criteria set out in Annex P and the Expert Panel's Review. Given that the programme was originally described as a feasibility study, we also comment on whether the broad objectives that were to be evaluated for feasibility were in fact demonstrated to be feasible.

Comments from Scientific Committee on the original proposal

Given that the Committee is now reviewing Iceland's overall programme, it is appropriate to recall comments from the Scientific Committee when the original proposal was reviewed (IWC, 2004, p.40-47):

> 'Some members questioned whether the proposal could appropriately be described as a feasibility study, as there is a large amount of relevant information pertaining from previous studies, and this information should have been sufficient to draw up a more complete proposal. Furthermore, the performance criteria were not specified. Those members concluded that initiating the research on a feasibility basis is therefore not justified and the proponents should be encouraged to prepare a full research proposal that can be reviewed properly next year.
>
> The question was again posed regarding performance criteria in the study. Specifically, the proponents were asked to provide, for any aspect of this feasibility study, an indication of results that would cause them to conclude that the proposed research was not feasible. The proponents re-iterated that they, for example, will determine if it is practical or not, based on whether a clear picture of feeding ecology and life history can be obtained. Some members did not consider this to be an adequate answer to the question raised.
>
> Other members welcomed the research initiative recognising that the overall objective of the programme is to increase understanding of the biology and feeding ecology of important cetacean species in Icelandic waters for improved management of living marine resources based on an ecosystem approach. However they noted that the proposal says too little about the future project that this feasibility study is intended to lead into. An ambitious long term programme might be inferred from the proposed feasibility study, but they suggested that an explicit formulation of this intended study would have been helpful to set the feasibility study in context.
>
> In response the proponents stated that the question of whether the proposal is called a feasibility study or a two-year pilot project of a full scale research programme is merely semantic. The proponents felt that it is clear that the ultimate objectives of the investigations will not be met within the two year time frame, but the results will undoubtedly clarify the situation and provide guidance on how to proceed with these fundamental questions upon the completion of the feasibility period.
>
> Concerns were expressed on insufficient plans to integrate prey research with stomach content sampling, as prey abundance and distribution from regular resource surveys would not be adequate to assess prey selectivity patterns on the micro-scale. Further, it was noted that the sampling of the common minke whale would occur primarily in regions of overlap with cod distribution, and that such samples will not provide information about what the common minke whales eat elsewhere. They felt therefore that large scale information about the prey base, is however not sufficient to assess prey selectivity among individual whales or small groups of whales at the micro-scale. Other members pointed out that estimating the functional responses of these predators at various temporal and spatial scales is theoretically a daunting but not impossible, task.'

The comments from the 2003 meeting make it clear that the Committee as a whole took the view that they lacked a sufficiently detailed proposal of what the feasibility study was intended to lead to, and this – by definition – meant that the review lacked the required criteria by which to undertake the review.

The final Review

General: objectives and sampling design

The justification for the programme was described in 2003 that 'for improved ecosystem based management of fisheries in Icelandic waters, there is an urgent need to increase knowledge on the role of cetaceans in the marine ecosystem in Icelandic waters' (Marine Research Institute, 2003). However, given the clarification in SC/F13/SP1 that the study was 'never expected to give definite answers to the research questions raised' it is not clear to what extent the programme that was completed in 2007 was intended to meet the stated objective of providing input into advice for improved management of living marine resources based on an ecosystem approach, or just as a basis on which to design a future sampling scheme. The Expert Panel repeatedly emphasised that the characterisation of the programme 'as a feasibility/pilot study made it difficult to fully review how well the programme could be said to have met its own objectives'.

If the data from the feasibility study are to be used in their own right rather than just to inform the design of future studies then the adequacy of sampling design needs further consideration. The Panel did agree (SC/65a/Rep03) that the method used to obtain representative samples was 'probably sufficient for a feasibility study'. However the Panel did not comment on the adequacy of design for any other uses. We share their concerns over sampling design and believe it would be necessary to review all the issues with the sampling design before any of the results could be used for input into ecosystem models.

Further to the sampling design issues noted by the Panel there are a number of issues which we believe make the data problematic.

(1) The shift in sampling numbers between the south and the north based on the results obtained part way through the study is problematic when the distribution of whales and prey is also changing between years.

(2) Sampling the first whale encountered after leaving port inevitably biases the sampling distribution towards the coast. Although this was addressed to some extent by stratifying by depth (greater or less than 100m) this was only done after more than half the whales had been taken and only in some areas.

(3) If whales are in aggregations then sampling the first whale encountered will bias samples towards whales on the edge of the aggregation. If whales are interacting such whales may consistently have different feeding opportunities to those more often found towards the middle of the aggregation (for example if the aggregation is centred on the most dense area of prey).

The Panel also note that the multi-species modelling approach is 'as yet poorly developed'. They note that the lack of even a simple model for 'evaluating how sensitive results are to different levels of uncertainty and determining appropriate sample sizes' is a 'major weakness' of the programme. Indeed, it is our strong view that an ecosystem model should represent the starting point from which any genuine research programme that aims to provide ecosystem model parameters should start. Not, as in the case of Iceland, to start with a programme built around lethal sampling of one element of an ecosystem, and then attempt to build a model from that basis.

When the programme was discussed by the Scientific Committee in 2003 the proponents commented that they would judge feasibility based on whether 'a clear picture of feeding ecology can be obtained' (IWC, 2004). A decade later, the lack of progress on modelling and concerns over sampling design mean that there is still no clear picture of the feeding ecology of minke whales around Iceland and so there would appear to be a consensus that the feasibility of this type of study has still not been demonstrated.

Annex P review criteria

The review of Iceland's programme has occurred under Annex P, including the review by the Expert Panel. Annex P is explicit in its terms of reference (IWC, 2009) and provides the framework on which the work should be reviewed. Despite this, in the papers prepared for the final review, and for this meeting, Iceland has not described how the research has met or will contribute to meeting the applicable 'Annex P' criteria.

Importantly:

- Iceland has not described how the information gained will contribute to the 'conservation and sustainable use of cetaceans';
- none of the information gained from the catches is necessary for the application of the RMP; and
- information on stock structure via genetic sampling could have been pursued by non-lethal means.

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ANNEX P2

RESPONSE TO ANNEX P1 CONCERNING THE ICELANDIC MINKE WHALE RESEARCH PROGRAMME

G.A. Víkingsson, C. Pampoulie, Th. Gunnlaugsson and B. Th. Elvarsson

Leaper *et al* (see Annex P1) provide their evaluation of the Icelandic research programme on common minke whales with reference to the objectives of the programme, previous discussions in the Scientific Committee, the criteria in Annex P and in light of the report of the Expert Panel (EP) (SC/65a/Rep03). We find their Review to be biased in many aspects, in particular those related to the interpretation of previous discussions within the Scientific Committee and the content of the report to the EP.

Sampling and research design

As clearly stated in the original research programme the sampling design was based on the Bormicon (later GADGET) multi-species framework developed for Icelandic waters in the 1990s (Stefánsson and Pálsson, 1997). More specifically, the design was based on preliminary multi-species modelling exercises including three species of cetaceans (Stefánsson and Pálsson, 1998; Stefánsson *et al.*, 1997) as well as other studies of multi-species interactions in this ecosystem (Magnússon and Pálsson, 1989; 1991). Therefore the description of the approach taken when designing the feeding ecology/multi-species part of the programme (i.e. that the design was not built on previous multi-species modelling work) is incorrect. The delay in further development of the multi-species modelling part of the programme is indeed unfortunate, but was due to practical reasons beyond the control of the proponents.

Some selected sections of the report from the Scientific Committee discussions in 2003 (IWC, 2004, p.40-47) are taken together as a support to the authors' view that the whole Scientific Committee had a unified view concerning the feasibility aspect of the research proposal. The divided views expressed in the Scientific Committee report (IWC, 2004, p.40-47) clearly indicate that this was not the case. However, we appreciate the view of the EP that some aspects of the programme were difficult to fully evaluate with the guidelines in Annex P. However, as the EP notes, these guidelines were developed and agreed after the implementation of the Icelandic research programme.

The authors of Annex P1 choose to interpret the conclusion of the EP that the sampling design is sufficient for a feasibility study (which the programme actually is) to mean that the programme (and thus the data resulting from the programme) is not sufficient for any other uses. This interpretation is highly inconsistent with the views of the EP as expressed throughout their report regarding the value of the data presented and analyses performed. However we are well aware that data from a feasibility/pilot study like this with a sample size of only 190 animals must be interpreted with caution.

The authors of Annex P1 considered the shift in sampling numbers between south and north based on preliminary results from the feeding study to be problematic. As explained in our response paper (SC/65a/SP01) this was due a pronounced difference in diet composition between the areas north and south of Iceland with much higher diversity in the northern areas. The purpose of increasing sample size in the northern areas was to decrease variation in the estimated diet composition in these areas. As all relevant analysis (e.g. of consumption rates) will be related to abundance in these subareas this change will not bias the results.

The authors of Annex P1 are concerned over the alleged strategy during the initial years of the study to sample 'the first whale encountered after leaving port'. This statement is based on misunderstanding as this was not the strategy applied in the programme. The strategy applied was to target the first whale encountered after entering a pre-determined small area. This was to avoid selective sampling, i.e. to avoid catching the most accessible whales.

Contrary to the views expressed in Annex P1, we believe that the programme has already appreciably increased our knowledge on feeding ecology of common minke whales in Icelandic waters. This in in accordance with the view of the following conclusion of the EP (SC/65a/Rep03, p.20):

> 'However it is clear that knowledge of the feeding ecology of common minke whales has been advanced through a variety of approaches including stomach contents, fatty acid and stable isotope analyses and the collection of data that can be used to inform a more systematic than usual examination of the results that can be obtained from lethal and non-lethal methods.'

In addition to the originally stated objectives, this study has provided important information on the changes occurring in Icelandic waters during the last decade. For example, the observed changes in diet of minke whales during 2003-07 conform well with decrease in abundance of sand-eel and capelin, breeding failure of puffin and other seabirds as well as with decreased abundance of minke whales themselves.

Relevance to the RMP and IWC resolutions and discussions

With reference to the guidelines in Annex P (which were written and agreed after the Icelandic programme) the authors of Annex P1 conclude that Iceland has not described how the information gained from the programme will contribute to the conservation and sustainable use of cetaceans in general and to the RMP in particular. This is contrary to view expressed in the report of the Expert Panel, which made the following conclusions regarding RMP.

Overall, the Panel **agreed** that the Icelandic survey data have improved knowledge about the abundance and distribution of the common minke whale in Icelandic waters, both for use in the RMP and for input to potential multispecies modeling (SC/65a/Rep03, p.10).

The Panel **agreed** that the proponents have conducted and reported research that addresses both of the objectives related to stock structure. The data collected and the analyses presented will provide valuable information relevant to the forthcoming RMP *Implementation Review* of North Atlantic common minke whales and the planned joint AWMP/RMP Workshop on the stock structure of this species in the region (SC/65a/Rep03, p.13).

In addition to the work related to ecosystems and environmental change discussed above, the Panel **agreed** that the work on stock structure and abundance was directly relevant to the Scientific Committee's work on the Revised Management Procedure, in particular with respect to the forthcoming *Implementation Review* for North Atlantic common minke whales and the joint RMP/AWMP Workshop on stock structure of common minke whales throughout the North Atlantic.

The Panel also **agreed** that many aspects of the programme were directly relevant to IWC resolutions and noted that this information has been made available to the Scientific Committee in papers presented at Annual Meetings as well as the present Workshop (SC/65a/Rep03, p.33).

Noting the importance of migration rates to the RMP and AWMP approaches, the Panel **especially welcomed** the efforts made to undertake the kinship analyses with the Norwegian samples and it encouraged further co-operative work in this regard throughout the North Atlantic. (SC/65a/Rep03, p.13).

In addition the EP made several recommendations for further analyses of the data from the programme for submission to the RMP *Implementation Review.*

Regarding the special objective of examining the utility of lethal and non-lethal techniques the EP made the following conclusion (SC/65a/Rep03, p.33-34):

> 'The Panel welcomed the efforts of the Icelandic programme to provide data to allow a more thorough and quantitative comparison of some lethal and non-lethal techniques than has previously been possible (see recommendation in IWC, 2010). It agreed that this work is valuable and informative not only for future studies on North Atlantic common minke whales but also for other populations and species (SC/65a/Rep03, p.33)'.

These conclusions of the EP clearly indicate that the output of the research programme is relevant both directly with respect to the RMP and other IWC resolutions and discussions.

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ANNEX P3

COMMENTS BY SOME MEMBERS ON THE SPECIAL PERMIT WHALING PROGRAMMES: GENERAL COMMENTS

Over the past few years the Scientific Committee has focused its discussions on whaling under Special Permit on methods to evaluate new, existing and terminating programmes (known as 'Annex P'). Notwithstanding the issues raised in relation to whether or not 'Annex P' has led to an improved review process some members are concerned that a lack of review and comment outside the periodic reviews under 'Annex P' should not be interpreted as an indication that any of the serious scientific concerns expressed about special permit whaling programmes have been addressed. These members recognise that it is not a good use of the Committee's time to repeat previous discussions.

These members wish to reiterate the view that the special permit programmes conducted by the Government of Japan (JARPN, JARPN II, JARPA and JARPA II), and the recent programme conducted by the Government of Iceland have not provided results relevant to the IWC and are unnecessary for the conservation and management of whales. Further, while the Committee has had to disrupt its work on other important, genuinely scientific issues to discuss special permit proposals that claimed an urgent need for research, this has not always been reflected in timely presentation of results. This is all the more serious due to the serious potential impact of these open-ended programmes on the status of some whale populations.

These members make reference to the extensive discussions in previous reports of the Scientific Committee that highlight many substantial, general and specific objections to the purpose and operation of Special Permit whaling programmes and their lack of any genuine response to scientific review processes. Whilst the Scientific Committee has on occasion referred to the *potential* relevance of some lethally-acquired data, that potential has never been realised and we believe it unlikely to be realised on any important issue. Moreover, the Scientific Committee has never stated that data from Special Permit whaling programmes are required for its identified research needs, or otherwise for the conservation and management of whales. The current whaling programmes that operate under special permit (JARPA II and JARPN II) continue to kill whales without any defendable scientific rationale or purpose.

ANNEX P4

RESPONSE BY OTHER MEMBERS TO ANNEX P3

It is unfortunate that the political controversy surrounding the Special Permit programmes has been making the scientific discussions at the IWC Scientific Committee unnecessarily difficult and confrontational. The Scientific Committee has been striving to make its working methods related to the Special Permit programmes less controversial by introducing such tools as Annex P. The proponents of the Special Permit programmes share the general desire of the Scientific Committee to make the discussions more scientific and constructive and have been cooperating in designing and following the agreed procedures, such as Annex P and Schedule paragraph 30, to improve the situation.

The scientific contributions of the Special Permit programmes have been recognised and duly recorded in the reports of the Scientific Committee. In the same way as other scientific discussions, conflicting views have been recorded in those reports. As long as they represent constructive scientific discussions, existence of conflicting views is quite useful for the progress of science. We therefore view the recognition of potential scientific contribution as positive evaluation of the programmes. While we do strive to make timely progress, we also recognise some tasks require long-term efforts. Decades of work before achieving scientific objectives are not uncommon, including in the field of population ecology.

We would also like to note that the proponents of the Special Permits have been faithfully responding to constructive scientific suggestions and critiques. Numerous 'homeworks' from the Scientific Committee have been responded to and resolved as recorded in the past reports of the Scientific Committee.

Because of the reasons above, we disagree with the views expressed in Annex P3.

ANNEX P5

DATA AVAILABLE FOR THE JARPA II REVIEW WORKSHOP (JARPA II SURVEYS 2005/06-2010/11) THROUGH THE DATA AVAILABILITY GROUP (DAG) AND PROCEDURE B*

Table 1

Data available for the JARPA II Review Workshop.

	Seasons	Sample size
Abundance estimate several species		
1. Angle and distance experiments	2005/06-2010/11	2,617 tests
2. Ice edge line	2005/06-2010/11	4,234 points
3. Effort data	2005/06-2010/11	43,161 activities
4. Weather data	2005/06-2010/11	34,694 records
5. Sighting Antarctic minke whale	2005/06-2010/11	7,344 schools
6. Sighting fin whale	2005/06-2010/11	605 schools
7. Sighting humpback whale	2005/06-2010/11	4,570 schools
8. Sighting blue whale	2005/06-2010/11	146 schools
9. Sighting southern right whale	2005/06-2010/11	150 schools
10. Sighting sperm whale	2005/06-2010/11	894 schools
11. Sighting southern bottlenose whale	2005/06-2010/11	310 schools
12. Sighting killer whale	2005/06-2010/11	352 schools
Ecological data (oceanographic, marine debris, krill)		
13. Temperature (XBT)	2005/06-2010/11	18 stations
14. Temp. salin. (XCTD)	2005/06-2010/11	347 stations
15. Temp. salin. (CTD)	2005/06-2010/11	361 station
16. Temp. salin. (EPCS)	2005/06-2010/11	482 days
17. Marine debris (stomach)[2]	2005/06-2010/11	3,280 whales
18. Marine debris (sea surface)	2005/06-2010/11	88 cases of debris observations
19. Echo sound (krill abundance/dist.)	2007/08-2008/09	326 days
20. IKMT net	2007/08-2008/09	68 stations
21. Body length krill	2007/08-2008/09	68 stations
Antarctic minke whale (biological, feeding ecology, pollutants, stock structure data)		
Biological data		
22. Catching date	2005/06-2010/11	3,264 whales
23. Catching location	2005/06-2010/11	3,264 whales
24. Sex	2005/06-2010/11	3,264 whales
25. Body length	2005/06-2010/11	3,264 whales
26. Age (earplug)[3]	2005/06-2010/11	3,264 whales
27. Age (racemization)[4]	2005/06-2010/11	41 whales
28. Transition phase[5]	2005/06-2010/11	3,264 whales
29. Presence/absence of corpora[6]	2005/06-2010/11	1,701 whales
30. Testis weight[7]	2005/06-2010/11	1,563 whales
31. Foetus length	2005/06-2010/11	1,127 whales
32. Foetus weight	2005/06-2010/11	1,127 whales
33. Foetus number[8]	2005/06-2010/11	1,701 whales
34. Foetus sex	2005/06-2010/11	1,127 whales
35. Lactation condition	2005/06-2010/11	1,701 whales
Feeding ecology/energetics		
36. Blubber thickness (two points)	2005/06-2010/11	3,264 whales
37. Body weight	2005/06-2010/11	1,598 whales
38. Freshness stomach contents	2005/06-2010/11	1,925 whales
39. Main prey	2005/06-2010/11	332 whales
40. Organ weight including fat weight	2005/06-2010/11	82 whales
41. Girth (two points)	2005/06-2010/11	3,264 whales
42. Stomach content (IWS)	2005/06-2010/11	3,264 whales
43. Stomach content weight	2005/06-2010/11	2,953 whales
44. Lipid content in blubber	2005/06-2010/11	35 whales
Pollutants/health[9]		
45. Heavy metals (whale)	2005/06-2010/11	195 whales
46. Organochlorine (whale)	2005/06-2010/11	10 whales
47. Heavy metal (prey)	2005/06-2010/11	20 preys
48. Gross pathological observations of internal organs[10]	2005/06-2010/11	3,264 whales
Stock structure		
49. Body proportion (8 measurements)	2005/06-2010/11	3,264 whales
50. mtDNA (sequences) (from catches)	2005/06-2010/11	1,803 whales
51. mtDNA (RFLP) (from catches)	2005/06	764 whales
52. Microsatellite DNA (from catches)	2005/06-2010/11	2,553 whales

Cont.

	Seasons	Sample size
Antarctic fin whale (biological, feeding ecology, pollutants, stock structure data)		
Biological data		
53. Catching date	2005/06-2010/11	17 whales
54. Catching location	2005/06-2010/11	17 whales
55. Sex	2005/06-2010/11	16 whales
56. Body length	2005/06-2010/11	16 whales
57. Age (earplug)[3]	2005/06-2010/11	16 whales
58. Transition phase[5]	2005/06-2010/11	16 whales
59. Presence/absence of corpora[6]	2005/06-2010/11	8 whales
60. Testis weight[7]	2005/06-2010/11	8 whales
61. Foetus length	2005/06-2010/11	3 whales
62. Foetus weight	2005/06-2010/11	3 whales
63. Foetus number[8]	2005/06-2010/11	8 whales
64. Foetus sex	2005/06-2010/11	3 whales
65. Lactation condition	2005/06-2010/11	8 whales
Feeding ecology/energetics		
66. Blubber thickness (14 points)	2005/06-2010/11	16 whales
67. Body weight	2005/06-2010/11	15 whales
68. Freshness stomach contents	2005/06-2010/11	14 whales
69. Main prey	2005/06-2010/11	15 whales
70. Organ weight including fat weight	2005/06-2010/11	15 whales
71. Girth (three points)	2005/06-2010/11	16 whales
72. Stomach content (IWS)	2005/06-2010/11	16 whales
73. Stomach content weight	2005/06-2010/11	15 whales
74. Lipid content in blubber	2005/06-2010/11	10 whales
Pollutants/health[9]		
75. Heavy metals (whale)	2005/06-2010/11	16 whales
76. Organochlorine (whale)	2005/06-2010/11	16 whales
77. Gross pathological observations of internal organs[10]	2005/06-2010/11	16 whales
Stock structure		
78. External measurements (41)	2005/06-2010/11	16 whales
79. mtDNA (sequences) (catches and biopsy)	2005/06-2010/11	C: 17; B: 13 whales
80. Microsatellite DNA (catches and biopsy)	2005/06-2010/11	C: 17; B: 13 whales
Stock structure other species		
Humpback whale		
81. mtDNA (sequences) (biopsy)	2005/06-2010/11	133 whales
82. Microsatellite DNA (biopsy)	2005/06-2010/11	0 whales[11]
83. Photo-id data	2005/06-2010/11	1,201 pictures
Blue whale		
84. mtDNA (sequences) (biopsy)	2005/06-2010/11	11 whales
85. Photo-id data	2005/06-2010/11	376 pictures
Southern right whale		
86. mtDNA (sequences) (biopsy)	2005/06-2010/11	34 whales
87. Microsatellite DNA (biopsy)	2005/06-2010/11	34 whales
88. Photo-id data	2005/06-2010/11	671 pictures

*Data for the items in this table are also available for the JARPA period (1987/88-2004/05), which were reviewed by the Scientific Committee in 2006. **Data associated with track-line and distances from the ice-edge in JARPA and JARPA II will be available, if possible.

Annotations

1. Standard Line Transect data. It should be noted that in some JARPA II surveys some areas could not be covered due to external interferences and sabotages from anti-whaling groups, and that some kind of extrapolation will be necessary.
2. The figure given corresponds to the total number of stomachs examined.
3. JARPA II age data of Antarctic minke whale were obtained by a new reader with expertise and training enough for this kind of work. The figure given here are the total number of earplugs examined. Age information could be obtained for 81.8% of the tota samples. An ageing calibration exercise was carried out (Kitakado *et al.*, in press). In the case of the fin whales age information could be obtained for 100% of the samples.
4. This sample size corresponds to the results of a pilot study to investigate the feasibility of the racemisation method for ageing purposes. At this stage these data were not produced for the purpose of biological parameters estimates but for examining the feasibility of the technique.
5. The figure given corresponds to the total earplugs examined. Transition Phase information in the Antarctic minke whales could be obtained for approximately 42.1% of the total samples (mature+immature). In the case of the fin whales transition phase information could be obtained for one animal out of 16.
6. Ovary samples were lost as an effect of the 2011 earthquake and tsunami so information on the number of corpora is not available. Information on the presence/absence of corpora (information necessary for determining sexual maturity in females) is based on examination of the ovaries conducted at the field.
7. While in JARPA both testis weight and histological approaches were used for determining sexual maturity in males, in JARPA II maturity of males was determined only by the testis weight criterion (due to 'man-power' limitation and economical considerations).
8. The figure given corresponds to the total females examined.
9. The 2011 earthquake and tsunami affected heavily the samples collected for pollutant studies. This explains the particular smaller samples size for this item.
10. This figure corresponds to the total number of whales examined for abnormal tissues or organs in gross pathology.
11. It is possible that some microsatellite data are produced at a later stage. People interested in genetic data for stock structure studies of humpback whales should consult the person in charge directly.

REFERENCE

Kitakado, T., Punt, A.E. and Lockyer, C. In press. A statistical model for quantifying age-reading errors and its application to the Antarctic minke whales. *J. Cetacean Res. Manage.* In press.

Annex Q

Report of the *Ad hoc* Group to Develop a List of 'Accepted' Abundance Estimates

Members: Brockington, Brownell, Butterworth, Donovan, Hammond, Kitakado

A small *ad hoc* group met to make progress on developing a list of 'accepted' abundance estimates. The aim of this exercise is to collate information on abundance estimates accepted by the Committee for various purposes in a consistent way and to use that to provide a simplified table of estimates suitable as a broad overview for the Commission and the public.

1. TABLE OF ACCEPTED ABUNDANCE ESTIMATES FOR COMMITTEE USE

The *ad hoc* group considered the information provided under the relevant agenda item for each sub-group together with similar information from last year's meeting. It identified some apparent gaps but agreed that the information provided could be presented consistently in a single table to represent an initial summary of the Committee's current set of 'accepted' abundance estimates. A simple example first draft of one group of entries is given below as Table A. However, the *ad hoc* group believed that producing the single table and ensuring consistency requires more careful attention than is available at this meeting. In particular, it wishes to examine the comments and examine commonalities that may make the table more consistent.

2. BROAD OVERVIEW TABLE FOR THE COMMISSION AND GENERAL PUBLIC

The *ad hoc* group also considered the most appropriate way to create another table that provided a broad overview for the Commission. It agreed to order estimates by species, then ocean basin, then specific area, as appropriate. It also agreed that estimates for disjoint areas should be summed if they were from the same year or years close together in time. Approximate 95% confidence intervals for summed estimates should be calculated from the CVs of the estimates and assuming a log-normal error distribution. Any additional variance would be ignored for this purpose.

Only the most recent estimates for a species and ocean basis should be given. Information on trend should be considered as an additional step to be pursued in the future, recognising the need for more consideration *inter alia* of information from modelling exercises. Again, the *adhoc* group believed that producing the overview table and ensuring consistency required more careful attention than is available at this meeting.

3. A WAY FORWARD

The *ad hoc* group agreed that the most appropriate way to make progress on further development of Table A and the overview table was to establish an intersessional Working Group that would consider all doubtful and potentially missing estimates and report to next year's Annual Meeting. The membership of this Working Group should comprise members representative of the Committee's relevant sub-groups and those familiar with methods for estimating abundance. That group will also produce a draft strategy for discussion at the next Annual Meeting for a process to ensure:

(a) regular updating of the tables; and
(b) a strategy to ensure consistency of the review of abundance estimates across sub-committees and working groups.

The objective is for this group to complete its work and circulate draft tables by the beginning of January 2014.

Table A
An example.

Population	Area	Category	Evaluation extent	Year	Method	Corrected	Estimate and approx. 95% CI and CV	IWC reference	Original reference	Comments
Common minke whale										
West Greenland	West Greenland	1	1	2007	DS	A+P	16,100 (6,930-37,400) (CV:0.43)	IWC (2010) SC/65a	Heide-Jørgensen *et al.* (2010b)	Known not to cover all population
West Greenland	West Greenland	1	1	2005	DS	A+P	10,790 (3,400-34,300) (CV:0.59)	IWC (2008)	Heide-Jørgensen *et al.* (2008)	Known not to cover all population
West Greenland	West Greenland	1	1	1993	DS	A	8,370 (3,600-19,440) (CV:0.43)	IWC (1995)	Larsen (1995)	Known not to cover all population

Key to table columns

Species
Use IWC list.

Population
This will depend on whether the sub-group has assigned populations/sub-stocks.

Area
This will depend on whether there are identified *Areas* in an RMP context but otherwise it is best to use broad categories and indicate whether total or partial coverage.

Category
As described above use either:

(1) acceptable for use in in-depth assessments or for providing management advice;
(2) underestimate - suitable for 'conservative' management but not reflective of general abundance; or
(3) while not acceptable for use in (1), adequate to provide a general indication of abundance.

In each case if not clear add an asterisk that the estimate needs to be considered further.

Evaluation extent
Degree to which the estimate was considered originally by the sub-group. Use:

(1) examined in detail;
(2) partially but method standard;
(3) unclear but method standard;
(4) partially and new method; or
(5) unclear and new method.

Year (to which estimate applies)
This will normally be the year of the survey unless the estimate is based on multiple years or an assessment model.

Method
E.g. distance-sampling; mark-recapture; spatial modelling; 'population assessment, 1+' – use DS, MR, SM, PA.

Corrected
Where applicable, indicate if corrected for availability and/or perception bias (A, P or A+P).

Estimates and intervals
Give approx. 95% confidence intervals (or equivalent) rounded to three significant figures of upper limit.

IWC reference
Give the reference to where discussed in the Scientific Committee.

Original reference
Give the reference of the originally presented analysis.

Comments
Any difficulties encountered.

Annex R

Email Correspondence Groups and Terms of Reference

Group		Terms of Reference	Membership
(1)	North Atlantic fin whales *IST*s (Steering Group)	Develop revised specifications for the North Atlantic fin whale trials.	Elvarsson (Convenor), Allison, Butterworth, Donovan, Gunnlaugsson, Punt, Witting.
(2)	Common minke whales (Working Group)	Prepare for joint AWMP/RMP Workshop on the stock structure of common minke whales in the North Atlantic.	Palsbøll (Convenor), Donovan, Glover, Pampoulie, Punt, Tiedemann, Skaug, Waples, Witting.
(3)	North Atlantic sei whales (Steering Group)	Review the available data for North Atlantic sei whales in the context of a *pre-Implementation assessment* and provide a report to the 2014 Annual Meeting.	Víkingsson (Convenor), Donovan Hammond, Øien, Palka, Palsbøll.
(4)	North Atlantic fin whale genetic studies (Steering Group)	Develop work on genetics studies on samples from the entire North Atlantic and ensure it is completed before the next *Implementation Review*.	Pampoulie (Convenor), Witting, Palsbøll, Skaug.
(5)	Amendments to the *CLA* (Working Group)	Formulate and run trials related to environmental degradation, taking account of the discussions in EM and report the results to the 2013 Annual Meeting.	Allison (Convenor), Butterworth, Cooke, de la Mare, Donovan, Punt, Walløe.
(6)	North Atlantic minke whale *Implementation Review* (Steering Group)	Co-ordinate planning for the 2014 *Implementation Review* of North Atlantic minke whales.	Walløe (Convenor), Butterworth, Donovan, Palsbøll, Punt, Víkingsson, Witting.
(7)	North Atlantic fin whales (Steering Group)	Examine the final modelling framework and trial specifications for North Atlantic fin whales being developed intersessionally including at an RMP intersessional Workshop and examine how this can be incorporated into *SLA* development.	Donovan (Convenor), Allison, Butterworth, Gunnlaugsson, Víkingsson.
(8)	West Greenland trials (Steering Group)	Finalise the trials for the West Greenland humpback and bowhead whales (including coding) to allow developers to work intersessionally. Ensure that standard software is available to produce agreed performance statistics, as well as tabular and graphical output.	Donovan (Convenor), Punt, Givens, Butter-worth, Witting.
(9)	NPM minke whale *Implementation* (Steering Group)	Co-ordinate the work needed to determine whether the abundance estimates marked with asterisks can be accepted for use in actual applications of the RMP.	Butterworth (Convenor), Allison, An, Baker, de Moor, Donovan, Double, Kanda, Kelly, Kitakado, Miyashita, Park, Pastene, Punt, Wade.
(10)	NPM research proposals (Advisory Group)	Provide feedback to those developing research programmes during the intersessional period.	Butterworth (Convenor), Allison, An, Baker, de Moor, Donovan, Double, Gaggiotti, Hoelzel, Kanda, Kelly, Kitakado, Miyashita, Park, Pastene, Punt, Wade, Waples.
(11)	Ship strike review (Working Group)	Continue to work on topics including data standardisation, database handbook and definitions of strikes.	Leaper (Convenor), Brownell, Cañadas, Donovan, Double, Ferguson, Holm, Mattila, Panigada, Ritter, Rowles.
(12)	Human induced mortality (Working Group)	Identify issues for priority attention within a longer-term plan of work.	Double (Convenor), Brockington, Leaper, Mattila, Ritter, Rowles, Schweitzer.
(13)	North Pacific gray whale review Workshop (Steering Group)	Prepare for a Workshop on range-wide review of the population structure and status of North Pacific gray whales.	Donovan (co-Convenor), Punt (co-Convenor) [other members to be decided by July].
(14)	Assessment of humpback whale Breeding Stocks D/E/F (Working Group)	To coordinate and facilitate the completion of assessment modelling recommended in Item 3.1.2.	Ross-Gillespie (Convenor), Butterworth, Double, Holloway, Jackson, Holloway, Kitakado, Pastene, Robbins, Zerbini.
(15)	Abundance estimates of Breeding Stock D humpback whales (Working Group)	To obtain a minimum abundance estimate of Breeding Stock D, possibly through strip-transect methodology, and investigate the sensitivity of data selection.	Zerbini (Convenor), Butterworth, Double, Hedley, Ross-Gillespie, Hammond, Holloway, Palka,, Salgado-Kent.
(16)	Pre-meeting to complete the assessment of humpback whale Breeding Stocks D/E/F (Steering Group)	To plan a pre-meeting Workshop to facilitate the completion of the assessment of Breeding Stocks D/E/F at SC/65b.	Robbins (Convenor), Butterworth, Double, Jackson, Zerbini.
(17)	Sperm whale assessment (Working Group)	Identify data availability and needs to undertake a future assessment of sperm whales. Information would be sought in the following categories: (1) population structure within ocean basins; (2) population size within ocean basins/abundance in smaller areas; (3) catch history; and (4) consideration of the development of a new assessment model.	Brownell (Convenor), Baker, Bannister, Bell, de la Mare, Hoelzel, Kasuya, Kato, Leaper, Mate, Matsuoka. Mesnick, Miyashita, Palacios, Perrin, Reeves, Smith, Whitehead.

Cont.

Group		Terms of Reference	Membership
(18)	SCAA (Working Group)	Assist with intersessional work.	Punt (Convenor), Butterworth, Cooke, de la Mare, Kitakado, Matsuoka.
(19)	IWC-POWER survey planning (Steering Group)	Finalise plans for the 2014 IWC-POWER survey.	Kato (Convenor), An, Bannister, Brownell, Clapham, Donovan, Ensor, Matsuoka, Miyashita, Murase, Pastene, Wade.
(20)	POWER Technical Advisory Group (Working Group)	Initial consideration of medium-term plans for POWER.	Matsuoka (Convenor), Bravington, Donovan, Hedley, Kelly, Palka, Kitakado.
(21)	IDCR/SOWER data validation (Working Group)	Assist in resolving data discrepancies in IDCR/SOWER.	Hedley (Convenor), Bravington, Burt, Donovan, Hughes, Kelly, Matsuoka.
(22)	Commemorative IDCR/ SOWER volume (Editorial Board)	Preparation of the IDCR/SOWER volume.	Bannister (Convenor), Best, Brownell, Donovan, Ensor, Hedley, Kato, Kitakado.
(23)	Stock definition terminology (Working Group)	Continue to develop a glossary of IWC stock related terms, and try to come up with a series of criteria for classifying populations within these terms.	Jackson (Convenor), Baker, Bickham, Cipriano, Double, Hoelzel, Kanda, Lang, Palsbøll, Pampoulie, Scordino, Tiedemann, Waples.
(24)	Western gray whale stock structure (Working Group)	Develop hypotheses of western gray whale stock structure.	Lang (Convenor), Baker, Bickham, Broker, Brownell, Dupont, Hoelzel, Jackson, Litovka, Mate, Reeves, Rosenbaum, Scordino, Tyurneva, Urbán, Waples.
(25)	Marine debris Workshop (Steering Group)	Prepare for 2nd Workshop on assessing the impacts of marine debris.	Simmonds (Convenor), Baulch, Fossi, Gallego, Holm, Iñíguez, Leaper, Mattila, Perry, Podestá, Parsons, Rosa, Williams.
(25a)	Global review of monodontids (Steering Group)	(a) Continue planning for a joint Workshop on monodontids with NAMMCO SC, the Canada-Greenland Joint Commission on Narwhal and Beluga, Alaska North Slope Borough and others. (b) Prepare a proposal for review Workshop. (c) Facilitate exchange of data between the involved groups.	Bjørge (Convenor), Aquarone, Donovan, Ferguson, Prewitt, Reeves, Suydam.
(26)	Marine debris (Working Group)	(a) Review the research-related recommendations from the marine debris Workshop to identify prioritised research. (b) Evaluate fishing practices and identify those that pose lower entanglement/gear loss risks. (c) Further investigate microplastics, their associated chemical pollutants, microbes and macroplastic digestion. (d) Liaise with the Pollution 2020 Steering Group over the issue of microplastics research. (e) Liaise with the Steering Group for the 2nd marine debris Workshop.	Simmonds (Convenor), Baulch, Fossi, Hall, Mattila, Parsons, Ylitalo.
(27)	Environmental threat CMPs development (Working Group)	(a) Examine the role the E SWG can play in CMPs. (b) Examine the potential environmental threat-based CMPs. (c) Examine potential species-based CMPs where environmental issues are a priority threat. (d) Prepare advice on the CMPs and environmental concerns.	Rojas-Bracho (Convenor), Iñíguez, Parsons, Rowles, Schweizer.
(28)	Cetacean Emerging and Resurging Diseases (Working Group)	Coordinate the work of the CERD work plan: (a) further develop CERD website and input additional data; (b) expand sections of the website (e.g. skin diseases, mortality events, visual health assessment); (c) upgrade software essential to CERD; (d) link and promote CERD website via social media; and (e) monitor large whale mortality events, mass stranding events, and unusual mortality events.	Rosa (Convenor), Brownell, Cozzi, Di Guardo, Fernández, Galletti, Iñíguez, Marcondes, Mattila, Mazzariol, Parsons, Podestá, Ritter, Robbins, Rowles, Weller.
(29)	Climate change (Correspodence Group)	(a) Collate recommendations of past climate change Workshops. (b) Identify key research gaps and priorities. (c) Evaluate progress in understanding the impacts and impli-cations of climate change for cetaceans. (d) Identify climate change priorities for the E SWG. (e) Continue to look at the issue of critical habitat in the context of climate change.	Simmonds (Convenor), Feindt-Herr, Holm, Palacios, Parsons, Rojas-Brachos, Simmonds, Smith, Stachowitsch, Wells.
(30)	Predicting soundfields Workshop (Steering Group)	Prepare for a Workshop to better inform cetacean conservation and management efforts related to the potential impacts of anthropogenic noise over regional to ocean-basin scales.	Dekelinge, Erbe, Frisk, Gedamke, Hatch, Porter, Tyack.
(31)	EM planning (Steering Group)	(a) Solicit contributions. (b) Liaise with prospective invited participants. (c) Prepare the agenda.	Palacios (Convenor), Butterworth, de la Mare, Punt, Walløe.
(32)	Applications of IBMs to RMP (Working Group)	(a) Liaise with Allison to ensure compatible model currencies. (b) Explore feasibility of linking IBMs directly; otherwise develop simple IBM emulator.	De la Mare (Convenor), Allison, Butterworth, Cooke, Kitakado, Punt.
(33)	Marine bushmeat (Intersessional Group)	Prepare for a Workshop on poorly documented hunts of small cetaceans for food bait or cash.	Cerchio (Convenor), Baker, Brownell, Reeves, Ritter, Scheidat, Simmonds.

Cont.

Group		Terms of Reference	Membership
(34)	MAWI - Modelling and Assessment of Whale-watching Impacts (Steering Group)	Define specific research questions and hypotheses that will benefit understanding of the impact of whalewatching, identify those whalewatching locations that would be most suitable and amenable for targeted studies addressing these questions, and summarise the current modelling tools available to analyse the data that will be collected.	New (Convenor), Carlson, Cook, Kaufman, Leaper, Parsons, Ritter, Robbins, Rose, Simmonds.
(35)	Background document for guiding principles (Working Group)	Draft a document explaining origin and evolution of guiding principles, i.e. whether they arose from research and/or 'best practise.'	Carlson (Convenor), Kaufman, Ritter, Rose.
(36)	Five-Year Strategic Plan for Whalewatching Handbook (Working Group)	Develop work plan and collate information for assisting Commission's Standing Working Group on Whalewatching to draft the Whalewatching Handbook.	Rojas-Bracho (Convenor), Carlson, Iñíguez, Kaufman, Luna, Parsons, Ritter.
(37)	Swim-with-whale operations (Working Group)	Assess the extent and potential impact of swim-with-whale operations.	Rose (Convenor), Kaufman, Parsons, Ritter, Sironi.
(38)	In-water interactions (Working Group)	Identify and investigate potentially dangerous recreational inter-actions between free-ranging cetaceans and people in the water, emphasising the extent of the problem and research on behavioural 'warning indicators'; identify research gaps and summarise information.	Ritter (Convenor), Gero, Parsons, Rose, Scheer, Simmonds, Vermeulen.
(39)	Oil spill capacity building (Working Group)	(a) Identify opportunities and needs for oil spill response and assessment capacity building for oil spills in critical areas or for specific species areas in areas of oil and gas development. (b) Arctic oil spill preparedness and response coordination.	Rowles (Convenor), Bjørge, Donovan, Hall, Mattila, Iñíguez, Punt, Rosa, Shigenaka, Víkingsson, Ylitalo.
(40)	Soundscape Workshop (Steering Group)	Prepare for a Workshop on noise soundscapes.	Gedamke (Convenor), Dekeling, Erbe, Hatch, Leaper, Parsons, Porter, Tyack.
(41)	POLLUTION 2020 (Steering Group)	(a) Website application and manual for use. (b) Complete report on microplastics. (c) Refine the PBTK model for PAHs. (d) Review the literature on dispersants. (e) Future priorities for Pollution 2020.	Ylitalo (co-Convenor), Hall (co-Convenor), Donovan, Fossi, Holm, Parsons, Rowles, Rosa, Simmonds.
(42)	Arctic Anthropogenic Impacts on Cetaceans Workshop (Steering Group)	Liaise with steering group on the intersessional Workshop on potential impacts of anthropogenic activities on cetaceans in the Arctic.	Moore (Convenor), Bjørge, Donovan, Palka, Reeves, Rosa, Rowles, Rosenbaum, Suydam.

Annex S

Statements on the Agenda

ANNEX S1
STATEMENT BY THE ICELANDIC, JAPANESE AND NORWEGIAN DELEGATIONS CONCERNING DNA REGISTER SYSTEMS

Members of the Scientific Committee and the Commission are aware that the Governments of Iceland, Japan and Norway have, on a voluntary basis, implemented national DNA register systems to provide for effective monitoring of whale meat products in the market and that information on these DNA register systems has been provided to the Commission.

This statement is to reassert the position of the Governments of Iceland, Japan and Norway that the monitoring of markets is outside the jurisdiction and competence of the IWC and that for this reason, inclusion of items related to DNA identification of market products on the agenda of the Scientific Committee and its Working Groups is inappropriate. For this reason, representatives of the Governments of Iceland, Japan and Norway and their appointed scientists will not participate in Scientific Committee discussions of this matter.

However, the Governments of Iceland, Japan and Norway will provide additional information on their DNA register systems as they deem appropriate including information on technical aspects of these systems. Further, we urge that the future work of the Scientific Committee on matters related to the use of DNA technologies and analyses take the position of our Governments into account. In this regard, documents dealing with the marketing of whale meat products should not be submitted to or discussed by the Scientific Committee.

ANNEX S2
STATEMENT BY THE JAPANESE DELEGATION CONCERNING WHALEWATCHING

It is the Government of Japan's position that whalewatching is outside the competence of the IWC. Further, the IWC has limited financial and human resources and should be focusing its efforts on important matters such as stock assessments.

ANNEX S3
STATEMENT BY THE JAPANESE DELEGATION CONCERNING SMALL CETACEANS

Resolution 1999-9 on Dall's porpoise is clearly outside the jurisdiction of the IWC, and therefore Japan continues not to provide data concerning small cetaceans at this year's Scientific Committee meeting. Furthermore, Japan will not participate in the meeting of the standing sub-committee on small cetaceans this year. It is unfortunate that the political attempt to expand the scope of the IWC's influence to include small cetaceans by Resolution 1999-9 has prevented the continued voluntary scientific co-operation of Japan in the field of small cetaceans.

However, Japan will make its data on small cetaceans available following this year's Scientific Committee meeting through appropriate means, such as the website of the Fisheries Agency of Japan.

Finally, although Japan may not make any comments on the draft report of the standing sub-committee on small cetaceans, this should in no way be taken to mean that Japan concurs with or supports the contents of the report.

Report of the Planning Meeting for the 2013 IWC-POWER Cruise

Report of the Planning Meeting for the 2013 IWC-POWER[1] Cruise[2]

The meeting was held in Tokyo on 25 and 26 October 2012. The list of participants is given as Annex A.

1. OPENING REMARKS AND WELCOMING ADDRESS

Kato (as Convenor) and Sakomoto (on behalf of the Fisheries Agency of Japan) welcomed participants to Tokyo and to the meeting.

Sakomoto was pleased that the 2012 cruise had been completed successfully. A valuable amount of data and samples was obtained including biopsy samples from blue, fin and sei whales. He looked forward to receiving reports on their analyses at next year's IWC Scientific Committee meeting. He expressed Japan's appreciation to the Governments of USA and Canada for issuing the relevant permits. He also expressed Japan's appreciation to the Republic of Korea and USA for sending scientists to the IWC-POWER cruise. The IWC-POWER programme was an excellent example of international cooperation. While the current Japanese financial situation was tight, the Fisheries Agency of Japan had a strong intention to continue with the POWER programme, given its importance for conservation and management of whales in the North Pacific Ocean. He emphasised that obtaining tangible results from the IWC-POWER cruises, including abundance estimates of whales, would be most useful in obtaining budgets for future cruises under the programme.

On behalf of the IWC, Donovan echoed Sakomoto's remarks on the value of the IWC-POWER programme. The IWC-POWER cruises were extremely important to the IWC and indeed provided an excellent example of international cooperation. He looked forward to a successful Planning Meeting for the 2013 cruise and ultimately valuable results to assist in the medium-term planning process.

The ship's crew, for logistical reasons, was represented at this meeting only by Mr Yoshemura of Kyodo Senpaku Co. Ltd. It was noted that it might be necessary to have greater crew representation at the Planning Meetings after the completion of the short-term component of the programme (i.e. after the 2014 cruise), to discuss the practical details of the medium-term programme.

2. APPOINTMENT OF CHAIR AND RAPPORTEURS

Kato was elected Chair. Bannister agreed to act as rapporteur, with assistance from Donovan and Matsuoka. Donovan agreed to coordinate preparation of the report.

3. ADOPTION OF AGENDA

The agreed Agenda is given as Annex B.

4. ORGANISATION OF MEETING

Kato thanked the organisers for providing such excellent facilities. Numata outlined the arrangements including the provision of a wireless connection. He reminded participants of the invitation from IWC Commissioner for Japan, Mr Kenji Kagawa, to an official reception on 26 October.

[1]North **P**acific **O**cean **W**hale and **E**cosystem **R**esearch.
[2]Presented to the meeting as SC/65a/Rep01.

5. REVIEW OF AVAILABLE DOCUMENTS

Documents available are listed in Annex C.

6. REVIEW OF DISCUSSIONS AT IWC/63

At last year's Scientific Committee meeting, the Committee endorsed the report and recommendations of the Technical Advisory Group (IWC, 2013b) on the short- and medium-term objectives and plans for the IWC-POWER cruises. These formed the framework for the discussions of the 2012 and 2013 cruises at the Annual Meeting and would be an important resource for the present meeting. The Committee had agreed the broad outline for the 2013 cruise given in Kato *et al.* (2012), noting that details would be discussed at this Planning Meeting.

7. PRELIMINARY RESULTS FROM THE 2012 CRUISE

Matsuoka spoke to a preliminary draft report of the cruise. It had taken place between 13 July and 10 September 2012, on the Japanese Research Vessel *Yushin-Maru No. 3*, with four researchers on board, two from Japan and one each from the USA and Republic of Korea. The area covered was in the eastern North Pacific, north of 40°N, south of Alaska, between 150°W and 135°W (see Fig. 1). The area was divided into two strata: a northern stratum within the EEZs of the USA and Canada; and a southern stratum. In both strata, over 80% of the planned tracklines were covered on effort (2,126 n.miles).

Of the large whale species sighted, sufficient sightings were made that will allow abundance estimates to be obtained for fin whales in both strata and sei whales in the southern stratum. A total of 14 cetacean species were seen as well as some sightings identified to genus (Mesoplodonts and Ziphiids). The cruise made one sighting of the rare North pacific right whale in the northern stratum (120 n.miles southwest of Kodiak Island, Alaska) and four sightings of blue whales in the northern stratum. Sperm whales – mostly solitary males – were common in both strata. Although only two sightings of common minke whales were made, this reflected the difficulty of sighting the under the prevailing conditions. The most common small cetacean species seen were Dall's porpoises (both strata especially the southern), common dolphins (southern only) and killer whales (both strata).

A total of 189 animals were photographed for individual identification (four blue whales, one north Pacific right whale, 26 humpback whales, 60 fin whales, 51 sei whales and 47 killer whales) and 52 biopsy samples were obtained (two blue whales, 12 fin whales, 37 sei whales and one killer whale). Some 230 objects of marine debris were recorded, including some dense concentrations and these were reported to the relevant authorities in the USA and Japan at weekly intervals as requested.

In discussion, it was noted that the Canadian authorities had not required a Canadian researcher to be on board as part of the permit requirements. Both Canada and the USA had requested information on the work carried out within their waters as part of the permit requirements. It was **agreed** the full results of the cruise will be transmitted to the

Governments of Canada and the USA once the cruise report has been completed; it will include appendices that provide information on work undertaken within each EEZ.

The meeting welcomed the very efficient biopsy sampling strategy employed on the cruise (over three quarters of the samples were obtained in less than 20 minutes of first sighting) and commended Matsuoka and the Captain for their work.

It was also pleased to receive some preliminary results from Mizroch on matches of humpback and killer whales and looks forward to a full report on the photo-identification work from the cruises including numbers of catalogued animals as well as matches at SC/65a in Korea. The general issue of data analyses for the IWC-POWER cruises, including photo-identification catalogues is consider under Item 20.

Sakamoto noted that the US and Canadian Governments had asked that a copy of the cruise report be provided to them within six months of the conclusion of the cruise. It was **agreed** that the full report be provided, not solely the information contained in Appendices B and C of the report.

The TAG had recommended that appropriate authorities should be contacted to ensure that the types of data on marine debris were suitable to contribute to full studies of this issue reports of marine debris should be circulated to relevant countries. At the Commission meeting, the USA and Japan held bilateral discussions and it had been agreed that the marine debris data collected by IWC-POWER was valuable and that weekly reports should be submitted to the relevant agencies in Japan and the USA. Matsuoka reported that this had been done.

The meeting requested that the final report should also tabulate effort by sea state. This will allow a better evaluation of the balance between acceptable conditions and sightings efficiency, especially for species such as the common minke whale for which sightings are rarely able to be made above sea state 4 (only two sightings of this species were recorded during the 2012 survey). Matsuoka undertook to provide the tabulation.

It was **agreed** that the authors should prepare a final definitive version of the 2012 cruise report, for circulation to Steering Group members for their comments, noting that final responsibility rests with the authors.

8. AVAILABILITY OF RESEARCH VESSELS

8.1 Research vessel offered by Japan

Sakamoto reported that the Fisheries Agency of Japan was negotiating its budget requests with the Ministry of Finance. Results of negotiations, which were revised budget requests, would become available at the end of December. After that, the revised budgets would be considered for approval by the Japanese Parliament in March 2013. While the Fisheries Agency of Japan was requesting the same level of funding for the 2013 cruise as for 2012, some reduction might not be avoidable. The Fisheries Agency of Japan would do its best to obtain the budget as close as possible to the 2012 figure for next year's POWER cruise, and this meeting could consider next year's plan on the assumption of the availability of a vessel with the same characteristics as *Yushin-Maru No.3* for a total of 60 days. It was **agreed** that if the result of these discussions was to reduce the number of ship days, this would require a revision of the cruise strategy including reconsideration of tracklines and coverage.

8.2 Other possibilities

Ohsumi noted that covering any area to the east of that surveyed in 2012 would be difficult if not impossible with a Japanese-based vessel because of the long transit distance. He asked whether the US Government could provide a vessel to cover such an area. Brownell noted that US vessel availability was always determined several years in advance and the earliest possibility of one being available would be from 2014 or 2015.

9. PRIORITY FOR THE 2013 CRUISE

The meeting referred to IWC (2013a, p.40), where the plans for the 2013 cruise were detailed. The rationale for choosing the research area is given in Kato *et al.* (2012, p.2). The area had been poorly covered by previous surveys and not at all in recent decades, with a resulting important information gap for several large whale species.

The meeting confirmed that the 2013 cruise objectives are the same as in previous years. The cruise will focus on the collection of line transect data to estimate abundance and biopsy/photo-identification data, to make a valuable contribution to the work of the Scientific Committee on the management and conservation of populations of large whales in the North Pacific in a number of ways, including providing:

(a) information for the proposed future in-depth assessment of sei whales in terms of both abundance and stock structure;
(b) information relevant to *Implementation Reviews* of whales in terms of both abundance and stock structure[3];
(c) baseline information on distribution and abundance for a poorly known area for several large whale species/populations, including those that were known to have been depleted in the past but whose status is unclear;
(d) biopsy samples and photo-identification photos to contribute to discussions of stock structure for several large whale species/populations, including those that were known to have been depleted in the past but whose status is unclear; and
(e) essential information for a medium-long term international programme in the North Pacific.

These objectives are in accord with the short-term priorities recommended in the TAG report.

10. REVIEW OF THE BUDGET

The meeting referred to Sakamoto's statement in Item 8.1. It **agreed** that for discussion purposes it would assume the same level of Japanese Government funding for the 2013 cruise as for 2012.

The detailed budget for expenditure of Commission funds is provided in IWC (2013a, p.75, table 13).

Donovan noted that the importance of the POWER programme to the Scientific Committee and the Commission continued to be reflected in the fact that at its meeting in Panama the Commission had approved the Committee's budget request of £60,754.

[3]The meeting noted that while attention had been drawn here previously to common minke whales as an example, the choice of sea state <6 as one component of acceptable conditions (part of the trade-off for multi-species cruises), it was unlikely that much new information on minke whales would be obtained as sighting efficiency for this species deteriorates rapidly in sea states above 3. However, considerable new information on Bryde's whales is expected that will greatly assist for *Implementation Reviews* for that species.

11. CRUISE PLAN

11.1 Priorities and allocation of research effort
The broad priorities for 2013 are given under Item 9. Given the available period of 60 days – the maximum operational period of the vessel without refuelling/resupply – and that as in 2012, 24 days would be required in transit from and to Japan given the eastern location of the research area (to 135°W), only 36 days are available for survey.

In terms of research time allocations amongst the various priorities, it was noted that a key governing factor from the planning perspective was the target distance per day allocated to the line-transect component. In the cruise outline given in Kato *et al.* (2012) it had been stated that a target distance of 90 n.miles per day was proposed based on experience in the area which was further south than previous IWC-POWER surveys and was much less subject to fog. The TAG report had suggested a general value of 65 n.miles per day that had been used in the surveys to date based on the available information.

In view of the importance of this assumption to the cruise, a small group under Donovan was established to further consider the available information before finalising the target distance. While it is impossible to predict weather conditions accurately, it is important to choose a target distance that is not too ambitious given the available knowledge – poor track coverage can affect the validity of abundance estimates if it seriously affects the key assumption of equal coverage probability. Choice of an overambitious target can also present problems for the Cruise Leader in terms of determining the appropriate balance between surveying and other priorities such as biopsy sampling and photo-identification work.

The sub-group examined information available from four surveys undertaken in similar areas by the Far Seas Fisheries Research Laboratory (prior to 1996) and a 2012 survey undertaken as part of the JARPN II programme. After examining the range of achieved searching distances per day (ranging from around 100-114n.miles although with little biopsy/photo-id effort), the numbers of sightings made during the 2012 survey and the range of times to obtain biopsy samples achieved during the 2012 IWC-POWER cruise, the sub-group **agreed** that the range of acceptable target distances per day was from 80 n.miles to 90 n.miles. The sub-group also **agreed** that within this range, the decision should be made by the Cruise Leader as it was his responsibility to implement any decisions and to ensure the appropriate balance of activities in the field. The sub-group therefore **recommended** Matsuoka's preferred target distance of 90 n.miles per day. This should allow for the two angle/distance experiments and about 50 biopsy/photo-id attempts if the weather conditions are similar to the cruise with the worst conditions recorded for this area during the five surveys examined (about 100 n.miles per day).

If the weather is better than expected (or less whales are encountered for biopsy/photo-id work) such that time is available at the end of the completion of the predetermined trackline, then the Cruise Leader will decide the appropriate strategy depending on weather conditions/forecast. It is not possible to add additional tracklines for use in abundance estimation (this will affect the equal coverage probability assumptions used to determine the original track) thus the time must be used to maximise additional biopsy/photo-id work. Options include: returning to a high density area and following an intuitive track; following the return transit track but in full searching mode and not steaming at night.

11.2 Itinerary
As in 2012, to minimise transit time and thus maximise research time, the home port will be Shiogama. The itinerary is shown in Table 1.

Table 1

Itinerary for the 2013 IWC-POWER cruise.

Date	Event
12 July	Vessel departs Shiogama, northern Japan
27 July	Vessel arrives at the research area start point at 135°00'W
29 August	Vessel completes the research at 160°00'W
9 September	Vessel arrives Shiogama

11.3 Research area
As agreed by the Committee (IWC, 2013a), the research area is as shown in Fig.1. This is also in accord with the recommended future short-term cruise plan recommended by the TAG report. The area is to be treated as a single stratum.

11.4 Research vessel
Depending upon funding (see Item 8) the *Yushin-Maru No. 3* should be available. Its specifications are given in Table 2. The vessel has proved to be a good sightings platform as well as of suitable manoeuvrability for efficient biopsy sampling/photo-id work.

Table 2

Specifications for *Yushin Muru No.3*.

Call sign	7JCH
Barrel height (m)	19.5m
Length overall	69.61m
Upper bridge height	11.5m
Moulded breadth	10.80m
Bow height (m)	6.5m
Gross tonnage	742
Engine power	5280/3900 (PS/kW)

11.5 Other matters
There were no matters to discuss under this item.

12. DETAILS OF THE CRUISE

12.1 Cruise track design
As already noted, the survey area will be considered a single stratum. Cruise track design (see Fig. 1) had been undertaken using 'Distance' software, following the IWC guidelines and the TAG report recommendation. The start point would be at 135°00'W (Waypoint 107), proceeding westwards to Waypoint 101 at 160° 00'W, based on 90 n.miles/day – as discussed under Item 11.2.

12.2 Survey mode and research hours
Activities onboard the ship are classified into two principal groups: on-effort and off-effort. On-effort activities are times when full search effort is being executed and conditions (such as weather and sea conditions) are within acceptable parameters to conduct research. Off-effort activities are all activities that are not on-effort. All sightings recorded while the ship is on-effort are classified as primary sightings. All other sightings are secondary sightings.

The TAG report had recommended that pending analyses of IO results for the 2010 survey and an examination of any other relevant studies for sei and Bryde's whales, the

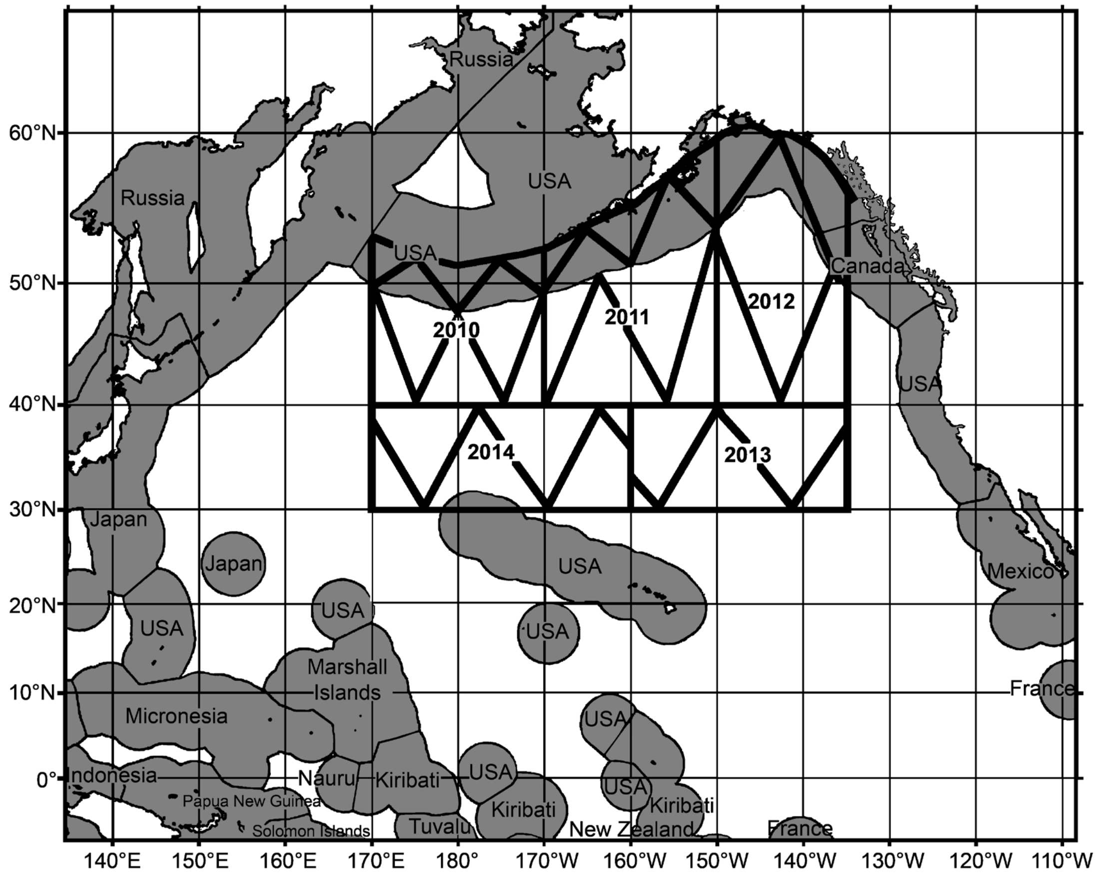

Fig. 1. The research area for the POWER cruise.Grey areas=EEZs.

surveys undertaken as part of the short-term plan should not operate in IO mode. It was therefore **agreed** that only NSP (passing with abeam closing as in 2011 and 2012) would be undertaken in 2013. The TAG report had recommended this as the most appropriate survey mode given the priority species and the need for confirming species identity and school size.

Sighting effort is conducted by the two primary observers; researchers and the chief engineer or deputies are also present. Primary search effort is only conducted in acceptable weather conditions. These conditions are used as guidelines; in some circumstances, less severe conditions may still be inappropriate for search effort (see below).

Research hours during the cruise will be the same as on recent SOWER cruises (from 6:00-18:00; begin 60 minutes after sunrise and end 60 minutes before sunset, with a maximum 12 hours per day). As in the SOWER programme, for biopsy sampling/photo-identification work on priority species (sei whales, Bryde's whales, common minke whales, North Pacific right whales, blue whales, humpback whales and fin whales - see items (a) and (b) under Item 9) there may be occasions when it is beneficial to extend research outside the normal research hours. The basis for such special extension of research hours will involve mutual agreement between the captain and Cruise Leader and an allocation of equivalent time-off the following morning or evening. Details of photo-identification and biopsy work are given under Items 12.8 and 12.9.

In transit, the research day will begin 30 minutes after sunrise and end 30 minutes before sunset, with a maximum of a 12-hour research day. Time-zone changes will be in 30-minute intervals, coming into effect at midnight.

The meeting **agreed** that if sightings were made outside official research hours (e.g. before sightings effort begins in the morning), then these should be recorded as 'off-effort' sightings as they can contribute useful information on distribution even though they are not suitable for abundance estimation.

12.3 Number of crew on effort

As in 2012, two topmen will observe from the barrel at all times in passing mode. Two primary observers will be in the barrel whenever full searching effort using reticle binoculars and angle board is conducted. Two primary observers (captain and helmsman) will be at the upper bridge with binoculars with reticles, regardless of the research mode. Also present on the upper bridge, whenever the sighting survey is conducted, will normally be the chief engineer (or an alternate). With four researchers on board, the Cruise Leader should ensure that the number of researchers searching from the upper bridge is standardised.

12.4 Navigation and research speeds

As in 2012, 11.5 knots will be maintained during research.

12.5 Acceptable weather conditions

In accord with the recommendation of the TAG report, the usual guidelines will apply, i.e. visibility (in principle for seeing common minke whales) >2.0 n.miles; wind speed <21 knots; sea state <Beaufort 6. As noted earlier, these conditions are not suitable to reliably see common minke whales but are sufficient for the other large whale species.

The meeting noted that while fog will be less of a problem, glare might pose more of a problem as the trackline will be further south than before (i.e. more intense sunlight). It was **agreed** that it is important to continue to collect good glare data, recognising that appropriate analytical techniques to incorporate this information into abundance estimates are still being developed.

12.6 Estimated angle and distance experiment

The experiment is designed to calibrate and identify any biases in individual observers' estimation of angle and distance. It was **agreed** that the experiment should be conducted during weather and sea conditions representative of the conditions encountered during the survey. The detailed protocol can be found in the Guide for Researchers.

In accord with the TAG report, the meeting **recommends** that every effort be made at least to conduct an experiment at the beginning and during the middle of the cruise, and that the IWC-POWER Steering Group continue to monitor the development and feasibility of using newer technology to improve estimated angle and distance, as detailed in IWC (2013b, p.344).

12.7 Data format

The survey will be conducted using data forms modified for the 2012 cruise from those used on the SOWER cruises and the 2011 cruise. It was **agreed** that Donovan and Matsuoka should update the Guidelines for Researchers accordingly.

12.8 Biopsy sampling

12.8.1 Priority of species

As appropriate and decided by the Cruise Leader, research time will be given for biopsy sampling of Bryde's whales, sei whales, common minke whales, blue whales, humpback whales, gray whales and fin whales (bowhead whales and North Pacific right whales are unlikely to be seen south of 40°N but should also be given priority if encountered). Biopsy of killer whales and sperm whales will be attempted on an opportunistic basis. Pastene advised that very few Bryde's whale samples were available for this area and it was agreed that priority in sampling should be given to that species rather than sei whales (which are usually found further north) in 2013.

12.8.2 Equipment

Biological sample collection will be by using biopsy sampling (skin/blubber collected by projectile dart). Projectile biopsies will be collected using either a compound crossbow or the Larsen gun system. During any single encounter, no more than five biopsy sampling attempts per individual will be made. It is rare that an animal would be targeted for biopsy more than twice during one encounter, but conservatively five sample attempts will be allowed as necessary. If signs of harassment such as rapid changes in direction, prolonged diving and other behaviours are observed from an individual or a group, biopsy will be discontinued on that individual or group. The animals to be sampled will either approach the vessel on their own or be approached by the research vessel during normal survey operations. The projectile biopsy sample will be collected from animals within approximately 5-30m of the bow of the vessel.

For large cetaceans, small samples (<1 gram) will be obtained from free-ranging individuals using a biopsy dart with a stainless steel tip measuring approximately 4cm in length with an external diameter of 9mm and is fitted with a 2.5cm stop to ensure recoil and prevent deeper penetration (so that only 1.5cm of the tip is available to penetrate the animal). Between sample periods, the biopsy tips are thoroughly cleaned and sterilised with bleach. Biological samples may be collected from adults, juveniles, females with calves and calves. The same size biopsy dart would be used for calves as for adults. No biological samples will be taken from newborn calves. The age of a calf would be determined by the subjective judgment of the researchers. They would err on the side of caution and not biopsy an animal that appeared too young.

Two compound crossbows will be provided from ICR, as in 2012, as back-up for Larsen guns. If necessary, ICR will provide supplies of darts.

12.8.3 Keeping of samples

It was **agreed** that all samples would be frozen and stored in cryo-vials. Based on advice from Mizroch, each sample would be split into skin and blubber, the latter not being required for genetic analysis. The skin sample would be divided, one portion to go to ICR, the other to IWC. The blubber sample would be retained whole (i.e. not be split) and held at ICR; analyses of blubber (e.g. for contaminants, hormones, fatty acids) generally require larger amounts of tissue and splitting already small quantities may render such analyses impossible. The meeting **agreed** that the question of future analysis of blubber samples, and access to them by researchers, should be discussed at the next IWC Scientific Committee meeting.

12.9 Photo-identification studies

12.9.1 Priority of species

As appropriate and decided by the Cruise Leader, research time will be made available for photo-identification and/or video taping of sei and Bryde's whales on this cruise, recognising that they and right whales, blue whales and humpback whales are also a priority. Killer whales are a 'non-target' cetacean with lower priority and should be photographed opportunistically. The estimated daily number of miles to be steamed in searching mode has a built in allowance for such work. Generally, large whales will be approached within approximately 15-20m. Photo-identification of adult and juvenile males and females will occur. If the opportunity arises, females accompanied by calves may be approached for photo-identification, but efforts will cease immediately if there is any evidence that the activity may be interfering with pair bonding, nursing, reproduction, feeding or other vital functions.

12.9.2 Equipment

At SC/64, funds were sought for IWC to purchase a new/refurbished cameras and lenses and associated spare batteries and memory cards. With the budget being approved, funds are now sufficient. The equipment will be delivered by hand by Donovan *en route* to SC/65a in Korea.

12.9.3 Keeping of data

The meeting noted that a master set of all photographs taken on the IWC-POWER cruises is kept at the IWC Secretariat within an Adobe Lightroom database; these are copyright of the IWC. Photographs that have been examined and catalogued as individuals for identification purposes will also be archived as the IWC-POWER Catalogue. As noted in the TAG report it is important to share such information with other researchers working in the North Pacific. A protocol to apply for use of the photographs for comparison or other purposes is available from the IWC Secretariat and will be made available through the IWC-POWER pages on the IWC website as well as via the Scientific Committee Handbook (a final decision on access is made by the IWC-POWER Steering Group). All researchers wishing to examine the photographs must obtain formal permission from the Secretariat. It was **agreed** that only in exceptional circumstances should researchers on the vessel send copies of photographs direct to other researchers during the cruise (e.g. where this is a condition of a permit to conduct research in national waters) – again formal permission must be obtained from the IWC. Donovan **agreed** to prepare the necessary protocol and he and Matsuoka will ensure that this will be included in the Guide for Researchers.

12.10 Acoustic studies

The meeting **agreed** that there would be no acoustic studies during the 2013 cruise. As noted last year, decisions on whether to conduct such studies depend *inter alia* on whether it is practical to use a towed array for sperm whales and whether it is possible to obtain suitable sonobuoys for baleen whales. The meeting **reiterated** the TAG recommendation that a desk-top feasibility study of the incorporation of acoustic studies in the programme should be undertaken in the context of the IWC-POWER priorities (e.g. biopsy sampling); the idea that a whole cruise could be dedicated to line transect acoustic studies and consideration of using sonobuoys to detect blue and fin whales should be explored as part of the medium-term programme.

12.11 Oceanographic studies

No specific oceanographic studies are planned for 2013.

12.12 Satellite tagging

As noted last year the TAG had noted the value of telemetry data to discussions of movement and stock structure but had recognised that at present, deployment requires small boat operations. It also believed that the IWC-POWER programme was not the appropriate platform for substantial technological development. Thus no telemetry work is recommended as part of the short-term plan (including 2013); however, it was again **agreed** that developments should be monitored for possible targeted studies in the mid-term.

12.13 Other matters

12.13.1 Marine debris

See earlier discussions under Item 7. Observations of marine debris are important in non-IWC contexts such as modelling the predicted movement of debris from the 2011 tsunami across the Pacific. The IWC Secretariat does not require the data weekly. Authorities from the USA and Japan will discuss whether weekly reports are required from the 2013 cruise and inform the Steering Group should this be the case.

13. INTERNATIONAL RESEARCHERS AND ALLOCATION OF RESEARCH PERSONNEL

13.1 Number of researchers

As in 2010, 2011 and 2012, up to four researchers can be accommodated on the vessel.

13.2 Nomination and allocation of researchers

For 2013 the following framework for researcher involvement was **agreed**:

(1) Japan (IWC-POWER range state, vessel provider, Matsuoka);
(2) Korea (IWC-POWER range state, name to be provided by An when known);
(3) Japan (IWC-POWER range state, vessel provider, Kumagai); and
(4) to be decided, will be from a range state.

Matsuoka was appointed Cruise Leader.

14. GENERAL PREPARATIONS FOR THE 2013 CRUISE

14.1 Identification of the home port organiser

Nishiwaki undertook to act in this capacity.

14.2 Entry and other permits

While there are no requirements under this item for the 2013 cruise, the meeting noted that the 2014 cruise will include the US EEZ (around Hawaii). It urged that discussions of the problems involving CITES permits be maintained, so that a satisfactory conclusion can be reached in good time for the 2014 cruise.

14.3 Review of recommendations from the 2012 cruise

Two matters were raised in the 2012 cruise report:

Biopsy sample numbering

The meeting noted that a satisfactory protocol, as detailed in the cruise report, had been adopted on the 2012 cruise, and **agreed** it should be maintained in 2013. For biopsy samples the year prefix (e.g. '2012') will not be included. This will be incorporated by Matsuoka and Donovan into the Guide for Researchers.

2010 cruise identification photographs

The meeting **agreed** that the photographs from the 2010 cruise be catalogued and integrated into the IWC catalogue as soon as possible. Donovan has received all photographs for the 2010-12 cruises on a hard drive at the meeting and will work with the Steering Group to ensure that this work is done.

15. IN TRANSIT SURVEY

15.1 Home port to research area and back

While recognising the need to move rapidly to and from the research area, and that standard passing mode would be adopted during transit, the meeting **agreed** that should the opportunity arise, biopsy and photo-identification could be undertaken on right whales, gray whales and blue whales, in that order of priority.

16. TRANSPORTATION OF DATA, SAMPLES AND EQUIPMENT

16.1 Equipment

It was **agreed** that the tabled equipment list be adopted as amended, and with responsibilities as indicated (see Annex D).

16.2 Data and samples and necessary permits

Within two months of the end of the cruise, all sightings data, validated, will be forwarded to IWC. Biopsy samples will be forwarded to SWFSC in La Jolla, California, in accord with CITES provisions. Matsuoka, as Cruise Leader, will submit all identification photographs and accompanying data to IWC. Any borrowed equipment (except IWC cameras and lenses) will be returned to its owners.

17. COMMUNICATIONS

17.1 Safety aspects (daily reports)

Daily vessel position reports should be submitted to ICR, NRIFS and the Fisheries Agency.

17.2 Between the Cruise Leader and the IWC
As in previous years, weekly reports will be provided to the IWC Secretariat and members of the Steering Group. Donovan **agreed** to establish a mailing list so that one address can be used for all.

17.3 Fog and sea temperature information
In 2012 fine-scale information was provided from NOAA at no cost apart from communication costs. Brownell commented that the same could probably be arranged for 2013; coverage was likely to be available even though further south. It was **agreed** that a sub-group comprising Mizroch, Matsuoka and a Company representative should discuss the level of communication costs for report to the pre-cruise meeting.

17.4 Other official communication
Given that there would be no operations within the US or Canadian EEZ, there would be no requirement in 2013 for official communications, e.g. over right whale sightings, as there was in 2012. There would be a need to communicate information on marine debris (perhaps weekly) in which case the costs would come under this item. It was **agreed** that this should be clarified at the pre-cruise meeting.

17.5 Private communication
The usual conditions apply, with individuals to meet the cost, and to pay before the vessel reaches the home port.

17.6 Terms of payment of communication costs
See Items 17.4 and 17.5.

18. MEETINGS

18.1 Pre-cruise meeting
A pre-cruise meeting will be held in Shiogama on 11 July 2012. In addition to the researchers and crew, at least all Japanese members of the Steering Group are encouraged to attend. The report will be circulated to the IWC-POWER Steering Group when completed.

18.2 Post-cruise meeting
As in previous years, the post-cruise meeting will be held onboard the vessel during the return transit leg.

18.3 Home port arrangements and responsible persons
Nishiwaki will co-ordinate the home port arrangements in co-operation with the Cruise Leader. The shipping agent in Shiogama will be Tohhoku Dock Tekko Co. Ltd.

18.4 Responsible persons
Nishiwaki will perform this task.

19. REPORTS

19.1 Planning meeting report
The final Planning Meeting report will be circulated to the IWC-POWER Steering Group. It will be tabled at the IWC/SC meeting in 2013.

19.2 Cruise report
The 2012 cruise report was drafted on the return journey of the cruise following the new guidelines provided by Donovan, although it had not been possible to provide a definitive final version before this Planning Meeting. As discussed in Item 7, the report will be circulated to the Steering Group before final preparation by the authors; the final version will sent to the Secretariat for submission to the IWC Scientific Committee as in the past.

20. OTHER LOGISTICS

20.1 Press releases
As in 2012 the Cruise Leader will prepare a draft with the final version being released by ICR in the format prepared by the IWC. Sakamoto stated that for domestic reasons he would like press releases to be available both before and after the cruise, as in 2012. Donovan reported that the IWC website will include a press release pointing to the relevant IWC-POWER cruise web page; there will also be a weekly review of activities on the website as the cruise progresses, and a summary at the end of the cruise. See also discussion under Item 21.2.

20.2 Security
Based on the 2010, 2011 and 2012 experience, no security problems are anticipated.

20.3 Accommodation and food costs
The IWC will cover the accommodation and food costs for the scientists involved; the cost (¥2,500 per day) remains unchanged from previous years.

20.4 Other matters
None were raised.

21. OTHER

21.1 Data validation and analysis
21.1.1 Validation

Donovan reported that the IWC Secretariat Computing section had raised with him a number of instances where their cruise data validation had revealed some discrepancies between sightings data provided from the cruises in both electronic and 'paper' versions. The question was whether this arose from coding errors by the researchers or deliberate changes in the electronic version that had not been noted in the paper version. It was important in the validation process to know which was the case.

Matsuoka responded that the IWC-POWER cruises were very different from the SOWER cruises in the much larger amount of automatic data entry now performed, resulting in many fewer errors. On the return transit checks were made between the two databases. There was an increasing trend towards automatic data entry. An reported that attempts were made to check data entries daily but with an electronic system it was difficult to discover errors; he believed both paper and electronic systems should continue to be used.

The meeting **agreed** that for all three cruises from 2010 double checking of paper against electronic data should continue. However, Donovan would discuss with Matsuoka arrangements for him to discuss the problem direct with the Secretariat coding personnel.

21.1.2 Analysis

In the past 'standard' sightings data analyses had been undertaken by St Andrews personnel under contract to the IWC but at recent Scientific Committee meetings results had been presented of analyses by Japanese scientists. Donovan raised the question of who should undertake such analyses in the future. The IWC Secretariat was developing a strategy to update DESS, to incorporate IWC-POWER cruise sightings data as well, eventually, as biopsy and photo-id information: a proposal is to be presented to the 2013 IWC Scientific Committee meeting (SC/65a) and will be circulated to the IWC-POWER Steering Group beforehand.

Matsuoka noted that the Japanese analyses, with sei and Bryde's whales as priority, had been undertaken in response to a request from the Scientific Committee's IA sub-committee. Japanese scientists were interested in undertaking analyses for those two species at least, and in having the results critically reviewed by the Scientific Committee. Sakomoto believed that Japanese scientists were interested in doing analyses for individual areas year by year; the question arose as to how analysis of the total area would be undertaken in two years' time.

Donovan noted that the question of the overall analysis would be raised for discussion at the next Scientific Committee meeting (SC/65a) to provide an answer well ahead of time. Priority should certainly be given to sei whales, probably fin, and also Bryde's (but in their case depending on the number of sightings). The meeting noted that there is a need to ensure that at next year's Scientific Committee meeting (SC/65a) a group should already have been established to meet to discuss future amendments to DESS, so that when the IWC-POWER programme moves into the mid-term a new system is already available.

21.2 IWC website

Donovan outlined the proposal as summarised in Annex E. He undertook to email full details for individual comment following the meeting. The meeting **agreed** it was an exciting prospect and looked forward to seeing it up and running.

In endorsing the proposal Ohsumi raised the question of intellectual property rights. Donovan noted that the text would be ©IWC, photographs would effectively be the IWC's while individual photographers would be acknowledged, and graphics would be in a form acceptable for viewing but not at a level for unauthorised reproduction.

21.3 Request from PICES

Kato reported that PICES had requested through him that a bird observer should be appointed to the cruise. The meeting **agreed** that if space was available it would be delighted to meet the request, but space was hardly sufficient to accommodate the IWC-POWER research needs. The question of bird data collection had also been raised. It was **agreed** that this would be difficult except opportunistically, and then only for observations at the same level, i.e. the sea surface, as for cetaceans, for example where concentrations of birds formed a sighting cue.

Kato undertook to report to the next PICES meeting that the Planning Meeting had officially considered the request in the above terms.

22. CONCLUDING REMARKS

On behalf of the IWC, Donovan thanked all those who had participated in the meeting. The IWC-POWER cruises are a particularly important component of the IWC's work. As the meeting has recognised an excellent example of international collaboration. He stressed the importance of an enthusiastic and efficient crew, without whom, the cruises could not succeed. He asked that the meeting's appreciation to the crew be conveyed to them. He thanked the Government of Japan for providing such excellent facilities in a beautiful setting, and in particular the Chair and the interpreters who had performed their difficult tasks with their customary efficiency and good humour. Finally Kato thanked everyone for their co-operation and hard work. The meeting concluded at 13:00 hours on 26 October 2012.

REFERENCES

International Whaling Commission. 2013a. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 14:1-86.

International Whaling Commission. 2013b. Report of the Technical Advisory Group (TAG) Meeting on the Short and Medium Term Objectives and Plans for the IWC-POWER Cruises. *J. Cetacean Res. Manage. (Suppl.)* 14:341-55.

Kato, H., Matsuoka, K., Miyashita, T., Murase, H. and Pastene, L. 2012. Proposal for the 2013 IWC-Pacific Ocean Whale and Ecosystem Research (POWER). Paper SC/64/O7 presented to the IWC Scientific Committee, June 2012, Panama City (unpublished). 13pp. [Paper available from the Office of this Journal].

Annex A

List of Participants

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Institute of Cetacean Research, Japan
Naohisa Kanda
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Seiji Ohsumi
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Kyodo Senpaku Co., Ltd., Japan
Isamu Yoshimura

National Research Institute of Far Seas Fisheries, Japan
Toshiya Kishiro
Tomio Miyashita

Southwest Fisheries Science Center, USA
Robert Brownell

Tokyo University of Marine Science and Technology, Japan
Hidehiro Kato

Invited Participant
John Bannister

IWC Head of Science
Greg Donovan

Interpreters
Yoko Yamakage
Hiroko Yasokawa

Annex B

Agenda

1. Opening remarks and welcoming address
2. Appointment of Chair and rapporteurs
3. Adoption of Agenda
4. Organisation of meeting
5. Review of available documents
6. Review of discussions at IWC/64
7. Preliminary results from the 2012 cruise
8. Availability of research vessels
    - 8.1 Research vessel offered by Japan
    - 8.2 Other possibilities
9. Priority for the 2013 cruise
10. Review of the budget
11. Cruise plan
    - 11.1 Priorities and allocation of research effort
    - 11.2 Itinerary
    - 11.3 Research area
    - 11.4 Research vessel
    - 11.5 Other matters
12. Details of the cruise
    - 12.1 Cruise track design
    - 12.2 Survey mode and research hours
    - 12.3 Number of crew on effort
    - 12.4 Navigation and research speeds
    - 12.5 Acceptable condition
    - 12.6 Estimated Angle and Distance Experiment
    - 12.7 Data format
    - 12.8 Biopsy sampling
        - 12.8.1 Priority of species
        - 12.8.2 Equipment
        - 12.8.3 Keeping of samples
    - 12.9 Photo-id studies
        - 12.9.1 Priority of species
        - 12.9.2 Equipment
        - 12.9.3 Keeping of data
    - 12.10 Acoustic studies
    - 12.11 Oceanographic studies
    - 12.12 Satellite tagging studies
    - 12.13 Other matters
13. International researchers/allocation of research personnel
    - 13.1 Number of researchers
    - 13.2. Nomination and allocation of researchers
14. General preparations for the 2013 cruise
    - 14.1 Identification of home port organiser
    - 14.2 Entry and other permits
    - 14.3 Review of recommendations from the 2012 cruise
15. In transit survey
    - 15.1 Home port to research area and back
16. Transportation of data, samples and equipment
    - 16.1 Equipment
    - 16.2 Data and samples and necessary Permits
    - 16.3 Responsible persons
17. Communications
    - 17.1. Safety aspects (daily report)
    - 17.2 Between Cruise Leader and IWC
    - 17.3 Weather and sea temperature information
    - 17.4 Other official communication
    - 17.5 Private communications
    - 17.6 Terms of payment of communication cost
18. Meetings
    - 18.1 Pre-cruise meeting
    - 18.2 Post-cruise meeting
    - 18.3 Home Port arrangements
    - 18.4 Responsible persons
19. Reports
    - 19.1 Planning meeting report
    - 19.2 Cruise report
20. Other logistics
    - 20.1 Press release
    - 20.2 Security
    - 20.3 Accommodation and food costs
    - 20.4 Other matters
21. Other
    - 21.1 Data validation and analysis
    - 21.2 IWC website
    - 21.3 Requests from PICES
22. Concluding remarks

Annex C

List of Documents

POWER/13/WP

1. International Whaling Commission. 2013. Report of the Technical Advisory Group (TAG) Meeting on the Short and Medium Term Objectives and Plans for the IWC-POWER Cruises. *J. Cetacean Res. Manage. (Suppl.)* 14:341-55.
2. International Whaling Commission. 2012. Report of the Planning Meeting for the 2012 IWC-POWER Cruise. Paper SC/64/Rep7 presented to the IWC Scientific Committee, June 2012, Panama City (unpublished). 14pp. [Paper available from the Office of this Journal].
3. International Whaling Commission. 2013. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 14:1-86 (extracts).
4. International Whaling Commission. 2013. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on In-Depth Assessments. *J. Cetacean Res. Manage. (Suppl.)* 14:195-213.
5. Kato, H., Matsuoka, K., Miyashita, T., Murase, H. and Pastene, L. 2012. Proposal for the 2013 IWC-Pacific Ocean Whale and Ecosystem Research (POWER). Paper SC/64/O7 presented to the IWC Scientific Committee, June 2012, Panama City (unpublished). 13pp. [Paper available from the Office of this Journal].
6. International Whaling Commission. 2012. Report of the Workshop on planning for an IWC co-ordinated North Pacific research cruise programme. *J. Cetacean Res. Manage. (Suppl.)* 13:369-92.
7. Cruise report of the 2012 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER).
8. Required equipment for the 2013 IWC-POWER.

Annex D

Equipment

Table 1

Equipment for the cruise.

Equipment	Numbers		Owner	Responsibility	
	YS3	Total		(Shipping)	(Discharge)
Sighting					
Reticle binocular (primary observer)	6	6	ICR	ICR	ICR
Reticle binocular (researcher)	3	3	ICR	ICR	ICR
Computers	2	2	IWC*	-	-
Computer programs	0	0	IWC*	-	-
Computer printer	0	0	ICR	-	-
Computer printer ink	0	0	ICR	-	-
Copy cartridge	1	1	IWC	ICR	ICR
Office supplies (pencil etc.)	-	-	-	Researchers	-
Biopsy					
Telescopic battery (CR2032)	4	4	ICR	ICR	ICR
Scope for Larsen gun	4	4	ICR	ICR	ICR
Larsen biopsy gun	4	4	ICR	ICR	ICR
Larsen darts and tips	50	50	ICR	ICR	ICR
Blank charges (Larsen)	500	500	ICR	ICR	ICR
Plugs (Larsen)	300	300	ICR	ICR	ICR
Compound crossbow (back up)	2	2	IWC	ICR	ICR
Sample bottles (Japan)	200	200	NRIFS	NRIFS	NRIFS
Sample bottles (IWC)	200	200	NRIFS	NRIFS	NRIFS
Sample kit	1	1	NRIFS	NRIFS	NRIFS
Pick up nets	2	2	ICR	Ship	Ship
Rack for Larsen gun	1	1	ICR	Ship	Ship
Photo-id					
Digital camera with 100-300mm	0	0	IWC*	-	-
English manual for digital	0	0	IWC*	-	-
Cleaning kit	2	2	ICR	ICR	ICR
Digital camera with 100-400mm	1	1	ICR	ICR	ICR
Digital camera with 100-300mm	1	1	ICR	ICR	ICR
Monopod for video recordings during dive time experiment	1	1	ICR	ICR	ICR
Digital video camera	1	1	NRIFS	NRIFS	NRIFS
Digital video camera English manual	1	1	NRIFS	NRIFS	NRIFS
Digital video tape (60 min.)	20	20	NRIFS	NRIFS	NRIFS
Digital video battery (long-life)	3	3	NRIFS	NRIFS	NRIFS
Cable for long-life battery	1	1	NRIFS	NRIFS	NRIFS
i-LINK cable from video to PC	1	1	NRIFS	NRIFS	NRIFS
Long cable in top platform	1	1	Ship	Ship	Ship
Data storage computer (hard disc)	0	0	IWC*	-	-
Record sheet					
Record sheet original	ALL	ALL	IWC/ICR	ICR	-
Record sheet	ALL	ALL	IWC/ICR	ICR	ICR
Copy paper (A4, box)	2	2	IWC	ICR	-
Other					
IWC flag (large)	1	1	IWC	Ship	Ship
IWC flag (small)	1	1	IWC	Ship	Ship
IWC banner	0	0	IWC	Donovan/Matsuoka	Ship
Newest IWC journal (electronic files)	1	1	IWC	Donovan/Matsuoka	Ship
Planning report (English)	1	1	IWC	Donovan/Matsuoka	-
Planning report (Japanese)*	1	1	ICR	Matsuoka	-
Information for researchers (English)	1	1	IWC/ICR	Donovan/Matsuoka	-
Information for researchers (Japanese)	1	1	ICR	Matsuoka	-

Annex E

Proposal for the POWER section of the IWC website

Greg Donovan

Level 1: Objectives
- Provide the long-term objectives and then link to the plans for the short-medium term objectives.
- Include tables summarising what is known by species and agreed list of priority species/questions/methods.
- Highlight international component and contributions from Japan, Korea, USA and IWC.

Level 2: Individual cruises
Provide information on each cruise and summaries of results (see also graphics and documentation):
- distribution and abundance;
- photo-identification; and
- biopsy sampling.

Provide 'accumulated' results summary.

Level 3: Documentation
Provide links to all of the background documentation since the inception of the programme including Workshops, Planning Meetings, cruise reports, etc.

Graphics:

(1) photos of the vessel and 'life on board';
(2) photos of the key species;
(3) photos of the techniques – observers, photo-id and biopsy;
(4) maps of each of the cruise tracks;
(5) maps showing sightings by species; and
(6) video clips: An-san.

Report of the Fourth AWMP Workshop on the Development of *SLA*s for the Greenlandic Hunts

Report of the Fourth AWMP Workshop on the Development of *SLA*s for the Greenlandic Hunts*

The Workshop was held at the Grønlands Repræsentation, Copenhagen from 15-18 December 2012. The list of participants is given as Annex A.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks

Donovan welcomed the participants to the Workshop. He noted that the focus of the Workshop would be to:

(1) progress work on the development of a trial structure for the Greenlandic humpback and bowhead whale hunts such that candidate *SLA*s can be evaluated and if possible adopted at the 2013 Scientific Committee meeting;
(2) review RMP/AWMP-lite and develop some preliminary scenarios in order to allow developers to begin to consider the more difficult cases of common minke and fin whales prior to the 2013 Scientific Committee meeting, recognising that final *SLA* development will be considered in the context of the relevant RMP *Implementation Reviews* and the forthcoming (after the 2013 Annual Meeting) workshop on common minke whale stock structure that will occur; and
(3) finalise the trials for the Makah hunt so that the *Implementation Review* can be completed at the 2013 Scientific Committee meeting.

1.2 Election of Chair

Donovan was elected Chair.

1.3 Appointment of rapporteurs

Allison, Butterworth, Punt, and Witting were appointed as rapporteurs.

1.4 Adoption of Agenda

The adopted agenda is given as Annex B.

1.5 Documents available

The documents available to the meeting were SC/D12/AWMP1-5 (see Annex C).

2. SUMMARY OF DISCUSSIONS AT SC/64 AND INTERSESSIONAL PROGRESS

Donovan summarised the discussions at the 2012 Scientific Committee meeting with respect to the Greenlandic hunts (IWC, 2013a).

The Committee had re-emphasised the importance of developing long-term candidate *SLA*s for the Greenlandic hunts as soon as possible and certainly before the Commission's biennial meeting in 2018, given that the interim approach for providing management advice had been agreed (IWC, 2009a) to be valid for up to two blocks. It had agreed that it should be possible to develop an appropriate trial structures and operating models for the more straightforward cases of the humpback and bowhead whale hunts before the 2013 Annual Meeting to enable candidate *SLA*s to be evaluated. To assist in this process it had agreed a research project (IWC, 2013c) to be undertaken by Punt to develop a draft approach for consideration at an intersessional Workshop.

The Committee had also emphasised the importance of developers beginning to consider the development of candidate *SLA*s for fin whales and common minke whales, recognising that this needed to be in the context of the work being undertaken on stock structure with the RMP sub-committee and the joint AWMP/RMP proposal for work on the stock structure of North Atlantic common minke whales (Donovan *et al.*, 2013). To assist this process, the Punt research project noted above also incorporated the development of an AWMP/RMP-lite program.

The Workshop noted that papers SC/D12/AWMP1 and AWMP2 presented the contract work undertaken by Punt. They are discussed below under the relevant agenda items. It thanked Punt for his usual prompt and thorough work, recognising that without this, the Workshop would not have been able to complete its agenda on time.

3. GENERAL ISSUES

3.1 Candidate *SLA*s including guiding principles

The Workshop noted that considerable effort had been put into general consideration of the development of *SLA*s at the beginning of the AWMP process (IWC, 2000; 2001a; 2001b; 2002). It also recognised that a document (co-ordinated by Donovan, Punt and Scordino) that provides advice on the development of *SLA*s and their evaluation will be presented at the 2013 Scientific Committee meeting.

However it agreed that it would be useful at this Workshop to briefly outline some guiding principles for *SLA*s to assist developers of candidate *SLA*s prior to the 2013 Annual Meeting. These are summarised below.

(a) The primary objective of any *SLA* is to meet the objectives set by the Commission with respect to need satisfaction and conservation performance, with priority given to the latter.
(b) *SLA*s must incorporate a feedback mechanism.
(c) Once need has been met for the 'high' need envelope while giving acceptable conservation performance, then there is no need to try to improve the performance of an *SLA* further.
(d) Simple *SLA*s are to be preferred, providing this simplicity does not compromise achieving the Commission's objectives.
(e) With respect to (d), empirical procedures may prove preferable to population model based procedures because: (1) they are more easily understood by stakeholders; and (2) the low likelihood of much updating of population model parameters (e.g. MSYR) over time as the extent of additional data will probably be limited for populations subject to aboriginal whaling only. Nevertheless, the choice of the form for any candidate *SLA* lies entirely in the hands of its developer, with selection amongst candidates to be based only on performance in trials.

More specifically with respect to the Greenlandic hunts, the Workshop recalled (IWC, 2009c) that the agreed 'interim' approach is 2% of the lower 5% confidence interval for the most recent estimate of absolute abundance. The 'interim' *SLA* will form the basis of at least one of the candidate *SLA*s

*Presented to the meeting as SC/65a/Rep02.

(to be chosen, alternative candidate *SLA*s must at least show improved performance compared to this). However, it was also **agreed** to modify the 'interim' *SLA* to include a variant that allowed additional abundance estimates by using an approach similar to that used under the *catch-cascading* option of the RMP (this is discussed further below and see Annex D).

The Workshop also noted that under the Aboriginal Subsistence Whaling Scheme (IWC, 2003a; 2003b; 2003c) agreed by the Committee (although not yet adopted by the Commission), if an acceptable new abundance estimate (relative or absolute as pertinent to the case concerned) is not obtained by the 10th year after the previous such estimate, a 'grace period' of up to 5 years applies during which the strike limit allowed previously is reduced by 50% until an acceptable new abundance estimate is obtained. After 5 further years, the allowed strike limit will drop to zero. This will be incorporated as necessary into the trial structure (see Annex D).

3.2 Component of the population to which MSYR refers

During the development of *SLA*s for the Bering-Chuckchi-Beaufort Seas (B-C-B) bowhead and Eastern North Pacific (ENP) gray whale populations, there had been considerable discussions within the Scientific Committee as to what was the appropriate 'currency' in which to express MSYR. Given the case-specific AWMP approach and the nature of the data available on bowhead and gray whales, the Scientific Committee **agreed** that it was most appropriate to express MSYR in terms of the 1+ component of the population (i.e. non-calves). This differed from the approach adopted for the generic Revised Management Procedure approach for commercial whaling of baleen whales which has expressed MSYR in terms of the mature component of the population. The Committee has discussed and accepted these two different approaches in the past (IWC, 1998; 2000).

The Workshop reiterated that use of different 'currencies' did not imply any differences in biology/productivity.

For species/populations not subject to commercial whaling (i.e. bowhead, gray and humpback whales), the Workshop **agreed** that the 1+ currency remains the most appropriate.

However, the Workshop noted that for North Atlantic populations of common minke and fin whales, the situation arises in which species within the same ocean basin are subject to commercial whaling (for which RMP *Implementations* and *Implementation Reviews* have been carried out) and aboriginal subsistence whaling off Greenland. The most appropriate approach to take here requires further consideration by the Scientific Committee. One option is that provided appropriate currency conversions are used to ensure that assumptions about biology and productivity are the same, then the AWMP process can still evaluate performance in the context of 1+.

3.3 Presentation of results and selection of *SLA*s

The Workshop agreed that the existing presentation style for the results of AWMP trials and the procedures used in the past to select amongst candidate *SLA*s remain appropriate (e.g. see IWC, 2008b).

4. DEVELOPMENT OF TRIAL STRUCTURE FOR HUMPBACK WHALES OFF WEST GREENLAND

4.1 Stock structure hypotheses

4.1.1 Present hypothesis/es

In 2007, the Committee had noted that the humpback whales found off West Greenland belong to a separate feeding aggregation whose members mix on the breeding grounds in the West Indies, with individuals from other similar feeding aggregations (IWC, 2008a, p.21). It therefore had agreed that the West Greenland feeding aggregation was the appropriate management unit to consider when formulating management advice.

4.1.2 New information

SC/D12/AWMP5 provided maps of tracks of 30 humpback whales tagged with satellite linked radio transmitters on their feeding grounds in Disko Bay, West Greenland, in June 2008, 2009 and 2010. The whales used the continental shelf areas along West Greenland between 60 and 70°N extensively and made few excursions outside the areas covered by aerial surveys in 2005 and 2007 during August-September. Two whales departed from West Greenland and took a route south along Labrador and Newfoundland. One of them had already departed from West Greenland in June and reached Newfoundland in July.

The Workshop thanked Heide-Jørgensen for his work and encouraged him to continue tagging whales as it may provide information on early migration, movement between feeding areas and behaviour during the survey period. It was noted that the animal that left West Greenland in June might indicate that some animals leave the West Greenland area before the time of surveys (August), leading to a negative bias in the abundance estimates.

The Workshop recognised the potential of photographs to provide alternative evidence of movement between feeding areas and it **agreed** that Witting should confirm that all photographs from West Greenland have been submitted to the North Atlantic humpback Catalogue; Donovan agreed to check with Carlson to see whether any matches have been made.

4.1.3 Hypothesis/es for use in trials

The Workshop **endorsed** the previous Scientific Committee recommendation that the West Greenland feeding aggregation was the appropriate management unit. Therefore it **recommended** that it should be treated as a single stock in the trials, noting that there is no evidence to suggest other hypotheses should be tested.

4.2 Abundance estimates and trends

See Table 1.

Table 1

Estimates of absolute abundance for West Greenland humpback whales from an aerial survey in 2007.

Year	*n*	CV	Remarks	Reference
2007*	2,154	0.36	Initial strip census analysis (Heide-Jørgensen *et al.*, 2008) accepted by the Committee in 2008 (IWC, 2009a) was 3,039 (CV=0.45) – see text	Heide-Jørgensen *et al.* (2012)
2007	3,272	0.50	The initial MRDS estimate accepted by the Committee was 3,299 (CV=0.57)	Heide-Jørgensen *et al.* (2008)

*Agreed for use in the trials.

4.2.1 Review of estimates for use in conditioning and trials
The Committee has agreed absolute abundance and trend estimates for West Greenland humpback whales (Heide-Jørgensen *et al.*, 2008; IWC, 2009a). The absolute estimates were obtained from aerial survey data using two different analytical methods: strip census and mark-recapture distance sampling (MRDS). As both estimates were similar, the Committee had accepted both estimates (although noting that the sample size was rather low for undertaking a MRDS analysis) but had adopted the strip census estimate as the 'best' estimate *inter alia* given its smaller CV. The Workshop noted that the subsequently published version of the paper (Heide-Jørgensen *et al.*, 2012) had a revised strip census estimate (2,154, CV=0.36 versus the original 3,039, CV=0.45) in response to comments from the referees. The Workshop **requested** Heide-Jørgensen to provide a short working paper for discussion at the 2013 Annual Meeting documenting the changes such that the Committee can agree a 'final' best estimate. For the present purposes, the Workshop **agreed** to use the published strip census value (see Table 1). The agreed annual rate of increase was 9.4% per year (SE 0.01) which was unchanged in the published paper.

The Workshop **agreed** to use the estimates of relative abundance from aerial surveys given in Table 2a to condition the trials. By contrast, the abundance estimates from the mark-recapture studies (Table 2b) cover a shorter period and are heavily correlated so it was **agreed** that at present these will only be used in a *Robustness Trial*. However, the Workshop **agreed** that given that mark-recapture abundance estimates may become common in the future for both humpback and bowhead whales, efforts should be made to develop ways to better integrate them into operating models.

Both absolute and relative estimates of abundance are expected in the future. The next aerial survey is planned for 2015 to cover a similar area to the previous survey and with humpback whales as one of the priority species. Given present abundance and the **agreed** estimated rate of increase (insert value), the Workshop **agreed** that future sample sizes should be sufficient to allow absolute abundance estimates to be obtained from future surveys. In view of this, only absolute estimates will be generated into the future.

4.2.2 Conclusions
The Workshop **agreed** that both the absolute estimates of abundance given in Table 1 and the relative estimates of abundance from aerial surveys given in Table 2a will be used to condition the trials. In addition, it **agreed** that the relative abundance estimates from the mark-recapture studies (Table 2b) will be used in a *Robustness Trial*. Only absolute estimates will be generated into the future.

Table 2
Estimates of relative abundance for West Greenland humpback whales.

Year	Estimate	CV
(a) Aerial surveys		
1984	99	0.4
1985	177	0.44
1987	220	0.62
1988	200	0.74
1989	272	0.75
1993	873	0.53
2005*	1,158	0.35
2007	1,020	0.35
(b) Photo-id mark-recapture		
1982	271	0.13
1989	357	0.16
1990	355	0.12
1991	566	0.42
1992	376	0.19
1993	348	0.12

*In 2009 the Committee had agreed that this uncorrected estimate was suitable for use in assessments.

4.3 Removals history
4.3.1 Direct catches
The full historic catch series for North Atlantic humpback whales was reviewed in Smith and Reeves (2010). There is considerable uncertainty concerning the level of catches prior to 1930. However, because of known difficulties with fitting a population model for the western North Atlantic from its pre-exploitation level, the inability to assign many of the past catches to feeding aggregations and the decision to treat the West Greenland feeding aggregation as the appropriate management unit, it was **agreed** that trials would begin in the year 1960, under the assumption that the age structure at the start that year is steady. Thus the catch series used in the trials (and see Annex E) is provided from 1960 onwards, since when the catches are known reliably and there is no need for an alternative series to be considered.

None of the photographic recaptures of humpback whales from St. Vincent and The Grenadines have been with animals from the West Greenland feeding aggregation, so these catches are not included in the catch series.

However, given possible migration routes (e.g. from telemetry data), the Workshop noted that Greenland animals may have been subject to direct catches outside the West Greenland area. In particular, it was noted that known direct catches occurred from whaling stations off the east coast of Canada after 1960 (see Annex E).

Making simple assumptions (Greenland whales are estimated to be off Newfoundland for ~1 month in comparison to Canadian whales which are there for ~6 months and taking the relative abundances of the two populations into account) leads to an estimated potential direct catch of Greenland humpbacks off Canada of up to 5% of the total direct catch. The Workshop **agreed** that this will be incorporated into the catch series. No future direct catches off Canada will be simulated.

4.3.2 Bycatches
Bycatches of humpback whales are known to occur off West Greenland; Table 3 presents the information available in National Progress reports since 2000. It was **agreed** that Allison will ensure that animals incorporated into the direct catch series (some were reported as shot for humane reasons) are not double counted; bycaught animals will be considered separately. Heide-Jørgensen noted that many of the bycaught animals were taken in the crab fishery which has now peaked. The Workshop **agreed** that future bycatches will be generated assuming that the exploitation rate due to bycatch in the future equals that estimated for the trial in question over the most recent five-years.

No bycatches were reported for the 1960-2000 period for West Greenland. It was noted that this assumption is conservative in that bycatches will be assumed for the future.

As was the case for direct catches, the Workshop noted that animals may be subject to bycatches outside the West Greenland area outside the feeding season. In particular it was noted that known bycatches occur down the east coast of Canada and especially Newfoundland/Labrador. Ledwell and Huntington (2010; 2012); and Ledwell *et al.* (2011) report recent entanglements off Newfoundland and Labrador. From 1979 to 2011 a total of 1,314 whales were entangled, with ~80% of these being humpback whales.

Table 3

List of bycatches and ship strikes of West Greenland humpback whales since 2000 (taken from the National Progress Reports).

Year	Bycatch	Ship strike
2000	2	0
2001	2	0
2002	3	0
2003	1	0
2004	2	0
2005	5	0
2006	0	0
2007	2	0
2008	3	0
2009	0	0
2010	1	0
2011	1	0

Declines in entanglement rates were observed following the 1992 moratorium on Atlantic cod fisheries, and an average of ~9 individual humpback whales were entangled each year from 2010 to 2012. Of these, on average, 1.5 were found dead, while 2 were successfully released.

These will be incorporated into the trial specifications and will be included in Annex E developed after the Workshop. As for direct catches, it was **agreed** that the estimated potential bycatch of Greenland humpbacks off Canada could be up to 5% of the total Canadian bycatch, including both dead and released animals.

4.3.3 Ship strikes

There are no known reports of ship strikes off West Greenland. Donovan and Allison will examine whether there are reports of ship strikes of humpback whales off Canada and if so, the same approach as for direct catches and bycatches will be used to generate ship strike series. Information will be included in Annex E developed after the Workshop.

4.3.4 Conclusions with respect to series to use

A single direct catch series will be used. The historic bycatch series will be finalised by Donovan and Allison and will be included in Annex E developed after the Workshop. Future bycatches will be generated assuming that the exploitation rate due to bycatch in the future equals the mean value over the most recent five-years.

4.4 Biological parameters

Prior distributions need to be specified for three biological parameters: (a) the non-calf survival rate; (b) the age-at-maturity; and (c) the maximum pregnancy rate. The objective is to develop priors (taken to be uniform for all three parameters) which are plausible based on the range of estimates in the literature. The values for these parameters used in the actual trials will encompass a narrower range than these priors because the priors will be updated by the data on abundance and trends in abundance during the conditioning process.

The Workshop **agreed** that the prior for non-calf survival, S1+, will be U[0.9, 0.995]. The lower bound for this prior is the lower 95% confidence interval for the estimate of non-calf survival obtained by Larsen and Hammond (2004) while the upper bound is the upper 95% confidence interval for the estimate of non-calf survival rate for humpback whales in Prince William Sound, Alaska reported by Zerbini *et al.* (2010). Zerbini *et al.* (2010) based their estimates of maximum rates of increase on the non-calf survival rate estimate for this population.

The maximum pregnancy rate, f_{max}, is the pregnancy rate in the limit of zero population and thus is not measureable but is expected to be higher than observed pregnancy rates. Based on its review of the available information, the Workshop **agreed** that the prior will be U[0.4, 0.8]. The lower bound for this prior is close to the average of the estimates of pregnancy rate for humpback whale stocks reported by Zerbini *et al.* (2010). The upper bound was based on the view that the theoretical maximum (i.e. all mature females giving birth every year) is infeasible but that an estimate that involved a high proportion of animals on a one-year cycle (individuals have been observed to do this) should be considered.

The Workshop **agreed** that the prior for the age-at-maturity will be U[4, 12]. This is based on data from individually identified whales and incorporated the lower ages-at-first parturition reported by Clapham (1992) and Gabriele *et al.* (2007) and the high value reported by Robbins (2007).

Recognising the great uncertainty in these priors given the paucity of data, the Workshop **agreed** that it was important to develop a *Robustness Trial* (see Item 4.7) in which the priors for the biological parameters are modified by lowering the upper bounds for the priors for S_{1+} and f_{max} and increasing the lower bound for a_m.

The abundance data are not informative about carrying capacity. The Workshop **agreed** that trials should be based on the prior for carrying capacity, *K*, proposed in SC/D12/AWMP2, U[0, 30,000], noting that the estimated total catch of North Atlantic humpback whales is approximately 30,000 (Smith and Reeves, 2010).

The **agreed** priors are summarised in Table 4.

4.5 Need

SC/D12/AWMP4 presented need envelope considerations following internal discussions in Greenland and proposed a

Table 4

The prior distributions for humpback and bowhead whales for use in the trials.

Parameter	Humpback	Bowhead
Non-calf survival rate, S_{1+}	U[0.90, 0.995]	N(1.059, 0.0378^2), truncated at 0.995
Age-at-maturity, a_m	U[4, 12]	N(20,3^2) truncated at 13.5 and 26.5
K^{1+}	U[0, 30,000]	U[0, 40,000]
$MSYL_{1+}$	Pre-specified	Pre-specified
$MSYR_{1+}$	Pre-specified	Pre-specified
Maximum pregnancy rate, $1/f_{max}$	U[1.25, 2.5]	U[2.5, 4]
Additional variation (population estimates), CV_{add}, in year ψ	U[0, 0.35]	U[0, 0.35]
Abundance in year ψ, P_ψ	$\ell nP_{2002}=N(\ell n3{,}270; (0.50^2 + CV^2_{add}))$	A: $\ell nP_{2002}=N(\ell n6{,}340; (0.38^2 + CV^2_{add}))$ B: $\ell nP_{2006}=N(\ell n1{,}229; (0.47^2 + CV^2_{add}))$
Additional variation (relative indices), CV_{add2}	U[0.2, 0.6]	U[0.2, 0.6]
Bias of relative abundance indices, B_c	$\ell nB_c \sim U$ [-∞, ∞] (see[1])	$\ell nB_c \sim U$ [-∞, ∞] (see[1])

[1]This is the non-informative prior for a scale parameter.

way forward for the purposes of the trials. Development and consideration of need envelopes is the pragmatic approach used in the *SLA* development process to enable management advice to be provided to the Commission for possible increases in agreed need over time (e.g. due to increasing human populations) without requiring that additional trials be developed and run. It should be stressed that the size and shape need envelopes (which are proposed by those representing the subsistence hunters) do not imply that need requests will necessarily increase or that the Commission will accept such requests. Any need requests that are for scenarios outside the need envelopes tested will require additional trials and may require further *SLA* development. Need envelopes that are very wide may mean that candidate *SLA*s that fully meet need objectives cannot be developed.

For the ENP gray whales and B-C-B bowhead whales, three need envelopes were considered that started at current need levels: one remained constant through time, one increased linearly over the 100-year period to twice the present level and one increased linearly over the 100-year period to three times the current level. SC/D12/AWMP4 suggested a similar approach for West Greenland humpback whales but with some modifications to account for: (a) the preference of the hunters for humpback whales rather than fin whales (see below); and (b) the multispecies nature of the fishery and the overall expression of need in terms of edible products.

That Greenlanders would generally rather catch humpback whales than fin whales is reflected in the historical catches. It was only in the 1980s that concerns over the status of humpback whales led to the move to catches of fin whales and the removal of the traditional exemption allowing Greenlanders to take humpback whales despite its protected status in the North Atlantic. Recently, the Commission has allowed a resumption of the hunt on humpback whales and Witting explained that the currently expressed need for ten humpback whales is to some degree a compromise between the historical limits agreed for fin and humpback whales. To allow for more flexibility in the expression of actual need on fin and humpback whales in the near future, he suggested that the starting level of the need envelopes on humpback whales should be around twenty whales. Reiterating that the determination of catch limits is a matter for the Commission but recognising that the Committee needs to be in a position to provide scientific advice on any need requests, the Workshop **agreed** that need envelopes that increased over the initial three quota blocks from ten to twenty whales should capture this issue. Hence, the following three need envelopes were agreed [10, 15, 20-20], [10, 15, 20-40] and [10, 15, 20-60], with the middle envelope being considered the base case (see Fig. 1).

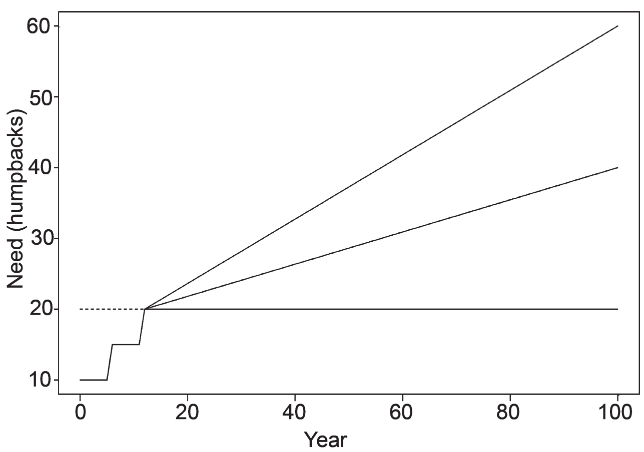

Fig.1. Need envelope for humpback whales (with the backup envelope shown by the dotted line).

Witting also proposed that a further case be examined to cope with unforeseen circumstances that may result in the allowable catch of especially minke whales being reduced. Using the interim conversion factors developed in Donovan *et al.* (2010), the amount of edible products from 50, 75 or 100 minke whales corresponds to the amount of edible products from 8, 12 and 16 humpback whales. He suggested consideration of an additional 'backup' scenario of initially adding ten humpback whales to the base case envelope (this would compensate for a decline in the minke whale strike limits of up to approximately 60 minke whales).

Witting agreed to discuss these need envelopes once again with managers in Greenland, and to report any suggested changes back to the AWMP Steering Group before the Annual Meeting.

4.6 *SLA*s to be considered

The general issue of the design of *SLA*s is discussed under Item 3.1. The Workshop **agreed** that all of the trials would be conducted for three 'reference *SLA*s', in addition to any other *SLA*s which might be proposed by developers (Annex D):

(1) the *Strike Limit* is set to the need;
(2) the *Strike Limit* is based on the interim *SLA* (IWC, 2009b); and
(3) the *Strike Limit* is based on a variant of the interim *SLA* which makes use of all of the estimates of abundance, but downweights them based on how recent they are.

The Workshop **agreed** that the developers would be provided with:

(1) total need for the next block;
(2) catches by sex;
(3) mortalities due to bycatch in fisheries and ship strikes; and
(4) estimates of absolute abundance and their associated CVs.

Witting and Butterworth/Brandão **confirmed** that they will be developing candidate *SLA*s.

4.7 Development of *Evaluation* and *Robustness Trials*

SC/D12/AWMP2 had provided a set of draft specifications for *Evaluation* and *Robustness Trials* for humpback whales off West Greenland based on those developed for the Eastern North Pacific stock of gray whales (IWC, 2005) One key feature was that the population dynamics model is initiated in a recent year (1960 for most of the trials) rather than under the assumption that the population was at carrying capacity at the start of the first year with catches. The Workshop **endorsed** this approach as suggested previously (IWC, 2013b) given the past difficulties to find population dynamics models which capture the entire period of exploitation and are able to fit the abundance data for the North Atlantic humpback whales adequately (Punt *et al.*, 2006) and the difficulties in assigning past catches to the West Greenland feeding aggregation. The operating model is conditioned to estimates of absolute and relative abundance. The trials proposed in SC/D12/AWMP2 explored the implications of uncertainty about $MSYR_{1+}$, the first year considered in the operating model, episodic events, need, survey frequency, and changes over time in natural mortality and carrying capacity.

Table 5

Factors to be tested in the trials for humpback and bowhead whales.

Factors	Other levels (Reference levels shown bold and underlined)	
	Humpback whales	Bowhead whales
MSYR$_{1+}$	1%, 3%, **5%,** 7%	1%, **2.5%,** 4%
Time dependence in *K**	**Constant,** halve linearly over 100 years.	
Time dependence in natural mortality, *M**	**Constant,** double linearly over 100 years.	
Episodic events*	**None,** 3 events occur between years 1-75 (with at least 2 in years 1-50) in which 20% of the animals die. Events occur every 5 years in which 5% of the animals die.	
Need in final year (linear change from 5/10 in 2011)	A:	**A: 5 ≥ 5 over 100 years**
	B:	B: 5 ≥ 10 over 100 years
	A:	**C: 5 ≥ 15 over 100 years**
	D:	
Survey frequency	5 years, **10 years**, 15 years	
Historic survey bias	0.8, **1.0**, 1.2	0.5, **1.0**
First year of projection, τ	**1960**	**1940**
Alternative Priors	$S_{1+} \sim U[0.9, 0.99]$; $f_{max} \sim U[0.4, 0.6]$; $a_m \sim U[5, 13]$	N/A
Strategic surveys	Extra survey if a survey estimate is half of the previous survey estimate.	
Canadian catches	N/A	A: 5 ≥ 5
		B: 5 ≥ 10
		C: 5 ≥ 15
		D: 2.5 ≥ 2.5

*Effects of these factors begin in year 2011 (i.e. at start of management). The adult survival rate is adjusted so that in catches were zero, then average population sizes in 250-500 years equals the carrying capacity. Note: for some biological parameters and levels of episodic events, it may not be possible to find an adult survival rate which satisfies this requirement.

Table 6

The *Evaluation Trials* for humpback whales. Values given in **bold** type show differences from the base trial.

Trial	Description	*MSYR*$_{1+}$	Need scenarios	Survey frequency	Historic survey bias	Conditioning option
1A	MSYR$_{1+}$=5%	5%	A, B, C, D	10	1	Y
1B	MSYR$_{1+}$=3%	**3%**	A, B, C, D	10	1	Y
1C	MSYR$_{1+}$=7%	**7%**	A, B, C, D	10	1	Y
2A	5 year surveys	5%	B, D	**5**	1	1A
2B	5 year surveys	**3%**	B, D	**5**	1	1B
3A	15 year surveys	5%	B, D	**15**	1	1A
3B	15 year surveys; MSYR$_{1+}$=3%	**3%**	B, D	**15**	1	1B
4A	Survey bias=0.8	5%	B, D	10	**0.8**	Y
4B	Survey bias=0.8; MSYR$_{1+}$=3%	**3%**	B, D	10	**0.8**	Y
5A	Survey bias=1.2	5%	B, D	10	**1.2**	Y
5B	Survey bias=1.2; MSYR$_{1+}$=3%	**3%**	B, D	10	**1.2**	Y
6A	3 episodic events	5%	B, D	10	1	1A
6B	3 episodic events; MSYR$_{1+}$=3%	**3%**	B, D	10	1	1B
7A	Stochastic events every 5 years	5%	B, D	10	1	1A
7B	Stochastic events every 5 years; MSYR$_{1+}$=3%	**3%**	B, D	10	1	1B

The Workshop considered the proposals in SC/D12/AWMP2 in light of its discussions above and the uncertainties involved. In particular, it **agreed**:

(a) trials will incorporate an assumption that additional variance is the same for all sighting surveys given that there are insufficient data to update the prior for additional variance by individual survey;

(b) *Strike Limit*s will be updated every six years rather than every five years to reflect the move to biennial Commission meetings;

(c) MSYR$_{1+}$ of 3%, 5%, and 7% will be examined (3% is low compared to observed rates of increase for other humpbacks stocks and well as humpback whales off West Greenland, 5% is close to the best estimate of the current rate of increase for West Greenland humpback whales and 7% is consistent with the rates of increase for other stocks of humpback whales of 10+%); and

(d) trials for which the survey period is every 15 years should be conducted with and without application of the rule related to the grace period (such trials also examine the situation in which the intention is to conduct surveys every 10 years, but a survey estimate cannot be produced that frequently).

With respect to *Robustness Trials* the Workshop **agreed** that *inter alia* these should include:

(a) trials in which the priors for the biological parameters exclude more productive values because the combination of the upper ends of the priors for S_{1+} and f_{max} along with the lower end of the prior for the age-at-maturity may be unlikely;

(b) at least one trial in which MSYR$_{1+}$=1%;

(c) a 'strategic survey' trial which assumes that a survey will be conducted in year *y*+1 if the survey in year *y* led to an estimate which is less than half of that from the preceding survey; and

(d) a trial in which the operating model is conditioned also to the mark-recapture estimates of abundance under the assumption that the estimates are independent.

Table 5 summarises the factors the Workshop **agreed** should be considered in the trials. Tables 6 and 7 summarise the **agreed** *Evaluation* and *Robustness Trials*. Annex F (to be completed after the Workshop[1]) provides the full specifications for the trials.

[1]See Annex E [the Report of the Standing Working Group on the Aboriginal Whaling Management Procedure] Appendix 2, this volume pp.205-213.

4.8 Consideration of results and/or future work

The code implementing the trials will be updated inter-sessionally and provided to potential developers. The full work plan and timeline is outlined in Item 9.

5. DEVELOPMENT OF TRIAL STRUCTURE FOR BOWHEAD WHALES OFF WEST GREENLAND

5.1 Stock structure hypotheses

The current working hypothesis in the Scientific Committee is a single Baffin Bay-Davis Strait stock of bowhead whales (see Fig. 2). However, pending the availability of some genetic analyses, the Committee has agreed that the possibility that there are in fact two different stocks present in the overall area, with the second located in the Foxe Basin-Hudson Strait region, cannot be ruled out (e.g. see IWC, 2009d).

No new information was available to the Workshop to revise this understanding of stock structure with its current uncertainties. Given that the Workshop's objective was to develop an *SLA* for the Greenland hunt of bowhead whales, it **agreed** to proceed first on a conservative basis that assumed that the absolute abundance of bowhead whales on the West Greenland wintering area would be informed by abundance estimates from data for that region only (see below). Only if such an *SLA* proved unable to meet need would abundance estimate information and stock structure considerations from the wider area shown in Fig. 2 be taken into account. This is discussed further under Item 5.7.

5.2 Abundance estimates and trends

Table 8 lists the abundance estimates for North Atlantic bowhead whales.

It is not possible to create an estimate of abundance for the entire Davis Strait-Baffin Bay-Foxe Basin area as would be required to model the total population as a single stock because the survey in Prince Regent Inlet was conducted in 2002 whereas the Foxe Basin-Hudson Bay survey was conducted in 2003: combining estimates from the two surveys could risk double counting animals. The Workshop agreed to condition the operating model using data for Davis Strait-Baffin Bay stock only (see Items 5.1 and 5.6).

The Workshop noted that the 2002 survey in Prince Regent Inlet might not be conducted again whereas regular surveys will be conducted off West Greenland. The Workshop therefore agreed to conduct trials: (a) in which the estimate for Prince Regent Inlet is treated as an estimate of absolute abundance; and (b) in which the estimates from West Greenland are treated as estimates of absolute abundance.

The sex ratio data from ~600 biopsy samples taken off West Greenland over the past 13 years show that the ratio of female:male animals in this area is ~80:20 (Heide-Jørgensen *et al.*, 2010a). There is no reason to expect that the current whole population does not have a 50:50 sex ratio since the large numbers of historical (pre-1900) catches were taken over the entire range and the catch ratio of recent Canadian catches is close to 50:50. Thus it is assumed that there is sex segregation on the feeding grounds. In view of this the trials will assume that the proportion of males available to the surveys will be the observed average male/female ratio in the biopsy samples.

Table 7

The *Robustness Trials* for humpback whales.

Trial no.	Factor	Need scenario	Conditioning option
1A	Linear decrease in *K*; $MSYR_{1+}$=5%	B, D	1A
1B	Linear decrease in *K*; $MSYR_{1+}$=3%	B, D	1B
2A	Linear increase in *M*; $MSYR_{1+}$=5%	B, D	1A
2B	Linear increase in *M*; $MSYR_{1+}$=3%	B, D	1B
3A	Strategic surveys; $MSYR_{1+}$=5%	B, D	1A
3B	Strategic surveys; $MSYR_{1+}$=3%	B, D	1B
4A	Alternative priors; $MSYR_{1+}$=5%	B, D	4A*
4B	Alternative priors; $MSYR_{1+}$=3%	B, D	4B*
4C	Alternative priors; $MSYR_{1+}$=7%	B, D	4C*
5D	$MSYR_{1+}$=1%	B, D	5D*
6A	Include mark-recapture estimates in the conditioning; $MSYR_{1+}$=5%	B, D	6A*
6B	Include mark-recapture estimates in the conditioning; $MSYR_{1+}$=3%	B, D	6B*

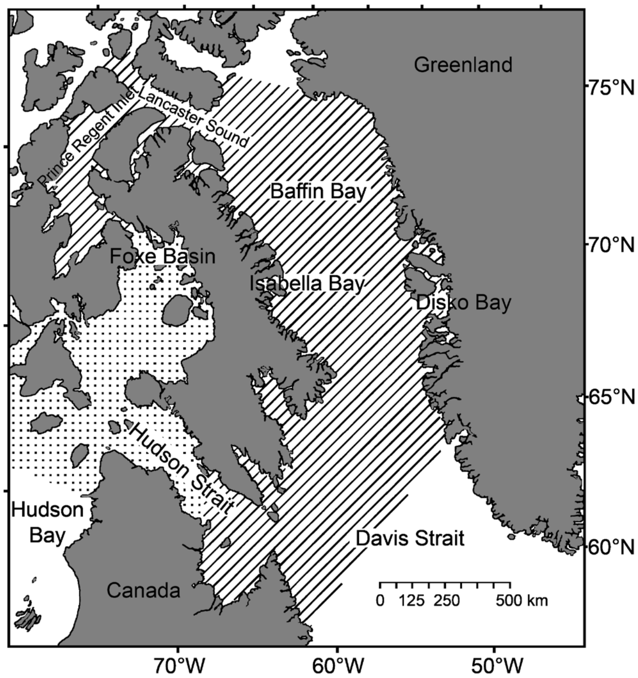

Fig. 2. Stock structure hypotheses for bowhead whales and place names referred to in the text. Hashed lines are for a Davis Strait-Baffin Bay stock while the dotted area refers to a Foxe Basin-Hudson Bay stock.

Table 8

Aerial survey estimates of bowhead whales.

Stock-Region	Year	*n*	CV/95%CI	Remarks	Reference
Prince Regent Inlet	2002	6,340	CI=3,119-12,906	Agreed to be used for management advice under alternative hypothesis	IWC (2009d)
Foxe Basin-Hudson Bay	2003	1,525	CI=333-6,990	Agreed to be used for management advice under alternative hypothesis	IWC (2009d)
West Greenland	2007	1,229	CV=0.47	Winter season – agreed to be used for management advice under alternative hypothesis	Heide-Jørgensen *et al.* (2007)
West Greenland	2012	829	CV=0.35	Preliminary (March-April surveys) – agreed for use in conditioning	Rekdal *et al.* (2013)
Isabella Bay	2009	1,105	CV=0.39	Summer season	Hansen *et al.* (2012)

Table 9
Estimates of relative abundance from aerial surveys. Data from 2012 are preliminary.

Year	Effort (units)	Sightings
1981	951	1
1982	2,273	1
1990	591	1
1991	1,088	3
1993	577	0
1994	1,092	0
1998	1,184	5
1999	1,104	0
2006	791	9
2012	1,574	25

Table 10
Estimates of relative abundance from genetic mark-recapture studies. Data from 2011 and 2012 are preliminary.

Year	Estimate	CV
2010	1,410	0.23
2011	1,681	0.28
2012	1,219	0.23

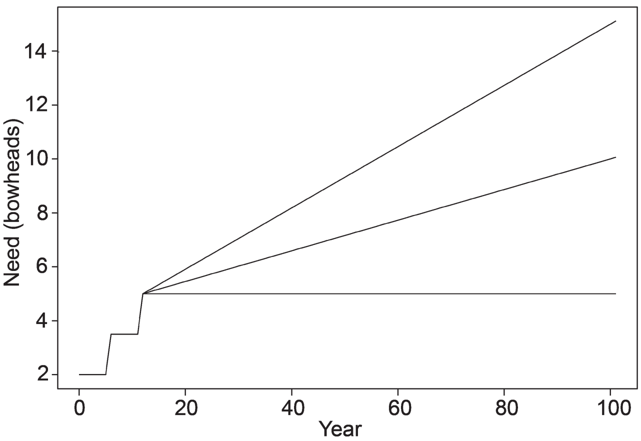

Fig.3. Need envelope for bowhead whales.

Estimates of relative abundance from aerial surveys are given in Table 9. The Workshop **agreed** that an overdispersion parameter should be estimated for these sightings data under the assumption that the data are negative binomially distributed.

The information provided to the *SLA* will be the results of surveys off West Greenland (relative indices if the operating model is conditioned to the estimate of abundance for Prince Regent Inlet and absolute if the operating model is conditioned to the estimate of abundance for West Greenland).

Estimates of relative abundance are also available from genetic mark recapture studies (Table 10). The potential of these mark recapture estimates (which are expected to continue in the future) was noted, but since time-series are not independent estimates, it will take some work to incorporate them into the trials. The Workshop **recommends** that work continue to enable these data to be used in the future, however, it accorded the work low priority at this time.

5.3 Removals

All the recent known direct catches of bowhead whales by Canada and Denmark (Greenland) are listed in Annex E. The catch series is believed to be complete for the period since 1940 (when the trials begin – see below) and the Workshop **agreed** that there was no need to consider an alternative catch series.

For 2011, Canada set an allowance of a maximum of four bowhead whales to be hunted in the Eastern Canadian Arctic. It is not known whether this allowance is for landed whales alone or whether it includes struck and lost whales. Allison will investigate this further.

The Workshop **agreed** that four scenarios regarding future Canadian catches should be considered (constant 5, 5 increasing to 10 over 100 years; five increasing to 15 over 100 years, constant 2.5; the last case reflects a situation in which half of the Canadian catches are taken from a different stock than the West Greenland catches).

The sex-ratio for the West Greenland catches should be set to the sex ratio observed in the biopsy samples taken off West Greenland over the 2002-11 period while that for the Canadian catches should be set to the observed sex-ratio (the observed ratio for the Baffin Bay/Davis Strait whales taken by Canada from 2002-11 is 6 male, 7 female, 4 unknown).

Recent bycatches of bowhead whales by Denmark (Greenland) and any information Donovan and Allison may find for Canada will be included in Annex E developed after the Workshop. It was noted that in future, if the number of ship strikes increases as the Northwest Passage opens up, this could trigger an *Implementation Review*.

5.4 Biological parameters

The Workshop received no new information on biological parameters. It therefore **agreed** to use the priors for f_{max}, S_{1+}, and a_m used for the *Implementation* for the Bering-Chucki-Beaufort Seas bowhead whales, noting that these incorporate considerable uncertainty for all three parameters.

5.5 Need

SC/D12/AWMP3 suggested three scenarios: each of which involves an increase to the need from two to five at the start of the projection period followed by either: (1) no increase of need; (2) a doubling; and (3) a tripling of need in a linear fashion over the total time period (and see Fig. 3).

5.6 *SLA*s to be considered

The Workshop **agreed** that the *SLA* developers will be provided with the total need for the next block, the catches by sex (separated into commercial and aboriginal catches [combined] and catches due to bycatch in fisheries and ship strikes [also combined], and catches by Canada), and the estimates of absolute abundance and their associated CVs. The *SLA* for bowhead whales may also wish to make use of the estimate of absolute abundance for Prince Regent Inlet of 6,340 (CV 0.38), noting that it cannot be assumed that abundance estimates from other than the West Greenland wintering area will be available in the future.

Witting and Butterworth/Brandão **confirmed** that they will be developing candidate *SLA*s.

5.7 Development of *Evaluation* and *Robustness Trials*

SC/D12/AWMP2 also provided a set of draft specifications for *Evaluation* and *Robustness Trials* for bowhead whales off West Greenland. As for humpback whales and for similar reasons, the Workshop **endorsed** the approach that population projections should begin from a recent year (1940). This is earlier than for humpback whales because of the extended age-structure of the population.

Given the uncertainty in stock structure (Item 5.1), trials could be conducted for one-stock and two-stock scenarios.

Table 11

The *Evaluation Trials* for bowhead whales (each conducted conditioning to the estimates of abundance for Prince Regent Inlet and West Greenland as absolute). Values given in **bold** type show differences from the base trial.

Trial	Description	$MSYR_{1+}$	Need scenario	Survey frequency		Historic survey bias	Conditioning option
(b) Bowhead whales (each conducted conditioning to the estimates of abundance for Prince Regent Inlet and West Greenland as absolute)							
1A	$MSYR_{1+}$=2.5%	1%	A, B, C	10	A	1	Y
1B	$MSYR_{1+}$=1%	**2.5%**	A, B, C	10	A	1	Y
1C	$MSYR_{1+}$=4%	**4%**	A, B, C	10	A	1	Y
2A	5 year surveys	2.5%	A, C	**5**	A	1	1A
2B	5 year surveys; $MSYR_{1+}$=1%	**1%**	A, C	**5**	A	1	1B
3A	15 year surveys	2.5%	A, C	**15**	A	1	1A
3B	15 year surveys; $MSYR_{1+}$=1%	**1%**	A, C	**15**	A	1	1B
4A	Survey bias=0.5	2.5%	A, C	10	A	**0.5**	Y
4B	Survey bias=0.5; $MSYR_{1+}$=1%	**1%**	A, C	10	A	**0.5**	Y
5A	3 episodic events	2.5%	A, C	10	A	1	1A
5B	3 episodic events; $MSYR_{1+}$=1%	**1%**	A, C	10	A	1	1B
6A	Stochastic events every 5 years	2.5%	A, C	10	A	1	1A
6B	Stochastic events every 5 years; $MSYR_{1+}$=1%	**1%**	A, C	10	A	1	1B
7A	Alternative future Canadian catches	2.5%	A, C	10	**B, C, D**	1	1A
7B	Alternative future Canadian catches; $MSYR_{1+}$=1%	**1%**	A, C	10	**B, C, D**	1	1B

Table 12

The *Robustness Trials* for bowhead whales.

Trial no.	Factor	Need scenario	Conditioning option
1A	Linear decrease in *K*; $MSYR_{1+}$=2.5%	A, C	1A
1B	Linear decrease in *K*; $MSYR_{1+}$=1%	A, C	1B
2A	Linear increase in *M*; $MSYR_{1+}$=2.5%	A, C	1A
2B	Linear increase in *M*; $MSYR_{1+}$=1%	A, C	1B
3A	Strategic surveys; $MSYR_{1+}$=5%	A, C	1A
3B	Strategic surveys; $MSYR_{1+}$=3%	A, C	1B

Neither scenario is straightforward to model, *inter alia* because: (a) no estimate of abundance for the entire Davis Strait-Baffin Bay-Foxe Basin area is available (the Prince Regent Island and Foxe basin surveys were surveyed in different years and cannot therefore be added together); (b) it is difficult to assign catches to stocks under the two-stock hypotheses; and (c) there is no guarantee that Canadians will undertake future abundance surveys.

The Workshop therefore **agreed** to condition the operating model using abundance data for the Davis Strait-Baffin Bay area only and remove all catches from the modelled Davis Strait-Baffin Bay-Foxe Island population. Both assumptions are conservative.

With respect to the Prince Regent Inlet survey estimate of 6,340 (CV 0.38), it was **agreed** to conduct trials initially only for the case in which the estimate of 1,229 (CV 0.47) off West Greenland is treated as an estimate of absolute abundance (after adjusting for the sex ratio), recognising that this clearly is an underestimate. The rationale is that if an *SLA* performs adequately when the operating model is conditioned to the West Greenland estimate alone, the *SLA* will perform adequately even in the absence of future surveys in Prince Regent Inlet. The information provided to the *SLA* will be the results of surveys off West Greenland. If it is not possible to develop an acceptable *SLA* under this assumption, then scenarios can be considered where the operating model is conditioned to the estimate of abundance for Prince Regent Inlet and estimates of abundance for West Greenland are considered to be relative.

The Workshop **agreed** that an overdispersion parameter should be estimated for the sightings data under the assumption that the data are negative binomially distributed, and that four scenarios regarding future Canadian catches should be considered (constant 5, 5 increasing to 10 over 100 years, 5 increasing to 15 over 100 years, constant 2.5; the last case reflects a situation in which half of the Canadian catches are not taken from the same stock as the West Greenland catches). The sex-ratio for future West Greenland catches should be set to the sex ratio of the biopsy samples off West Greenland over 2002-11 while that for future Canadian removals should be set to the observed sex-ratio.

The historical catches of bowhead whales were taken throughout the entire Davis Strait-Baffin Bay-Foxe Basin area, so it is reasonable to assume that the sex ratio of the entire population(s) at the start of 1940 is 50:50, despite the recent female-biased catches off West Greenland. The latter reflects the sex ratio of the animals found in the West Greenland wintering area as determined from over 600 biopsy samples. Clearly not all males in the population(s) are available when the survey is conducted.

The Workshop noted the factors that had been agreed for humpback whales, recognising that most of these were also appropriate for bowhead whales. Table 5 summarises the factors the Workshop **agreed** should be considered in the trials. Tables 11 and 12 summarise the **agreed** *Evaluation* and *Robustness Trials*. Annex E provides the full specifications for the trials.

5.8 Consideration of results and/or future work

The code implementing the trials will be updated intersessionally and provided to potential developers. The full work plan and timeline is outlined in Item 9.

6. PROGRESS WITH RESPECT TO COMMON MINKE WHALES AND FIN WHALES

6.1 Use of RMP/AWMP-lite

SC/D12/AWMP1 provided the specifications for RMP/AWMP-lite, which is a platform written in R which implements an MSE (management strategy evaluation) framework for evaluating the performance of catch and strike limit algorithms. The essence of RMP/AWMP-lite is the use of an age-aggregated model rather than an age-structured model to considerably speed up calculations; this will allow developers more easily to explore the properties of candidate *SLA*s before they are submitted to rigorous full testing. This framework can be used to evaluate management schemes where multiple stocks of whales are exploited by a combination of commercial and aboriginal whaling operations. The operating models can be conditioned to the actual data to allow an evaluation of whether stock structure assumptions and other hypotheses are comparable with the available data. The framework is applied for illustrative purposes to fin whales in the North Atlantic.

The Workshop welcomed SC/D12/AWMP1, which will help the Committee as it designs a trial structure for the North Atlantic common minke and fin whales, and will assist potential developers prepare for the development process. The Workshop **agreed** that the following modifications should be made to RMP/AWMP-like prior to the *Implementation Review* for the North Atlantic fin whales, which is scheduled to start during a pre-meeting prior to the 2013 meeting of the Scientific Committee:

(a) allow the *SLA*s to be coded as an executable file which is called from RMP/AWMP-lite so that developers do not need to be familiar with R;
(b) add headers to all output files;
(c) replace the Schaefer production model by a Pella-Tomlinson model so that MSYL can be specified to occur at 0.6*K*;
(d) allow MSYR to be a parameter of the model (instead of the intrinsic growth rate).
(e) simplify the use of folders so that it is easy for users to implement the software on their machines;
(f) add a tagging likelihood so that the tagging data can be used to inform the values in the mixing matrices;
(g) allow the population model to be initiated in a recent year and apply this version of the model to data for the North Atlantic fin whales; and
(h) extend the model to allow for dispersal among breeding stocks and use this extension of the model to implement Stock Structure Hypotheses I, II, III, V, and VI for the North Atlantic fin whales (IWC, 2009b).

The Workshop **agreed** that this work should be funded from the AWMP Developers Fund.

The Workshop recognised that production models can be biased compared to age-structured models. However, it **agreed** that any such bias was unlikely to be marked for baleen whales because the age-at-recruitment and the age-at-maturity are often similar and are usually not very different from age 1. The MSYR parameter in RMP/AWMP-lite should therefore be treated as being effectively in the $MSYR_{1+}$ currency. The Workshop noted that RMP/AWMP-lite can make use of 'minimum estimates' of abundance; minimum estimates are those for which coverage and precision are such that true abundance will certainly be larger than the point estimate from the survey.

6.2 Stock structure

The Commission has agreed that in cases of overlap, achievement of aboriginal need has a higher priority than allowing for commercial catches. Therefore, the process of developing *SLA*s and RMP *Implementations* for stocks in regions where both commercial and aboriginal catches occur should be: (a) development of a trials structure which adequately captures uncertainties regarding stock structure, mixing, MSYR, etc.; (b) identification of an *SLA* which performs as adequately as possible if there are no commercial catches; and (c) evaluation of the performance of RMP variants given the *SLA* selected at step (b).

6.2.1 Fin whales

Six stock structure hypotheses were identified during the *Implementation* (IWC, 2009b). These hypotheses will be reviewed during the *Implementation Review* scheduled for the 2013 meeting of the Scientific Committee.

The Workshop had an initial discussion regarding whether it would be possible to base the *SLA* for fin whales off West Greenland on operating models which considered West Greenland only, i.e. in effect assuming that the animals found off West Greenland comprise a single stock that is adequately represented by the abundance estimates obtained off West Greenland. The rationale for this is that even if there are multiple stocks off West Greenland (as was suggested in some hypotheses considered during the RMP *Implementation*), it may be reasonable to assume that they are susceptible to capture in the aboriginal hunt proportionally to their abundance when the survey is conducted. In contrast, varying proportions of the multiple stocks over time would violate this assumption. The Workshop **agreed** that the RMP *Implementation Review* should be asked to consider carefully any evidence that there may be more than one stock mixing off West Greenland.

6.2.2 Common minke whales

The trials structure for North Atlantic minke whales was developed for the 1992 RMP *Implementation* (IWC, 1993). The stock structure hypotheses considered at that time (and in subsequent *Implementation Reviews*) focused on the central and eastern stocks. Clearly additional focus on the western end of the range is required to adequately capture the range of hypotheses regarding stock structure for the minke whales hunted off West Greenland. Information on, for example, changes over time in catch sex ratios (or the lack thereof) confirms that the minke whales hunted off West Greenland do not comprise an entire stock. The Committee has recognised the need for a full evaluation of common minke whale stock structure in the North Atlantic in both an AWMP and RMP context. It has therefore agreed that a joint AWMP/RMP stock structure workshop be held in the intersessional period between the 2013 and 2014 Annual Meetings. The results of this Workshop will clearly be essential to the *SLA* development process.

6.3 Abundance estimates

The abundance estimates agreed by the Committee for the West Greenland fin and minke whales are listed in tables 3 and 4 of Witting (2013). The Workshop noted that the published paper (Heide-Jørgensen *et al.*, 2010b2) had updated the estimates originally accepted by the Committee; the Workshop **recommends** that the published estimates be accepted by the Committee.

6.4 Removals

The removals due to commercial and subsistence whaling are well documented for West Greenland fin and minke whales. However, the RMP *Implementation Reviews* will need to document and include information on bycatches and ship strikes.

6.5 Biological parameters

Unless new information becomes available, the existing biological parameter values used in the RMP should also be used for the AWMP.

6.6 Need

6.6.1 Fin whales

Witting advised the Workshop that the three scenarios (see Fig. 4) regarding the need envelope were:

(1) 19 whales in each year over the 100-year projection period;
(2) 19 whales each year increasing to 38 over the 100-year projection period; and
(3) 19 whales each year increasing to 57 over the 100-year projection period.

6.6.2 Minke whales

Witting advised the Workshop that the three scenarios (see Fig. 5) regarding the need envelope were:

(1) 200 whales in each year over the 100-year projection period;
(2) 200 whales each year increasing to 400 over the 100-year projection period; and
(3) 200 whales each year increasing to 600 over the 100-year projection period.

6.7 Candidate *SLA*s/developing teams

Witting and Brandão/Butterworth indicated that they were likely to develop candidate *SLA*s for common minke and fin whales.

6.8 Potential trials structure

6.8.1 Fin whales

The residual pattern for the fit of the operating model to the abundance estimates is common across areas, which suggests that there is model mis-specification. Future trials should consider alternative model structures such as initialising the population dynamics model more recently that the year corresponding to the first catches. The Workshop **recommends** that this matter be further considered by at the forthcoming *Implementation Review*.

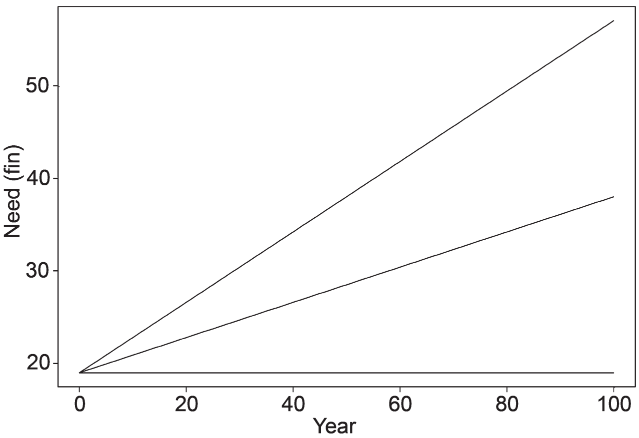

Fig.4. Need envelope for fin whales.

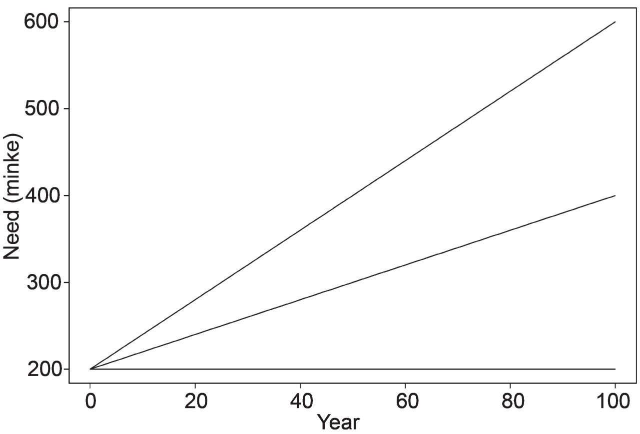

Fig.5. Need envelope for common minke whales.

6.8.2 Minke whales

The trials structure needs to account for the sex-ratio of past and future catches during the aboriginal and commercial hunts. Consideration should be given to sex-biased migration. A structure to allow for such migration is given in Witting (2012).

7. FUTURE CONSIDERATION OF OPERATIONAL MULTISPECIES ASPECTS IN THE PROVISION OF MANAGEMENT ADVICE

Earlier discussions (IWC, 2011; Witting, 2008) on this matter have noted that Greenland's need is expressed in terms of tonnes of edible products, and for operational reasons some flexibility to allow for temporal variability in the species composition of this tonnage is important and would be preferred. The inclusion of such flexibility within a set of *SLA*s for a number of species, where these *SLA*s would need to be inter-linked, is a challenging scientific task in terms of designing the necessary simulation tests. The Workshop re-iterated previous advice (IWC, 2012) that this aspect is best pursued only after separate *SLA*s, which operate independently for each species, have been developed and accepted.

8. COMPLETION OF GRAY WHALE *SLA* EVALUATION FOR THE MAKAH HUNT (VIA SKYPE)

Following the discussions at the 2012 Scientific Committee meeting, SC/D12/AWMP3 noted that two *SLA* variants (one with research provisions) were agreed by the Committee to meet the conservation objectives of the Commission. However, the Committee also noted that the two variants did not exactly mimic the proposed hunt and expressed concern that the actual conservation outcome of the proposed hunt was not fully tested. The reason that an exact variant was not tested was because there is a temporal rule in the proposed hunt, such that all struck and lost whales from December through April are not counted against the Allowable PCFG Limit (APL), whereas any struck and lost whales in May are counted against the APL. There are insufficient data to determine the proportion of strikes that would occur in May or prior to May, and hence the two variants of the hunt were developed to bracket the range of possible monthly strikes. SC/D12/AWMP3 proposed the testing of the following six variants to span the full range of possible strikes occurring in May or prior to May.

(1) Allow only one strike prior to May.
(2) Allow two strikes prior to May.
(3) Allow three strikes prior to May.
(4) Allow four strikes prior to May.
(5) Allow five strikes prior to May.
(6) Allow six strikes prior to May.

The Workshop **endorsed** the approach outlined in SC/D12/AWMP3 and **recommended** that the full set of trials be repeated for these six variants (in addition to the two *SLA*s agreed by the Committee [1 and 2]). Annex G summarises the performance for the eight trials used by the Committee during 2012 to contrast *SLA*s 1 and 2 for these six variants.

Table 13
Work plan.

Task	Species	Who	When
Get final catch series (to 2012) [by sex]	Both	CA	15 April 2013
Get bycatches	Both	GD, LW	15 April 2013
Get Canadian catches [by sex]	Bowheads	CA	15 April 2013
Scenarios for ship strikes	Both	GD, LW	15 April 2013
Specifications for grace period	Both	GD?	15 April 2013
Negative binomial likelihood implemented	Bowheads	AEP	12 January 2013
Estimate overdispersion parameter (in R)	Bowheads	AEP	12 January 2013
Implement and test grace period	Both	AEP	12 January 2013
Generate ‘q’ for relative index	Bowheads	AEP	12 January 2013
Additional variance the same for relative and absolute indices	Both	AEP	12 January 2013
Pass additional catch series to the *SLA* code	Both	AEP	12 January 2013
Add switch to select among default *SLA*s	Both	AEP	12 January 2013
Read in historical and future Canadian catches (assign future catches to sex)	Bowheads	AEP	12 January 2013
Read in historical and future bycatches and ship strikes	Both	AEP	12 January 2013
6-year strike limit	Both	AEP	12 January 2013
Implement strategic surveys	Both	AEP	12 January 2013
SLA coded as executable option	Both	AEP	12 January 2013
Distribute all conditioning files, runstreams, etc.	Both	AEP	12 January 2013
Update graphs	Both	AEP	12 January 2013
Specifications document updated	Both	AEP	12 January 2013
All runstreams checked	Both	AB/CA	31 January 2013
Check whether all photographs from West Greenland have been submitted to the College of the Atlantic catalogue and confirm whether any matches have been made	Humpback whales	GD/LW	15 April 2013
Produce short paper documenting any changes in published abundance estimates from papers presented to Scientific Committee meetings	All (especially humpback)	MPHJ	1 May 2013
Further discussion of need envelopes with managers in Greenland	All (especially humpback)	LW	1 May 2013
Develop an approach for simulating the availability of future mark-recapture estimates of abundance	General	AEP/CA/AB	‘Low priority’

The Workshop also **recommends** that the photo-id catalogue for the Eastern North Pacific gray whales that will be used to assess whether landed whales are from the PCFG be made publicly available as it is a key component of the management approach. It was pleased to be informed that funding is available to digitise the catalogue.

9. WORK PLAN

The Workshop **agreed** to the work plan given in Table 13.

10. ADOPTION OF REPORT

The report was adopted at 15:45 on 18 December 2012 apart from some editorial work and fact checking. The Chair thanked the participants for a constructive and successful Workshop. In particular, he thanked Mads-Peter Heide-Jørgensen and the staff of the Grønlands Repræsentation for the excellent facilities, Alice Heide-Jørgensen for helping out so efficiently at the weekend, and the rapporteurs. Finally he thanked Jette Donovan Jensen for acting as social secretary. The Workshop thanked the Chair for his usual effective and good humoured chairing of the Workshop.

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Annex A

Agenda

1. Introductory items
    - 1.1 Convenor's opening remarks
    - 1.2 Election of Chair
    - 1.3 Appointment of rapporteurs
    - 1.4 Adoption of Agenda
    - 1.5 Documents available
2. Summary of discussions at SC/64 and intersessional progress
3. General issues
    - 3.1 Candidate *SLA*s including guiding principles
    - 3.2 Component of the population to which MSYR refers
    - 3.3 Presentation of results and selection of *SLA*s
4. Development of trial structure for humpback whales off west Greenland
    - 4.1 Stock structure hypotheses
        - 4.1.1 Present hypothesis/es
        - 4.1.2 New information
        - 4.1.3 Hypothesis/es for use in trials
    - 4.2 Abundance estimates and trends
        - 4.2.1 Review of estimates for use in conditioning and trials
    - 4.3 Removals history
        - 4.3.1 Direct catches
        - 4.3.2 Bycatches
        - 4.3.3 Ship strikes
        - 4.3.4 Conclusions with respect to series to use
    - 4.4 Biological parameters
    - 4.5 Need
    - 4.6 *SLA*s to be considered
    - 4.7 Development of *Evaluation* and *Robustness Trials*
    - 4.8 Consideration of results and/or future work
5. Development of trial structure for bowhead whales off west Greenland
    - 5.1 Stock structure hypotheses
    - 5.2 Abundance estimates and trends
    - 5.3 Removals
    - 5.4 Biological parameters
    - 5.5 Need
    - 5.6 *SLA*s to be considered
    - 5.7 Development of *Evaluation* and *Robustness Trials*
    - 5.8 Consideration of results and/or future work
6. Progress with respect to common minke whales and fin whales
    - 6.1 Use of RMP/AWMP-lite
    - 6.2 Stock structure
        - 6.2.1 Fin whales
    - 6.3 6.2.2 Common minke whales
    - 6.4 Abundance estimates
      Removals
    - 6.5. Biological parameters
    - 6.6 Need
        - 6.6.1 Fin whales
        - 6.6.2 Minke whales
    - 6.7 Candidate *SLA*s/developing teams
    - 6.8 Potential trials structure
        - 6.8.1 Fin whales
        - 6.8.2 Minke whales
7. Future consideration of operational multispecies aspects in the provision of management advice
8. Completion of gray whale *SLA* evaluation for the Makah hunt (via Skype)
9. Work plan
10. Adoption of report

Annex B

List of Participants

Denmark
Mads-Peter Heide-Jørgensen
Lars Witting

USA (via Skype)
Jonathan Scordino
John Brandon
Dave Weller
Steve Stone

Japan
Toshihide Kitakado

Invited Participants
Doug Butterworth
Anabela Brandão
André Punt

Secretariat
Greg Donovan
Cherry Allison

Annex C

List of Documents

SC/D12/AWMP

1. Punt, A.E. A Full Description of RMP/AWMP-lite.
2. Punt, A.E. Trial specifications for humpback and bowhead whales off west Greenland.
3. Brandon, J. and Scordino, J. Suggested additional *SLA* variants to further evaluate the proposed Makah hunt.
4. Witting, L. Suggestions for need envelopes.
5. Heide-Jørgensen, M-P. Maps of humpback whales tracked by satellite in West Greenland 2008-2010.

Annex D

A weighted-average interim-*SLA*-like *SLA*

André E. Punt

The interim-*SLA* determines the *Strike Limit* as the lesser of need and

$$0.02\hat{N}e^{-1.645CV} \quad (1)$$

where $\hat{N}$ is the most recent estimate of abundance and CV is the coefficient of variation of $\hat{N}$.

Equation 1 has the disadvantage of ignoring all the estimates of abundance except for the most recent estimate. An alternative estimator which uses all of the abundance estimates (but ignores any trend in the population size) would replace $\hat{N}$ and CV in Equation 1 by:

$$\hat{N} = \exp\left[\sum_i \frac{0.9^{t_i}\,\ell n N_i}{CV_i^2} \Big/ \sum_i \frac{0.9^{t_i}}{CV_i^2}\right] \quad CV = \frac{\sqrt{\sum_i 0.9^{2t_i} / CV_i^2}}{\sum_i 0.9^{t_i} / CV_i^2} \quad (2)$$

Where:

N_i is the i^{th} estimate of abundance,

CV_i is the coefficient of variation of N_i, and

t_i is the time (in years) between when the i^{th} estimate of abundance was obtained and the first year of the block for which a *Strike Limit* is needed.

Annex E

Direct catches, bycatches and ship strikes to be included in the trials for humpback and bowhead whales

A revised version of the Catch Series is given in Annex F of the January 2014 Workshop report, available on the IWC website, *http://www.iwc.int*.

Annex F

Trial specifications for humpback and bowhead whales off West Greenland

See Annex E, Appendix 2, in this volume (pp.205-213).

Annex G

Summary results from additional runs requested for the proposed Makah hunt of gray whales

	Final depletion		Rescaled final depletion		Final depletion		Rescaled final depletion	
SLA variant	Low 5%	Median	Low 5%	Median	Low 5%	Median	Low 5%	Median
	Trial GB01C				**Trial GB08B**			
SLA 1	0.259	0.343	0.314	0.383	0.357	0.458	0.505	0.594
6 strikes before May	0.259	0.343	0.314	0.383	0.357	0.458	0.505	0.594
5 strikes before May	0.259	0.342	0.314	0.383	0.357	0.460	0.505	0.596
4 strikes before May	0.262	0.344	0.317	0.383	0.359	0.462	0.512	0.598
3 strikes before May	0.267	0.346	0.323	0.386	0.365	0.463	0.509	0.601
2 strikes before May	0.273	0.349	0.330	0.394	0.371	0.468	0.525	0.611
1 strike before May	0.280	0.356	0.338	0.403	0.384	0.484	0.542	0.628
SLA 2	0.290	0.365	0.352	0.414	0.396	0.504	0.560	0.656
	Trial GP01C				**Trial GB10B**			
SLA 1	0.382	0.461	0.400	0.472	0.492	0.556	0.492	0.557
6 strikes before May	0.382	0.461	0.400	0.472	0.492	0.556	0.492	0.557
5 strikes before May	0.382	0.460	0.400	0.472	0.492	0.556	0.492	0.557
4 strikes before May	0.390	0.464	0.406	0.476	0.487	0.560	0.487	0.562
3 strikes before May	0.396	0.468	0.414	0.479	0.508	0.566	0.510	0.567
2 strikes before May	0.405	0.476	0.424	0.488	0.533	0.584	0.535	0.584
1 strike before May	0.417	0.494	0.439	0.509	0.550	0.604	0.552	0.606
SLA 2	0.438	0.515	0.460	0.528	0.575	0.633	0.576	0.635
	Trial GP02C				**Trial GP08B**			
SLA 1	0.231	0.272	0.255	0.295	0.330	0.442	0.475	0.578
6 strikes before May	0.231	0.272	0.255	0.295	0.330	0.442	0.475	0.578
5 strikes before May	0.231	0.272	0.256	0.295	0.330	0.442	0.475	0.582
4 strikes before May	0.234	0.276	0.260	0.299	0.341	0.441	0.486	0.579
3 strikes before May	0.241	0.281	0.267	0.304	0.343	0.443	0.489	0.582
2 strikes before May	0.258	0.297	0.284	0.319	0.345	0.451	0.497	0.595
1 strike before May	0.274	0.320	0.303	0.345	0.360	0.466	0.517	0.610
SLA 2	0.299	0.347	0.334	0.372	0.364	0.482	0.528	0.635
	Trial GI01C				**Trial GP10B**			
SLA 1	0.378	0.446	0.399	0.459	0.475	0.536	0.476	0.538
6 strikes before May	0.378	0.446	0.399	0.459	0.475	0.536	0.476	0.538
5 strikes before May	0.378	0.449	0.399	0.46	0.475	0.537	0.476	0.538
4 strikes before May	0.381	0.451	0.401	0.465	0.475	0.542	0.476	0.543
3 strikes before May	0.387	0.455	0.407	0.469	0.482	0.549	0.483	0.549
2 strikes before May	0.395	0.465	0.416	0.478	0.508	0.566	0.510	0.567
1 strike before May	0.414	0.477	0.433	0.491	0.528	0.587	0.530	0.588
SLA 2	0.434	0.497	0.457	0.513	0.556	0.619	0.557	0.621

Report of the Expert Workshop to Review the Icelandic Special Permit Research Programme

Report of the Expert Workshop to Review the Icelandic Special Permit Research Programme[1]

The Workshop was held at the Marine Research Institute, Reykjavík from 18-22 February 2013.

1. INTRODUCTORY ITEMS

1.1 Chair's opening remarks

The Workshop was chaired by Kitakado, Chair of the IWC Scientific Committee. He welcomed the Panel members, observers and Icelandic proponents to Reykjavík and thanked the Marine Research Institute for hosting the Workshop.

He recalled that at the IWC Scientific Committee meeting in 2003, Iceland proposed a Scientific Permit for its wide ranging research objectives on cetaceans in Icelandic waters (Marine Research Institute, 2003) and explained further in SC/F13/SP1 and Item 3 below. The proposal intended to conduct a feasibility study with multiple objectives. The originally planned sample sizes were 200 common minke whales, 200 fin whales and 100 sei whales for a two-year period. The review of the proposal by the Scientific Committee can be found in IWC (2004) but there was no consensus Committee view of the proposal. Subsequently, the research plan was in practice reduced to 200 minke whales for a five-year period, which was completed in 2007.

The Chair commented that the Committee's review of the programme had been delayed for a number of reasons, but it had been agreed to be undertaken prior to the 2013 Annual Meeting.

The Committee has held several review workshops for special permit and its procedure for review has been evolving into what is colloquially called 'Annex P.' This process (DeMaster *et al.*, 2008; IWC, 2008b) was first followed for the review of the ongoing JARPN II programme in the western North Pacific (IWC, 2010a) and after that the Committee considered whether any modifications were necessary. Following this, 'Annex P' was clarified with respect to: (1) admission of observers; (2) selection of panel members; and (3) data availability. The final version of 'Annex P' is given in IWC (2013b).

1.2 Terms of reference

'Annex P' contains Terms of Reference for review of ongoing proposals and completed proposals but not all are relevant to the latter. These can be summarised as examining:

(1) how well the original objectives were met;
(2) whether the programme made other contributions to important research needs;
(3) the relationship of the research to IWC resolutions and discussions; and
(4) utility of lethal and non-lethal techniques.

1.3 Overview of the process for developing advice for the Commission

The first component of the process is the present small specialist workshop (this has to be held at least 100 days before the Scientific Committee meeting), with a limited number of invited experts chosen by a Standing Steering Group (SSG); a limited number of proponent scientists, primarily to present the proposal and answer points of clarification; and a limited number of observers. The SSG comprises past chairs of the Committee as well as the present Chair, vice-chair and Head of Science. Based on the proponents papers submitted by 1 December, in accordance with 'Annex P' the SSG drew up a shortlist of potential Panel members. Final selection was governed by availability (many of the potential members were unable to attend), the need for balance (including between Scientific Committee and non-Scientific Committee members) and the available funds. The final Panel is listed in Annex A and comprised two ex-chairs of the Committee, two scientists who had not participated in the Scientific Committee, one scientist who no longer regularly participates in Scientific Committee meetings and one regular member of the Scientific Committee; this is in addition to the Chair and Head of Science.

Four members of the Scientific Committee attended as observers and their names are given in Annex A as are the proponent scientists who attended some or all of the open sessions.

The report of the Workshop is made available for proponents at least 80 days ahead of the Scientific Committee meeting. They are able to comment on the Panel report and to revise documents for submission to the Scientific Committee in light of comments within the Panel's report. The final report, attached comments from proponents and any revised or new documents developed as a result of recommendations will be made available to the Scientific Committee at least 40 days before the Scientific Committee meeting.

The Scientific Committee may make additional comments and the report of the Workshop, comments by proponents and comments by the Committee itself will be sent to the Commission.

1.4 Meeting arrangements and work schedule

The Chair explained that he intended to follow the previous Workshop format, i.e. two types of sessions:

(1) open sessions where a limited number of scientists associated with the proposal present the proposal and answer questions from the Panel – this is also open to observers; and
(2) closed sessions where only the Panel members discuss the proposal and develop their report.

There may be a final closing session for the Panel to ask further questions of clarification.

In particular, his general intention was that for the morning sessions on days 1-3, the Icelandic scientists would provide their PowerPoint presentations for each of Items 4-9, although he recognised that some flexibility would be required and presentations may run into the early afternoon. Days 4 and 5 were for the Panel to discuss its overall conclusions and develop its report.

In the afternoon/evening sessions, the Panel will hold a closed meeting for summarising conclusions and recommendations for each agenda item. During the closed sessions, he noted that it was possible that the experts may want to ask further clarifications and questions to the

[1]Presented to the meeting as SC/65a/Rep03.

proponent scientists. He therefore requested that where possible that they remained at the venue in the afternoon, although in the event this was rarely necessary. The Panel may request working papers from the proponents on specific topics as was the case in the JARPN II review.

He referred to the 'Annex P' guidelines which state that Scientific Committee observers will 'not normally participate in discussions unless invited to do so by the Chair under special circumstances'. He was pleased to note that three papers from Committee members had been submitted to the Workshop and that the authors of two of the papers were present as observers. These provided valuable input into the Panel's discussions and assisted the Panel in its work. The Chair stated that if panel members had any questions on these documents he would invite observers to respond as the issues arose in the agenda, although in the event this was not necessary.

1.5 Review of documents and data

SC/F13/SP1-30 (papers from proponents), SC/F13/O1-3 (papers from Scientific Committee members) were made available to the Workshop in accordance with deadlines specified in 'Annex P'. The list of documents is given as Annex B. A number of background papers were also available and these are referred to where appropriate in the text. The proponents prepared PowerPoint presentations on each of the major topics (sometimes these applied to individual papers and sometimes they incorporated the results of several papers). It was agreed that where the agreement of authors was obtained that these would be made available to observers as well as Panel members but would be treated in a confidential manner.

2. ADOPTION OF AGENDA

The adopted Agenda is given as Annex C.

3. PROPONENTS' OVERVIEW OF THE RESEARCH OBJECTIVES AND RESULTS

This section was written by the proponents. The Panel's views can be found under the remaining items of the agenda. It is largely their summary of SC/F13/SP1, presented as an overview of the research programme, including a summary of the original research proposal, its implementation and main results. The original programme, as introduced and discussed by the Scientific Committee in 2003, included takes of three species, fin (n=200), sei (n=100) and minke (n=200) whales spread over a two year period. As indicated by the low sample size, the programme was designed as a feasibility/pilot study aimed at trying out the methods suggested and providing preliminary results that could guide the design of future research, rather than producing definite answers to the research questions.

The implementation of the programme started in August 2003, but only for the sub-project on common minke whales. As the original programme was stratified by species, with each species as a sub-project with minimal inter-dependence, the omission of fin and sei whales from the programme should not affect the scientific value of the minke whale component. Sampling of the originally proposed 200 minke whales (including 10 struck and lost animals) was completed in 2007. While the total sample size was retained, the sampling period was thus extended to five years. The objectives, methodology, total sample size and spatial and seasonal distribution of the sample remained largely unchanged from the original proposal (for details see Marine Research Institute, 2003) and the modifications involved primarily reduced rate of sampling.

3.1 Sampling

The sampling area was restricted to the Icelandic economic zone. No size limit was imposed but lactating females and accompanying calves were not allowed to be taken. To avoid selective sampling, exhaustive attempts were made to catch the first whale sighted within a given subarea and period. Several other operational rules were employed to distribute sampling within the nine sub-areas (and see Annex F, developed in response to a request by the Panel). The sub-areas used were part of the BORMICON framework for multispecies modelling of Boreal systems that was available at the time and has now been extended into GADGET[2]. This area division is based on oceanographic and ecological characteristics of the Icelandic continental shelf area. In addition to the nine BORMICON areas, the planned sampling was stratified seasonally into five units. The purpose of such a fine scale stratification (45 spatio-temporal sampling units in a study with n=200) was primarily to secure distribution of the sampling all around Iceland in this feasibility study. As indicated in the original proposal, analyses would be conducted by merging these areas into larger units as appropriate.

The realised temporal and spatial distribution of the samples was broadly in accordance with the original plan of representative sampling. The original sampling design had assumed the sampling intensity to be proportional to the relative abundance of minke whales in Icelandic continental shelf waters in time and space as indicated by previous sightings surveys 1986-2001 (Borchers *et al.*, 2009). Some modifications were made as the programme progressed (based on preliminary findings from simultaneous surveys and analysis of diet) to account for changes in distribution of minke whales and spatial variation in diet diversity (Table 1). Preliminary results from the first two years gave clear indications of much higher variability in the diet composition in the northerly areas than off the south and southwest coasts where the diet consisted overwhelmingly of sandeel. As the northern areas had been assigned relatively low sample sizes (based on the pre-2003 distribution from surveys) it was decided to increase the sample size there at the cost of sample size along the south coast where most stomachs contained only sandeel. This change in effort allocation will not affect the results as diet composition will be estimated separately for the northern and southern areas. Some limited flexibility was allowed for transfer of catches to neighbouring areas or days if whales could not be found in the small-scale time/area frame outlined in Table 1. These changes in sampling distribution were reported to the Scientific Committee (IWC, 2007) and should not affect the overall results, as the analyses will take account of geographical variation and most analyses are conducted on a larger spatio-temporal scale (i.e. larger than the 9x5 units in Table 1).

As shown by more recent sightings surveys (Pike *et al.*, 2011; SC/F13/SP6), considerable changes in distribution and abundance of minke whales occurred during the implementation of the research programme (Fig.1). Very few sightings of minke whales were made in offshore areas in the 2007 survey compared to the 2001 survey. This explains the difficulties encountered in sampling minke whales in offshore areas west of Iceland. Given the large changes occurring in distribution and abundance of minke whales and

[2]*http://www.hafro.is/gadget/userguide/userguide.html.*

Table 1

Original sample scheme (Plan) and realised sampling (Sample) in the nine subareas after changes made to the programme. Numbers in parentheses are struck-and-lost animals.

	April-May		June		July		August		Sept.-Oct.		Total	
Area	Sample	Plan	Sample	Plan	Sample	Plan	Sample	Plan	Sample	Plan	Sample	Plan
Area 1	4 (1)	5	10	15	12 (1)	14	19 (1)	15	7	5	52 (3)	54
Area 2	3	1	5	6	6	5	14 (1)	5	3	1	31 (1)	18
Area 3		1	8 (1)	6	5 (1)	5	3	5	-	1	16 (2)	18
Area 4	1	1	8	2	4	3	2	1	1	1	16	8
Area 5		1	4	4	4	4	2	4	1	1	11	14
Area 6	2	3	8	6	5	7	7 (1)	7	2	3	24 (1)	26
Area 8		1	-	2	2	2	1	2	1	1	4	8
Area 9	1	4	2	11	16 (2)	12	10 (1)	11	2	4	31 (3)	42
Area 10		1	7	3	1	4	5	3	2	1	15	12
	11 (1)	18	52 (1)	55	55 (4)	56	63 (4)	53	19	18	200 (10)	200

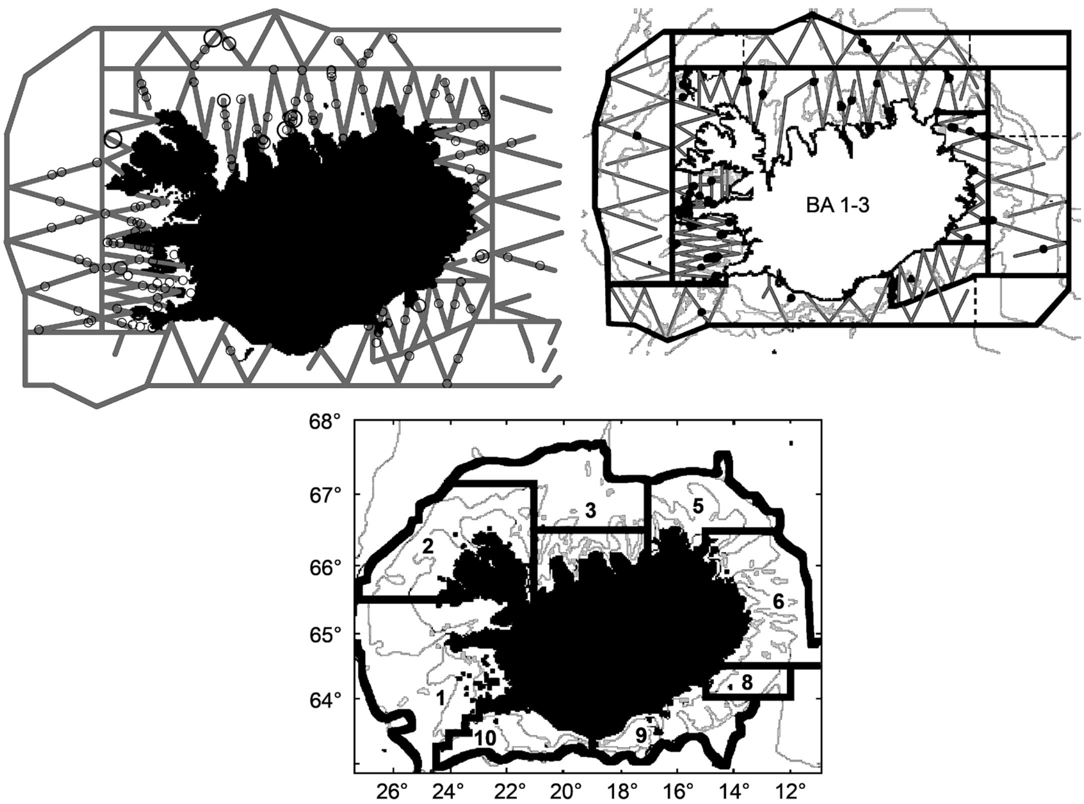

Fig.1. Distribution of sightings of North Atlantic common minke whales in Icelandic waters from aerial surveys performed in 2001 (top left) and 2007 (top right). The sampling distribution presented in the bottom-right reflects the 2007 abundance estimates and shows the original BORMICON areas (note that there is no sub-area 7 shown as this falls outside the research area).

the ecosystem in general during the sampling period (SC/F13/SP2), we conclude the sampling was representative for the distribution of minke whales in the period investigated to the extent possible.

The primary objective of the part of the research programme concerning common minke whales was to increase knowledge on the feeding ecology of minke whales in Icelandic waters by studies on diet composition, energetics, seasonal variation in distribution and abundance, estimation of consumption rates and multispecies modelling.

The programme also had the following secondary objectives.

(1) Examination of population structure:
   (a) comparison of the genetic structure of common minke whales off Iceland, Norway (including the Jan Mayen area), the Faroes and Greenland;
   (b) monitoring the movements of common minke whales by satellite telemetry; and
   (c) investigate other methods relevant to stock structure.
(2) Monitoring and evaluation of the morbidity of potential pathogens.
(3) Investigate potential temporal changes in biological parameters.
(4) Analyse contaminant burden and evaluation of the health status of individual common minke whales and populations.
(5) Evaluate the applicability of non-lethal research methods in studies on feeding, energetics and pollutant burden.

With respect to sub-sampling for different projects, the same set of animals was selected for the studies on contaminants and stable isotope ratios. They were intended to represent the areas north and south of Iceland, with equal sex ratios from both areas and as large a length span as was possible. The samples were all from 2003 and 2004 except for 10 additional animals from 2006 examined for stable isotope ratios for comparison with the previous sample given the observed changes in diet. In addition, for dioxins and dioxin-like PCBs, a small set of five male animals in the length interval 5.08-8.45m from 2003 were chosen from southwest and north of Iceland.

Animals chosen for fatty acid analysis were selected to reflect both the northern and southern areas and a range of diet found in their stomachs. Both sexes were equally represented. Veterinary inspections were based upon the availability of the expert scientist in the field with no pre-determined choice of animals.

The choice of tissues and organs in the chemical studies took account of the comparison with skin samples (representing biopsies) related to the objective of evaluating the applicability of non-lethal methods. For example, blood was assumed to have the fastest turnover rate and thus represented the most recent feeding timescale in the fatty acid and isotope studies.

3.2 Feeding ecology and energetics

Feeding ecology (SC/F13/SP2-SP4) and energetics studies (SC/F13/SP5, SC/F13/SP8-SP9 and SC/F13/SP11) on the common minke whale greatly improved the previously limited knowledge in this field for Icelandic waters. These studies provided new information on spatial and temporal variation in diet composition, its relation to changes in prey abundance, estimates of seasonal energy deposition, seasonal variation in abundance and the estimation of consumption rates.

In addition to the traditional analysis of stomach content, several other methods were applied in the study of feeding ecology including stable isotope ratios and fatty acid analysis. These alternative analyses generally did not reflect the results of the stomach contents analysis. For example, the stable isotope analysis indicated a lower trophic level than the stomach content analysis. This could be explained by the different time periods reflected by these two methods. For the purpose of describing the diet of minke whales in Icelandic waters during the sampling period (April-October), and for use in multi-species modelling, the stomach contents analysis is more appropriate than the other two methods which may be reflecting diet consumed in other areas and time periods. The results from the analysis of the stomach contents showed large changes in diet composition compared to the limited previously available data from 1977-84 and also appreciable changes during the research period 2003-07 which appeared to reflect simultaneous changes in availability of prey species. The energetic studies confirmed a similar pattern of seasonal energy deposition as found in other balaenopterid species including fin whales. They also showed spatial and temporal variation in body condition consistent with changes in abundance of important prey species and abundance of common minke whales in Icelandic waters. A model for estimating total blubber mass from measurements of blubber thickness was presented. Aerial surveys provided new information on seasonal variation in distribution of common minke whales in Icelandic waters. The historic catch distribution seems to reflect the low presence of common minke whales in the spring. Results from platforms of opportunity support the results in spring and autumn.

3.3 Stock structure

Stock structure was investigated using genetic markers, telemetry and several other methods.

The main study, performed with 16 microsatellite loci and mtDNA (SC/F13/SP16-SP17, first presented to the IWC Scientific Committee in 2008) includes samples collected during the special permit programme (2003-07) and historical samples (1981-85) collected in Icelandic waters. It also includes samples collected in Greenland, Norway coastal region, Barents Sea, North Sea and Spitsbergen, to ensure comparisons with other geographical areas and IWC stock boundaries. None of the analyses revealed any pattern of genetic structure at feeding grounds, although interestingly, two haplotype groups were detected (without any pattern in their geographic distribution). Another study was performed with a subsample (2003-04, for a total of 60 whales) of the genetic data from the special permit programme (SC/F13/SP16). This study, which used 16 different microsatellite loci and mtDNA, suggested the presence of two putative populations. However a thorough examination of this study revealed that the observed genetic pattern was weak and uncertain. The development of genetic techniques similar to other DNA registries of minke whale (same set of 10 microsatellite used) allowed for additional analyses which were conducted in recent years and were not planned in the original proposal. In addition to the samples used in SC/F13/SP17, samples from Norway (2002-04) were therefore included in the analyses. Using relatedness analysis based on the likelihood odds score (LOD) and false discovery rate (FDR) methods, SC/F13/SP20 demonstrated a high rate of relatedness across the North Atlantic, therefore suggesting high dispersal rate. Although the combination of several datasets (Norway and Iceland) and the development of relatedness analyses seemed to be promising, SC/F13/SP20 also reported on the necessity to access more biological information (such as age data) to understand the type of relationship observed.

SC/F13/SP19 is an extension of Christensen *et al.* (1990), including Icelandic data from 2003-09. The morphometric analysis was based on 17 characters measured on Icelandic samples which were also combined with data from Norway for area comparisons. The results suggested differences for both sexes and areas, but the large variance of the estimates gave a non-significant pattern and therefore inconclusive results related to stock structure.

SC/F13/SP18 provided the first documentation of the autumn migration route and possible winter destination of common minke whales in the North Atlantic via satellite telemetry. It is noteworthy that during the total combined tracking period of 370 days (eight individuals combined), no whale was observed crossing the IWC Schedule boundaries for the Central North Atlantic stock. Although informative, these data are still insufficient to make firm conclusions on stock structure.

Based on the Scientific Committee's comment in 2012 'The Committee reaffirms the importance of using a suite of techniques', the Panel requested that a summary of the information from the programme on other techniques (*inter alia* stable isotope ratios, fatty acid signatures and pollutant levels) that were potentially informative in the context of stock structure issues, should be compiled. This is given as Annex D.

3.4 Parasites and pathology

The results of parasites and pathology studies (SC/F13/SP27-SP29) highlighted the first discovery and description of a new species *Caligus elongatus* on a cetacean host, the first insight into gross pathology of Icelandic minke whales and the evaluation of parasite prevalence in the digestive tract.

3.5 Biological parameters

SC/F13/SP15 emphasised the importance of the development and testing of a new ageing method developed for common minke whales, as previous techniques (ear plugs, tympanic bullae) have been problematic for many decades. This study uses eye nuclei from 38 earplug-aged Antarctic minke whales (*Balaenoptera bonaerensis*) and eye nuclei from 21 foetuses of Icelandic minke whales (*B. acutorostrata*) to construct the aspartic acid racemisation (AAR) model for estimating age of the Icelandic minke whale. The age of Icelandic minke whales was found from the regression of age on transformed D/L ratios for the Antarctic minke whale and the foetuses of Icelandic minke whale. The model is based on Antarctic minke whales in the age interval 2-48 years while the minimum and maximum age estimated for the Icelandic minke whale was 3 and 42 years, respectively. The standard prediction error is about 4 years while the SE of the left and right lens nuclei is on average between 2.5 and 3 years.

SC/F13/SP12 presented updated information on various biological parameters including age and length at sexual maturity and reproductive rates.

SC/F13/SP13 reported on seasonal changes in testosterone and progesterone levels in minke whales, indicating for example differences between Iceland and Norway in reproductive seasonality.

SC/F13/SP14 reported on the geographical, temporal and size segregation of sexes of North Atlantic minke whale in Icelandic waters based on the catch data from 1974 to 2009, including the Scientific Permit samples. The results indicate that males tend to arrive later from the south to Icelandic waters, because their spring and summer distributions were observed to be more southerly (areas 1, SA and 10) than the distribution of females. Later in the summer and the autumn they have arrived at the northern part of Icelandic waters, dominating in the catch there too. One could speculate that the females may by then have left the Icelandic whaling area and moved even more northerly or to East Greenlandic waters. There was an observed difference between the West and East coastal areas in this respect. These findings are similar to the views of the whalers, an earlier description by Sigurjónsson (1982) and are also in accordance with sex-ratio differences in minke whales in Greenland waters (Laidre *et al.*, 2009).

3.6 Pollutants

A summary of extensive analyses of 11 trace elements, 27 legacy POPs, dioxins, dioxinlike PCBs, 14 PCNs, up to 10 PBDEs, eight methoxylated PBDEs, and Cs-137 in several tissues was presented in seven reports and publications (SC/F13/SP21-26, 30). These included analyses of spatial variation and highlighted their relevance to potential stock structure issues. However, investigations on relationship between pollutant levels and health status were not feasible due to the low number of animals analysed and the fact that all the animals analysed were quite healthy.

3.7 Lethal *vs* non-lethal techniques

An evaluation of the applicability of several non-lethal methods was included as a special objective in the research programme. This was *inter alia* achieved by comparisons of results from a mimicked biopsy (skin and the outermost part of the blubber) with those from internal tissues and organs. Such comparisons were made for several studies included in the programme, including diet composition vs. fatty acid (FA), diet composition vs. stable isotope ratios (SIR), and the comparisons of pollutants levels (SC/F13/SP3-SP4, SC/F13/SP21-SP26). In most cases, the skin and outer blubber layer were concluded not to be a valid predictor of trace element concentrations in tissues except for mercury in muscle tissues. However, biopsies were suggested to be relevant for a third of the comparisons made for POP's, including HCB, β-HCH, p,p'-DDT, o,p'-DDT, and Tox-26 (1:1 ratio) estimations (Table 2). Comparisons were also made between several methods for determining diet composition (stomach content, fatty acid profiles and stable isotope ratios) as mentioned above (see Item 3.2). This comparison revealed different results, probably reflecting different time scale represented by the different methods. Thus, while the stomach content is the best indicator for the research period and area (Icelandic continental shelf May-September) the alternative methods may better reflect feeding outside this spatio-temporal scale.

In addition, the proponents noted that while generally genetic studies can be conducted by non-lethal methods (skin biopsies) such methods cannot provide additional information required when performing genetic relatedness analyses such as age data to investigate the type of relationship among related pairs detected. The applicability of lethal and non-lethal techniques must also be considered from a practical or logistic point of view. SC/F13/SP1 included a summary table of the research objectives of this programme from both a theoretical and practical perspective (Table 3).

3.8 Proponents' conclusion

With reference to the original objectives of this feasibility or pilot study with a sample size of only 200 animals the proponents concluded that the study has been successful for all of its major components. Clearly not all objectives were fulfilled, some minor components were deemed infeasible and the project had to be scaled down in some fields for economic reasons after the Icelandic bank system collapsed in 2008. However, the project has greatly increased our knowledge on most aspects of the biology of minke whales in Icelandic waters, which was very limited before the implementation of the programme. While not providing definite answers to all raised research questions (as expected and outlined in the proposal) the results will serve as a valuable basis for future research.

Except for a delay in development of a multi species model for logistic/practical reasons, the studies related to the primary objective of the programme were conducted successfully. In particular, the research has provided important data to guide the development of a multi-species model including minke whales using GADGET. These include data for estimation of the following input parameters.

(1) Abundance, stock structure and movements. These are necessary for the construction of migration curves for estimating residence times in Icelandic waters.
(2) Consumption rates by: (a) quantification of seasonal energy deposition; and (b) urinalysis.
(3) Biological parameters (growth rates, age/length at sexual maturity, reproductive rates) necessary for modelling the minke whale population.
(4) Diet composition.

Table 2

The relationship between concentrations of trace elements and POP's in a mimicked biopsy and inner tissues and organs.

Compounds	Total no. of comparisons	1:1 Relationship	Other potentially useful relationships	% Biopsy representativeness (1:1 (total))
Trace elements	53	1[1]	3	1.9 (7.5)
POP's	90	6[2]	24	6.7 (33.3)

[1]Mercury skin/muscle; [2]HCB, β-HCH, p,p'-DDT, o,p'-DDT and Tox-26 for outer blubber ('biopsy') *vs* blubber core and p,p'-DDT for 'biopsy' *vs* muscle.

Table 3

Proponents' summary of their primary (1) and secondary (2) research objectives with respect to applicability of non-lethal techniques. Under Applicability, +++ denotes 'full' applicability, '++' partial and '+' limited applicability. '-' means unsuitable. Under Conclusion, this relates to the question: Can lethal/non-lethal methods provide the required information within the specified time frame?

		Applicability					
		Theoretical		Practical		Conclusion	
Research objective: primary (1) or secondary (2)		Lethal	Non-lethal	Lethal	Non-lethal	Lethal	Non-lethal
1. Feeding ecology							
Diet composition	1°	+++	++	+++	+	+	-
Energetics (feeding rates)	1°	+++	-	+++	-	+	-
Seasonal abundance	1°	-	+++	-	+++	-	+
2. Stock structure							
Genetics	2°	+++	+++	+++	++	+	+
Movements	2°	-	++	-	++	-	+
Biological parameters	2°	+++	+	+++	+	+	-
Parasites	2°	+++	-	+++	-	+	-
Morphometrics	2°	+++	+	+++	+	+	-
Biological parameters	2°	+++	++	+++	+	+	-
3. Parasites and pathology							
Veterinary investigation	2°	+++	-	+++	-	+	-
4. Biological parameters							
Age at sexual maturity, fecundity etc.	2°	+++	+	++	-	+	-
5. Pollutants							
Analysis of pollutants by age, sexual maturity, feeding ecology etc.	2°	+++	+	+++	-	+	-

In addition to meeting the primary objectives of the research programme concerning feeding ecology and energetics, these studies provided interesting insights into the large environmental changes occurring in Icelandic waters during the research period. Despite the small sample size, the results concerning diet composition and body condition clearly reflect these changes. Minke whales appear to have responded to these changes both by changes in diet and a shift in distribution.

In addition to the original objectives (Marine Research Institute, 2003), SC/F13/SP1 presented a summary of collaborations/studies initiated during the project, on brain anatomy, Cs-137, the climate change aspect, genetic relatedness analyses, and analysis of BFRs, PBDD/Fs, PCNs and MeO-PBDEs.

The presentation also highlighted the relevance of the present results to IWC Resolutions and discussions, such as marine mammal fisheries interactions (IWC, 2002), environmental changes and cetaceans (Resolutions - IWC, 1995; 1996b; 1999; 2000) the importance of stock structure (key element in the implementation of the RMP and AWMP) and the importance of lethal *vs* non-lethal techniques comparisons (IWC, 1996a).

4. ABUNDANCE

With respect to abundance, the primary objective of the special permit programme was to increase knowledge of seasonal variation in distribution and abundance and to use this information as an input to the multispecies modelling component of the research programme in conjunction with information on *inter alia* consumption rates.

4.1 Proponents' summary

The off-summer (i.e. outside the peak season when abundance surveys for use in the RMP are conducted) component of these abundance surveys was directly part of the special permit programme for common minke whales, although the results of all aerial surveys covering most of the continental shelf waters of the Icelandic economic zone during 1987 to 2009 are relevant with respect to temporal and seasonal patterns. The survey data indicated that there could have been a large scale ecosystem change in Icelandic waters starting sometime between 2001 and 2007. To investigate if data collection issues could have biased this conclusion, the effects of observers and searching behaviour were investigated in SC/F13/SP6. Despite the fact that the same observers have participated in only a few of these surveys, it was found that the changes in common minke whale sighting rates between years were fairly consistent for the two primary observers (on the left and right side of the plane) and they were also consistent in repeated coverage of the same blocks within survey year, although there were some observer differences. The observers appeared to have differed in their search patterns and so their detection functions differed. This could potentially affect the estimates of abundance and corrections for animals missed by the observers which were based on limited independent observer data. In addition, sighting rates of the smallest cetacean (harbour porpoises), detected only at close range, differed greatly between observers and inversely to the sightings rates for large whales that become inflated when the observers had more effort at greater distances from the track line. From these investigations the authors concluded that simple sighting rates of common minke whales was a more robust index of relative abundance than absolute abundance estimates derived by fitting detection functions in each case and that the aerial surveys sighting rates provided a good overview of distribution changes over time and season.

Using the aerial survey data, the sighting rates of common minke whales were lowest in the spring (late April-early May) and rates in September were about 1/3 that of the midsummer rates (June-July). The changes in sighting rates also indicated that variation between years was even greater than the intra-annual changes and there was an observable change over time in the abundance and distribution of the common minke whales in Icelandic waters. The intra-annual pattern conclusions were also supported by the historic catch distribution and results from platforms of opportunity.

However, because surveying later than September was not practical, these surveys did not provide information on the time by which most of the minke whales had left Icelandic waters. The high variation observed during the surveys and difficulties with surveying during off-summer months resulted in less surveying than had been initially planned. In addition because the survey area was limited to the waters around Iceland and there were high sighting rates at the outer edges of the northern survey area, it was not possible to come to firm conclusions about the spatial distribution of common minke whales in these northern waters. For future surveys, the authors suggested that independent observer (IO) data would need to be augmented with video or photographing, which would ensure comparability between past and future surveys.

4.2 Panel discussion, conclusion and recommendations

The Panel **welcomed** the information on the Icelandic surveys, recognising the considerable work involved in undertaking them and analysing the data. In particular, it appreciated the logistical difficulties in undertaking surveys outside the summer period given the prevailing weather conditions around Iceland. It noted that many of the summer surveys have already been documented, presented, and accepted by the IWC Scientific Committee as suitable for use in the RMP (e.g. IWC, 2011c, p.113).

In the context of the special permit programme, the primary purpose of the survey data was to describe the spatial-temporal use patterns of common minke whales and to provide quantitative input into multispecies models and assist in their conditioning. The Panel appreciated the information in SC/F13/SP6, which briefly summarised the methods used, differences in data collection and analytical methods over the years, and discussed the results and possible biasing factors.

Overall, the Panel **agreed** that the Icelandic survey data have improved knowledge about the abundance and distribution of the common minke whale in Icelandic waters, both for use in the RMP and for input to potential multispecies modelling. It noted that earlier survey data (from the 2001 aerial survey) were used to develop the original sampling programme and later data were in part used to modify the programme (see Item 3.1). Despite the logistical difficulties, the off-summer surveys provided valuable new information, especially in the context of any future multi-species modelling. The Panel **agreed** that the research has demonstrated the feasibility of undertaking surveys outside the summer season.

However, given the temporal and geographical quantity of good survey data, the Panel **believed** that a clearer summary paper of all of the survey data was warranted. It recognised that low sample sizes precluded reliable estimation of detection functions for the off-season surveys using those data alone. However, given the difficulties noted by the authors with respect to changes in observer searching patterns and in one case survey altitude, it believed that the use of uncorrected sighting rates for comparisons advocated in SC/F13/SP6 was over-simplistic. It **recommended** that the proponents investigate more fully the available data and use covariates (e.g. weather, environmental factors, observer, year, month, etc.) to model the detection function and encounter rates. This would allow better development of density/abundance estimates for surveys with low effort, as will be required for multispecies modelling. Thus, the summary review paper should also present information and results at the spatial and temporal level to be used in multispecies modelling.

In addition, the Panel **agreed** with the authors' suggestion that it will be valuable to conduct additional spring and autumn surveys, especially in years when a full midsummer survey will be conducted. Of particular importance is coverage outside the normal aerial survey region (including to the north and to east Greenland) to determine whether this is where the 'missing' common minke whales are to be found. It will be valuable if future surveys are conducted in conjunction with prey species surveys to more fully explore possible correlations and spatial-temporal overlaps.

5. STOCK STRUCTURE

The special permit programme was intended to be a feasibility study to determine whether a more extensive research programme was feasible. Two specific goals were identified with respect to stock structure of minke whales:

(1) comparison of the genetic structure of minke whales off Iceland, Norway (including the Jan Mayen area), the Faroe Islands and Greenland; and
(2) monitoring the movements of minke whales by satellite telemetry.

5.1 Proponents' summary

5.1.1 Genetics

SC/F13/SP16 has been published in a peer-reviewed journal (Anderwald *et al.*, 2011). This study used microsatellite DNA and mtDNA markers to investigate minke whale population structure across the species' range in the North Atlantic, including samples from the Icelandic special permit programme. No evidence was found of geographic structure when comparing putative populations in recognised management areas, although some limited structure had been indicated in earlier studies. However, using individual genotypes and likelihood assignment methods, the authors identified two putative cryptic stocks distributed across the North Atlantic in similar proportions in different regions. Differences in the proportional representation of these populations could explain some of the apparent differentiation between regions detected previously. The implication would be that minke whales range extensively across the North Atlantic seasonally, but segregate to some extent on at least two breeding grounds. This means that established stock boundaries in the North Atlantic, currently used for management, should be re-considered to ensure the effective conservation of genetic diversity.

The main genetic structure study of the North Atlantic minke whale (SC/F13/SP17[3]) used a suite of 16 microsatellite loci and mtDNA. A total of 565 samples were analysed across the North Atlantic, including samples collected in the Barents Sea, Spitsbergen, North Sea, Norwegian coast, and West Greenland, in addition to those obtained from the special permit programme The objectives of the genetic analyses were four-fold:

(1) to analyse the genetic composition of animals in Iceland with the same genetic methods as used in the Norwegian and Japanese individual identification registry;
(2) to compare with reanalysed Icelandic samples collected in the past and samples from animals taken in nearby areas such as Greenland and Norway;
(3) to analyse temporal variation and heterogeneity of Icelandic minke whales with respect to the possibility of a mixture of more than one breeding stock at the feeding grounds; and
(4) to compare historic genetic samples, collected prior to 1986, with samples from the present time in order to study the effect of protection for the past 18 years (stock expansion and/or decline).

In addition, results were compared with those of a published study that employed samples collected during the proposal (SC/F13/SP16).

Neither type of genetic marker used during this study revealed any significant genetic differentiation among the samples collected at feeding grounds. This was reflected in non-significant pairwise comparisons for both the 16 microsatellite loci and the mtDNA. In addition, samples collected from the past did not differ significantly from more recent samples, suggesting temporal stability from 1981 to 2007. These results are at odds with previously published results obtained with isozymes (Daníelsdóttir *et al.*, 1992; Daníelsdóttir *et al.*, 1995) and human α–globin 3’HVR (Árnason and Spilliaert, 1991), both of which found subtle structure among samples from the feeding grounds of West Greenland, Iceland and Norway.

SC/F13/SP17 also compared geographical regions by pooling samples, as Andersen *et al.* (2003) reported genetic differentiation at microsatellite loci of samples collected in the following four geographical-ecological regions: Iceland, Greenland (west), Norway and North Sea. These tests were performed using a hierarchical analysis of molecular variance (AMOVA); no genetic differentiation could be found, which contradicted the results of Andersen *et al.* (2003). Although results for nuclear DNA markers in the present study suggested no genetic structure at feeding grounds, an interesting pattern emerged from the mtDNA data. Two groups of haplotypes were detected in the collected samples, but no geographical pattern could be detected between the haplotype groups. These results might suggest the existence of two putatively breeding populations at feeding grounds, as has been suggested previously with microsatellite loci (SC/F13/SP16). These results might be important to consider in ‘Stock structure’ hypotheses. SC/F13/SP16 used some of the samples collected during the present study, and employed 16 different microsatellite loci for the analyses of samples. SC/F13/SP17 did not detect any of the subgroups observed by SC/F13/SP16, and did not find any genetic pattern among haplotype groups using the microsatellite loci.

[3]First presented as Pampoulie *et al*. (2008).

The initial objective described above having been accomplished with SC/F13/SP17, the proponents used the opportunity to conduct additional analyses that were not included in the original proposal. Specifically, SC/F13/SP20 tested for genetic relatedness within individuals used in SC/F13/SP17 and a dataset from the Norwegian DNA registry. Relatedness was evaluated by computing likelihood odds (LOD) scores using the false discovery rate (FDR) procedure. The FDR procedure was calibrated to detect most mother-foetus pairs (where relationships were known), while at the same time limiting the number of false-positive determinations (calling two individuals related when they are actually unrelated). Results showed a high rate of relatedness among samples collected in different geographical areas, suggesting high dispersal rates. Although this method can be based on non-lethal collection, the analysis of the results crucially depends on the availability of additional biological information such as age data. Without age data, it is impossible to establish the type of relationship detected.

In summarising the genetic studies, the proponents believed that all of the stated objectives were achieved, and noted that some unplanned analyses (genetic relatedness of individuals) were also performed. Globally, the genetic studies performed revealed a lack of genetic structure at the feeding grounds. In addition, the development of similar techniques to the Norwegian and Japanese DNA registries allowed for comparison of data across the North Atlantic for the first time. Combining data from the Icelandic and Norwegian DNA registries to conduct relatedness analyses seems to be a promising area for future research.

5.1.2 Morphometrics

SC/F13/SP19 extended the results of Christensen *et al.* (1990) to include new Icelandic data from 2003-09. Multivariate statistical analyses of 17 morphometric characters were performed to evaluate potential heterogeneity between predefined common minke whales stock unit areas in the North Atlantic (West Greenlandic, East Greenlandic, and Icelandic waters, North Seas and Norwegian and Barents Sea). Results from principal component analyses (PCA), multivariate analyses of variance (MANOVA), linear discriminating analyses (LDA) and cluster analyses (CA), suggest that data cannot be regarded as random samples drawn from one uniform distribution. Males could best be divided into two clusters, eastern and western North Atlantic common minke whales, while females could best be divided into three groups; eastern, central and western North Atlantic common minke whales. The overlap between groups was too substantial, however, to allow a firm conclusion concerning the question of isolated breeding stocks versus a large common breeding pool. It is important to note that common minke whales are caught in their feeding areas during the summer in northern waters and their breeding areas are not well documented. Although breeding segregation is unknown, segregation in relation to sex and size has been observed on the feeding grounds.

5.1.3 Satellite telemetry

SC/F13/SP18 summarised experiments to track (via satellite telemetry) movements of common minke whales summering in Icelandic waters. These experiments were primarily included in the research programme as a method to elucidate stock structure. A total of 11 minke whales were instrumented with satellite tags during 2004-11, and five of these provided useful information. The low success rate indicates the difficulties associated with tagging minke whales compared to large balaenopterid species. The data were analysed together with data for three previously tagged whales. The results documented movements of three minke whales out of Icelandic waters during autumn. The start of the autumn migration for these whales extended over the period mid-September to late October. The southbound migration appears to take place in the middle of the North Atlantic, far from coastal areas. Minimum swimming speeds during migration were in the range of 110-176km/day. It is noteworthy that during the total combined tracking period of 370 days, no whale was observed to cross the IWC Schedule stock boundaries for the Central North Atlantic stock. Signals were received from one minke whale off the west coast of Africa in early December 2004, 101 days after tagging and 3,700km from the tagging site off SW Iceland. This study provides the first documentation of the autumn migration route and destination of common minke whales in the North Atlantic.

5.2 Panel discussion, conclusion and recommendations

The Panel **agreed** that the proponents have conducted and reported research that addresses both of the objectives related to stock structure. The data collected and the analyses presented will provide valuable information relevant to the forthcoming RMP *Implementation Review* of North Atlantic common minke whales and the planned joint AWMP/RMP workshop on the stock structure of this species in the region. As for many of the other aspects of the programme, the rather general objectives of the programme and its characterisation as a feasibility or pilot study made it difficult for the Panel to quantitatively assess the programme's success in meeting its objectives. With respect to the feasibility component, it is of course well known that it is possible to collect samples for a number of techniques to better understand stock structure from carcases (as well as from biopsy samples for some aspects of the study, as the proponents' note).

The Panel **welcomed** the analyses presented, recognising the considerable amount of field and laboratory work they represented. It appreciated the effort that had been expended in comparing the data obtained from the programme with data from elsewhere, as is critical for such studies. However, it **recommended** further effort to integrate information regarding stock structure from the variety of genetic and non-genetic sources; that was a weak point in the papers submitted to the Workshop. One step in this direction has been achieved in the summary presented in Annex D, developed by the proponents in response to a request from the Panel. A full, integrated analysis will be of considerable value to the forthcoming IWC Workshop.

One general challenge facing that IWC Workshop and the Scientific Committee is the absence of any formal definition of what constitutes a 'stock' from a conservation and management perspective, within or outside the RMP. This is rarely addressed by genetic stock structure papers. As is common, the papers at the present Workshop generally focused on analyses that tested the hypothesis of panmixia. This is often a useful place to start in evaluations of stock structure, but it is rarely sufficient by itself to address all of the complex issues involved. This broad issue is beginning to be addressed by the Committee (IWC, 2013a), and the Panel believed that it would have been (and will be) useful for the genetics papers to discuss this issue and to suggest criteria (e.g. the level of divergence that is sufficient to merit recognition as a separate stock) that might be reasonable to apply to problems of stock identification in North Atlantic common minke whales.

Noting the importance of migration rates to the RMP and AWMP approaches, the Panel **especially welcomed** the efforts made to undertake the kinship analyses with the Norwegian samples and it encouraged further co-operative work in this regard throughout the North Atlantic. An attractive feature of this paper is that it acknowledged the important trade-offs of type I versus type II errors that are inherently involved in studies of this type. The criterion chosen to balance the risks of over and under-reporting of close kin is not the only one that could be used, but the rationale was clearly explained.

The comments and suggestions of the Panel that appear below are intended to help find ways to ensure that the study produces the maximum amount of useful information. With respect to the genetics studies given in Anderwald *et al.* (2011) and SC/F13/SP17, the Panel noted that while both studies used microsatellites and mtDNA to examine evidence for stock structure of North Atlantic minke whales, the relationship between the two papers was not sufficiently clear. A revised version of the unpublished paper should include further discussion of this including:

(a) how the objectives of the two studies differed;
(b) the rationale for and effect of using partially overlapping but substantially different sets of geographic samples; and
(c) a better integration of the results of both studies to provide insights into stock structure.

With respect to Anderwald *et al.* (2011), the Panel noted that including Japan as an outgroup was a useful addition. The authors correctly noted that STRUCTURE will generally identify the strongest level of genetic differentiation first, while more weakly differentiated populations might go undetected because their signal is overwhelmed by the strong differences. The standard approach is then to repeat the analysis without the population(s) responsible for the strongest signal to see whether subtler differences among remaining samples are revealed. In this case, the reverse happened: the analysis including Japan slightly favoured two Atlantic stocks, but the analysis that used only Atlantic samples found no evidence for more than one population. The Panel was surprised that the authors chose to put more credence in the analysis that included Japan as an outgroup. The Panel also identified a serious problem of circularity (the same data are used to partition the individuals and then evaluate whether the partitions are meaningful) that calls into question the results of all the subsequent analyses in the paper, as well as its conclusions regarding a 'cryptic' population. The Panel **recommended** that this be considered further by the forthcoming IWC workshop. It noted that one way to address the circularity problems would be to simulate genetic data for a single panmictic population, apply STRUCTURE to the data, and use results for k=2 to partition the individuals into two putative gene pools. The other genetic analyses could then be performed using this partition of the overall sample. To lend credence to their claims regarding stock structure, the authors need to be able to demonstrate that analyses of data for a single population will not produce results comparable to those reported in SC/F13/SP16.

SC/F13/SP17 found two groups of mtDNA haplotypes and suggested that these groups might be associated with different breeding grounds. The Panel questioned the logic for this conclusion, as it is not necessary to postulate stock structure to produce this result.

The Panel **appreciated** that SC/F13/SP16 and SP17 mentioned that they adhered to the IWC guidelines for DNA data quality. However, at least for the unpublished paper, the Panel **recommended** that the authors should provide details regarding key aspects of the analyses to demonstrate the quality standards were met.

The Panel was **encouraged** to see the morphometric work included in the stock structure component but **recommended** that more is done with the existing data. Specific suggestions included:

(1) consider dropping variables that are strongly correlated to others, instead of eliminating individuals with some missing data;
(2) account for size by dividing each measurement by overall length, so the result is a proportion (this approach does not require one to discard the first principle component); and
(3) minimise effects of allometry on these proportions by restricting analyses to physically mature individuals or consider other categories for immature individuals to distinguish mature animals.

With respect to telemetry, the Panel noted that though the tagging project was initiated to investigate stock structure, and provided new information on the potential location of winter breeding areas, it also produced information on the minke whale's local use of Icelandic waters.

The Panel **appreciated** the logistical difficulties of applying satellite tags to common minke whales compared to larger species and commended the proponents for their efforts. Although of limited sample size, this new information was informative and the Panel **recommended** that further tagging be conducted. Future tagging efforts should place great emphasis on gathering as much information about the tagged animal as is possible. It is **recommended** that the objective should be to attempt to simultaneously biopsy the animal when placing the tag and to photograph the animal before or as it is being tagged. The latter may be valuable for comparisons with existing photo-ID catalogues within Iceland and beyond. A Panel recommendation on the use of telemetry for feeding studies is provided under Item 7.2.

This telemetry project has, like previous studies, illustrated the practical difficulties in placing tags on common minke whales. Thus, the Panel **encouraged** Icelandic and other researchers to continue the development of improved delivery and attachment systems. It noted the value of the information obtained on blubber thickness and composition for the development of improved attachment mechanisms.

With respect to the overall stock structure work, the Panel **emphasised** the following recommendations:

(1) produce a more fully integrated paper incorporating the information from genetics, morphometrics, telemetry, biological parameters, stable isotopes and pollutants for the forthcoming IWC workshop on the stock structure of North Atlantic common minke whales; and
(2) develop an experimental design for future studies that maximises the amount of stock-structure information that can be obtained, in the context of existing samples of the species from around the North Atlantic.

The Panel also **referred** to its recommendations on feeding ecology, biological parameters, pollutants and parasites that may provide additional information on stock structure.

6. BIOLOGICAL PARAMETERS

The general objective of this component of the programme was to obtain basic information on biological parameters that could be incorporated into multi-species models. More specific objectives included: development of a reliable and feasible method to determine age in minke whales; comparison of the information on growth and reproduction of common minke whales caught during the special permit programme (2003-07) with previous and subsequent commercial whaling; improved information about the population biology of the North Atlantic common minke whale including the possibility of sex- and age-segregation around Iceland (as has been observed elsewhere in the North Atlantic); to examine changes in serum testosterone and progesterone over time, with body size and reproductive status.

6.1 Proponents' summary

SC/F13/SP15 uses eye nuclei from 38 earplug-aged Antarctic minke whales and eye nuclei from 21 foetuses of Icelandic minke whales to construct an AAR-model for estimating age of the Icelandic minke whale. The racemization rate, k, of the Antarctic minke whale was found to be 0.00147 ± 0.00006/y (SE) which is higher than that obtained for Icelandic fin whales, bowhead whales, and harp seals but lower than that found for harbour porpoises. The ratio of D and L at birth, $(D/L)_0$, found for the Icelandic minke whale foetuses and the regression of the transformed D/L-ratio of the Antarctic minke whales on earplug readings was found to be 0.0196 ± 0.0009 (SE) which is in the lower range of values found for other marine mammals. Since the Antarctic minke whale has more biological resemblance to the Icelandic minke whale than other marine mammalian species for which racemization rate has been estimated so far, the Antarctic minke whale is assumed to be the presently best model of the racemization behaviour in the lens nucleus of the Icelandic minke whale. However, further studies are needed to better understand what governs the values of racemization rate and $(D/L)_0$.

The age of Icelandic minke whale was found from the regression of age on transformed D/L-ratios for the Antarctic minke whale and the foetuses of Icelandic minke whale. The model is based on Antarctic minke whales in the age interval 2-48 years while the minimum and maximum age estimated for the Icelandic minke whale was 3 and 42 years, respectively. The standard prediction error is about 4 years while the SE of the left and right lens nuclei is on average between 2.5 and 3 years.

SC/F13/SP12 presented biological data collected to estimate biological parameters the Icelandic minke whale research programme in 2003-07, with minor additions from the commercial whaling in years 2006, 2008 and 2009. A total of 208 minke whales were collected (107F:101M). The total sample covers the period April-November with highest sampling effort during June-August, a period when whales are most abundant in Icelandic waters. Standard length at birth was estimated with the von Bertalanffy growth model as about 2 (95% CI 0-7) meters. Females grew faster and attained lager size than males. Asymptotic standard length was 795 (SE 13.48) and 842 (SE 12.30) cm for males and females respectively. Estimated age and standard length at sexual maturity was 7 and 10 years and 639 and 713cm for males and females. Pronounced seasonality was observed in testes weight and in the diameter and cover of seminiferous tubules, indicating a continuing testes development throughout the summer and autumn. Lack of data from the winter makes the exact timing of parturition and mating unknown. About 91% of mature females were pregnant based on corpus luteum, indicating a predominantly annual reproductive cycle. The study confirmed earlier findings of parturition and conception occurring in mid-winter and gestation about 11 months. However, there was great temporal variability in estimated parturition and conception, indicated by high variability of standard length of foetus in relation to day of the year.

In SC/F13/SP13, sex hormone measurements, progesterone (P) and testosterone (T) concentrations, were obtained from 23 females and 47 males, respectively, caught during June-September 2003-07 as a part of the Icelandic programme. The frequency distribution of female serum P measurements in Norwegian catches has been shown to have two clusters, one consisting mainly of immature animals and the second of pregnant ones, with mean serum values of about 0.49±0.04 (S.E.) and 44.2 ± 2.84 nmol/L, respectively. Therefore only females with no observed foetuses and in some cases one or both ovaries missing were measured to provide information on the reproductive status. The Norwegian frequency distribution of male serum T did not show any group-specific distribution during the hunting season. Only males longer than 5.70m were measured for comparison. Contrary to earlier reports on the Antarctic minke whale, serum T values rose during the hunting season in the mature males as also observed in the Norwegian sample. This increase agrees with the predominantly annual reproduction cycle of minke whales. However the rise in the T measurements in the Icelandic sample occurs during days 215-243 of the year while the rise in the Norwegian measurements appears earlier or during days 180-220 of the year.

The P measurements are valuable when other means of determining the reproductive status are inconclusive and give additional support to the high proportion of pregnant females in Icelandic waters. One female caught mid-July was observed with a small CL but a low P measurement and therefore possibly only recently pregnant. In such cases when no foetus is found, samples of uterine tissue might resolve the issue. This raises the possibility that some females caught early in the season and classified as anoestrous would have been observed pregnant if caught later in the season. As no genetic divergence has been observed between the Icelandic and Norwegian samples and low diversity in the North Atlantic in general, the difference in the timing of the rise in T values is likely due to segregation by reproductive status as has been observed by sex and age. T value measurements later in the season would be valuable, but no minke whales have been caught then.

SC/F12/SP14 presented size and sex segregation from catch data (lethal sampling). The catch data from the common minke whaling in Icelandic waters was divided into three periods: early commercial whaling occurring from 1974-85 (E); special permit whaling from 2003-07 (V); and late commercial whaling after 2007 (C). Available information on the catch was partitioned into sexes and placed into the BORMICON areas of the Icelandic waters. Areas 8 and 9 were combined into one and named SA. For investigating segregation of sexes (F females and M males) in relation to, standard length (L) in relation to latitude (in decimal degrees; Lat), years (years – 1973; Y) and months (month – 6; M), as predictor variables, 1 = females were taken as a response variable and 0 = male, and the three catching periods (E, C and V; P), and two coastal areas (A) of Icelandic waters (East and West areas divided by the -18° longitude) taken as factors. The two way interaction terms of predictor variables were also included.

The observed pattern in the catch-data of common minke whales in Icelandic waters, could be explained with males arriving later from the south to Icelandic waters, because their spring and summer distributions were observed to be more southerly (areas 1, SA and 10) than the distribution of females. Later in the summer and the autumn they have arrived in the northern part of Icelandic waters, dominating the catches. One could speculate that the females may by then have left the Icelandic whaling area and moved even more northerly or to West and East Greenlandic waters. There was a difference between the West and East coastal areas in this respect. These findings are quite similar to the views of the whalers and earlier description by Sigurjónsson (1982) and also in accordance to sex-ratio differences in minke whales in Greenland waters (Laidre *et al.*, 2009).

Segregation by size in the catch in Icelandic waters has not been thoroughly analysed before. Such analysis has been hampered by low numbers of whales caught in most of the periods and limited spatial distribution of the commercial whaling. The scientific sampling programme has improved the data set with more representative sampling. The low proportion of immature animals in the sample might indicate segregation by length/age out of the reach of the study area which was confined to Icelandic EEZ (200 n.miles). However the significant interaction term of year-1973 and standard length points strongly toward such segregation, size selection of whaling boats through the studied years. The authors concluded that a sampling scheme as prepared and performed for the special permit whaling, would make possible further studies on the segregation of common minke whales by sex and size, in Icelandic waters.

6.2 Panel discussion, conclusion and recommendations

The Panel **recognised** the extensive amount of field and laboratory work that had been undertaken and presented, noting that the procedures followed were standard good practice discussed at previous IWC meetings (e.g. Perrin and Donovan, 1984). However, it noted that the general nature of the objectives made it difficult to fully evaluate whether they had been satisfactorily met, although more information is certainly available now for Icelandic waters than prior to the programme. Evaluating the feasibility of collecting information on biological parameters of sufficient precision and accuracy to inform multi-species modelling requires examining the sensitivity of model results to the parameters concerned (which can be an iterative process). As the modelling (see below) was not as advanced as had been originally planned in the programme, this evaluation cannot yet be conducted. It was noted that the *CLA* development process had shown that it was relatively insensitive to the values of biological parameters; such values are not essential input for the *CLA* although they can contribute to and improve the *Implementation* and *Implementation Review* process.

One of the most important feasibility questions relates to the issue of ageing common minke whales. The Panel **commended** the effort undertaken to determine a new approach for common minke whales because the 'traditional' approach of using earplugs is not feasible for the North Atlantic population given the fragility of the earplugs.

The study reported in SC/F13/SP15 used eye nuclei from 38 earplug-aged Antarctic minke whales and eye nuclei from 21 foetuses of Icelandic minke whales to construct an Aspartic Acid Racemization (AAR) model to estimate the age of North Atlantic common minke whales. As for most cetacean species, the general absence of known age animals complicates efforts to validate ageing approaches. From the perspective of modelling, it is especially important to be able to quantify the uncertainty surrounding estimated ages. The authors' approach to use a closely-related species with more suitable earplugs is generally sound. However, the Panel considered that although the study represents considerable progress in the ageing of North Atlantic common minke whales, further work is needed to validate its use in multi-species models. The Panel **recommended:**

(1) that the study moves from the simplistic (and incorrect) assumption that the true age of the Antarctic minke whales from earplugs is accurate and precise; a revised analysis should take into account the extensive work on uncertainty in reading Antarctic minke whale earplugs undertaken as part of an IWC research project by Lockyer (2010) and Kitakado and Punt (2010) - the relationship between the sample provided by Japan for the Iceland study and the sample used in the IWC project should also be investigated;
(2) that the study be expanded to include animals and foetuses of the same species, i.e. common minke whales in the North Pacific, whose earplugs are also considered suitable for ageing;
(3) further consideration of the factors that can influence racemisation rates, especially temperature (this is recognised by several studies on other species such as bowhead whales and narwhals but is not easy to fully address);
(4) a more complete evaluation of the uncertainty surrounding the technique so that this can be incorporated into the estimation of biological parameters for modelling purposes; and
(5) an evaluation of the robustness of model results to the estimated uncertainty surrounding ageing.

In addition to the information presented on certain parameters that require age estimation which will require revision once the ageing work recommended above is completed, the Panel suggested some additional work, especially with respect to the datasets for females. The Panel noted that the very high pregnancy rates found for common minke whales here and elsewhere (i.e. a one year breeding cycle) make interpretation of corpora counts easier than for other baleen whale species on longer cycles.

Despite this, further effort should be made to determine whether the reproductive status of some females was misclassified. For example, the present study appeared to assume that all females with a corpus luteum: (a) are pregnant (this would in effect over-estimate pregnancy as not all ovulating females are indeed pregnant); and (b) if a foetus was not recorded it had been aborted. Abortions may occur as a result of the hunt as well as naturally. The Panel noted that measurements of the uterine horn, mammary glands and (for a subset of animals) hormone levels are available and **recommended** that the complete suite of data should be used to better characterise reproductive status. It was subsequently clarified by the proponents that where there was doubt about the reproductive category then progesterone levels were examined to confirm status (apart from for one individual).

With respect to a suggestion in SC/F13/SP2 that the data on testis weight (which appeared to level off or even slightly decrease at the highest ages) suggested possible senescence, the Panel **agreed** that the data did not provide such evidence; sample sizes were very small, the spread in the data was large, and testes size would be expected to level off.

The Panel's general discussion of the representativeness of the sampled animals of those off Iceland and those in the wider Central management area can be found under Item 11 and is relevant to interpretation of biological parameters. However, the lack of small animals in Icelandic waters (which is common to many North Atlantic feeding areas) is interesting and the reason for this, and where they are, is unknown. Length at birth was estimated at about 2m (but with a wide confidence interval) and the smallest animal taken was 4.61m. Two possible reasons are that small whales do not migrate into Icelandic waters, or that weaned animals grow so quickly that they are not easily identifiable. The Panel **recommended** examining the length data for the only area where 'very small' common minke whales have been reported in the past (i.e. the Vestfjord area of Norway), for comparison with the smallest Icelandic animals.

7. FEEDING ECOLOGY

The primary objective of the part of the research programme concerning common minke whales was to increase knowledge on the feeding ecology of minke whales in Icelandic waters through studies on diet composition, energetics, seasonal variation in distribution and abundance, estimation of consumption rates and multispecies modelling. It also incorporated a comparison of lethal and non-lethal methods.

7.1 Proponents' summary

SC/F13/SP2 reports on studies on diet composition of minke whales from analysis of stomach contents. Most (97.4%) of the stomachs contained food remains, up to 200 litres (106 kg). A total 12 prey species were identified. The diet was primarily composed of fish, with krill contributing only 8.6% in terms of weighted frequency of occurrence (WFO) and 8.4% in terms of reconstructed weight (RW) to the diet. Sandeel (*Ammodytidae* sp.) was the most important prey type overall with 45% and 47% prevalence in terms of WFO and RW, respectively. Other common prey species were herring (*Clupea haerengus*), capelin (*Mallotus villosus*), haddock (*Melanogrammus aeglefinus*) and cod (*Gadus morhua*). Together, large demersal fish (gadoids) constituted 22% of the diet respectively according to both these measures. The size range for cod was 0 to 92.51cm with a mean size of 61.99cm. The age of cod prey ranged from 0 to 14, with a mean of 6 years. The mean length of haddock was 41.63cm, ranging from 2.6 to 91.78cm, and mean age was 3.9 years, ranging from 0 to 9 years.

Differential digestion rates of prey species is a potentially biasing factor that may lead to underestimation of invertebrates in stomach content analyses. In this case, planktonic crustaceans (krill) might be subject to a downward bias particularly concerning reconstructed weight (RW). Comparison of stomachs containing fresh v/s digested food remains however, did not reveal significant difference in diet composition although sample sizes were small. This indicates that this was not a serious problem in this study although some underrepresentation of krill is not unlikely when using the RW measure. Irrespective of this, the results concerning temporal changes should not be biased in relative terms as sampling methods were similar throughout the study period.

The diet composition varied considerably with geographic location. Sandeel dominated the diet in the southern and western areas, while the diet was more diverse off northern and eastern Iceland.

The results show pronounced spatial and temporal variation in the diet. The temporal changes include a decrease in the proportion of sandeel in the diet over the study period and a corresponding increase in herring and haddock particularly in the southern area. The diet also differed markedly from the limited previously available data from Icelandic waters with less krill and the cold water species such as capelin and more gadoids and herring in the more recent period. These changes in diet composition are consistent with recent changes in the Icelandic continental shelf ecosystem including increased sea surface and bottom temperatures and changes in distribution and abundance of several fish species including sandeel, haddock and capelin. Although natural fluctuations cannot be ruled out at this stage, these dietary changes, together with decreased abundance in coastal waters, may reflect the responses of minke whales to a changed environment, possibly driven by global warming.

The main objective of the isotope study (SC/F13/SP3) was to evaluate the applicability of stable isotope analyses via non-lethal sampling as an alternative method by in feeding ecology studies of the common minke whale (objective no. 6 in the project proposal). Three main questions were addressed as follows.

(1) How well do skin samples from the mid dorsal region (D4) resemble other tissues of the minke whale?
(2) How do information on the minke whale diet obtained by stable isotope analyses compare to traditional stomach content analyses?
(3) Can stable isotope ratio analyses lead to conclusive interpretations on the minke whale diet without supplementary information from stomach content analyses?

A total of 94 and 92 tissue samples from 36 whales were analysed for δ13C or δ15N, respectively consisting of blood, muscle D4, skin M4.5 and skin D4 (D4, M4.5 etc. refer to places on the body at which measurements were made or samples collected, see SC/F13/SP1, Appendix 3) in June to September in 2003, 2004 and 2006. A total of 50 samples from 8 common prey species of the minke whale were collected in 2003-07. The selection of whale samples for the study was scheduled to cover all areas, both sexes, all months and length classes. Ten samples of one tissue type were added to the sample pool in 2006 in an attempt to detect sudden shifts in the diet observed in the stomach analyses.

The selection of tissue types was based on multiple interests. SkinD4: represent biopsies, SkinM4.5: M4.5 is a standard sample site and has therefore a value for comparison to other studies, muscleD4: muscle is probably the easiest tissue to obtain from future commercial catch and the information may therefore have value for future comparison. Blood may represent the most recent feeding activity among the tissues analysed.

The study mainly focused on skinD4 to meet the objectives of testing the applicability of non-lethal methods.

Models fitting the relationship of isotope ratios to a set of explanatory variables were built using GLMM (GLMMADMB package in R) with a Gaussian link function. The variability of the model parameters were assessed by running post hoc Markov chain of 50000 MCMC iterations. The explanatory variables used in the models were tissue type, body length, period (2003/04 and 2006) and region (SW and NE). Models testing for interactions between region and period were evaluated. To model the measurement correlation the ID of the whale was used as a random effect in the models tested. The relationship between stable isotope ratios in skinD4 compared to blood, muscleM4 and skinM4.5 was evaluated using paired t-test.

The overall measured level of δ15N indicates trophic level between levels 3 and 4, similar to herring, above krill and sand eel and below adult cod fishes. This suggests that krill and fishes at low trophic level may be important in the minke whale diet weeks or months prior to the sampling. The overall level of δ13C was at level with adult codfishes but higher than krill, sand eel and the pelagic herring and capelin.

Comparison of the overall isotope levels in muscle samples revealed difference between the Icelandic minke whale and results from studies from other areas in the N-Atlantic. This supports segregation of these animals in the weeks or months prior to the sampling.

A GLMM fitting best to the δ13C data was based on the explanatory variables tissue type, region, length and period and for the δ15N data on the tissue type and length.

Significant difference was observed in δ13C and δ15N between skinD4 and other tissues from the GLMM and paired t-tests. However, the difference is not large and therefore biopsies from the mid dorsal region are likely to give reasonably representative information on the isotope levels in other tissues.

Comparison of stable nitrogen isotope and stomach content analyses shows a somewhat lower trophic level in the isotope study. On the other hand, the spatial and temporal difference observed in the δ13C could be interpreted in line with the stomach content analyses, and suggests larger importance of prey of coastal origin in the SW and in 2003/04 compared to larger proportions of pelagic diet in the NE region and in 2006. However, the relatively complex model fitting the variability for carbon isotopes call for further studies in order to conclude and interpret the patterns of carbon isotope levels in the minke whale in Iceland.

Age composition of prey cannot be obtained by stable isotope studies and it may be difficult to draw conclusions on prey identification from stable isotope analyses on a generalist feeder such as minke whale. Migrating behaviour of the predator causes further complications in interpretation since the measurement represent feeding activity weeks or months prior to sampling.

Further complications of interpreting the stable isotope results for the minke whale arrive from the methodology in general. Indices used in the analyses may be species and tissue specific. However, very limited information are available on enrichment and turnover rates in minke whale tissues. The authors concluded that stable isotope analyses may therefore give information on the 'average' diet weeks or months prior to sampling. but cannot provide conclusive answers without further supplementing information.

The authors concluded with respect to stock structure that stable isotopes may give information on intra seasonal difference in minke whales between areas in the North Atlantic. With respect to the use of stable isotopes they concluded that they provide broad information on trophic levels of minke whale and indications on changes in the diet or in the ecosystem in general but that this is not alone sufficient for detailed data sampling and multispecies modelling.

In SC/F13/SP4, fatty acid (FA) profiles of the total lipids of 23 common minke whales were analysed in tissues of outer blubber, inner blubber and blood and in some of the minke whales potential prey the years 2003, 2004 and 2006 in the waters around Iceland. The main objective was to study how FA profiles reflect the diet of minke whales around Iceland. In this study we have used FAs qualitatively as Quantitative Signature Analysis has not been developed for whales. These three tissues were tissue-specific (i.e. samples from each tissue group together in multivariate analysis) and the inner blubber, which has to be collected in a lethal way, best reflected diet. Not surprisingly, the FA profiles did not reflect the stomach contents of the minke whales as FAs reflect diet over longer time period than stomach content analyses, which provide information about the last meal(s). Thus, the prey in the stomach of the whale when captured is not expected to show up in the FA composition of the whales until later. However, the large variance in FA composition of the inner blubber indicates a diverse diet of the minke whales in agreement with the stomach contents. Clear temporal variation were observed, the FA profiles indicated that before the collapse of the sandeel stock around 2005 the food variety of minke whales was more diverse than in the year 2006 when the sandeel stock had collapsed. In 2006, the *Calanus* based food-web was of higher importance than in 2003. The authors conclude that the use of Qualitative FAs signature analysis in trophic studies of whales is a complementary way of studying trophic interactions but do not substitute stomach content analyses.

SC/F13/SP7 is a preliminary report from a multi-species modelling effort that studies the role of minke whales in Icelandic waters. The approach is based on preliminary modelling exercises conducted by Stefánsson *et al.* (1997) upon which the data needs were originally defined (Marine Research Institute, 2003). In this initial phase, the emphasis has been on developing single species models of the common minke whale in a statistical modelling framework (GADGET) with the aim of connecting it to a previously implemented model for cod (*Gadus morhua*) in a multi-species model.

The paper identifies available data sources, such as abundance data from aerial surveys (SC/F13/SP6), length distributions both from commercial catches and surveys and various information regarding growth and maturation (i.e. SC/F13/SP12 and SC/F13/SP15).

The model, in its current form, is an age-length based forward simulation model of two stock components, mature and immature whales with a Pella-Tomlinson type spawning process. Based on the results from SC/F13/SP2, where a preference to sandeel is suggested, the abundance of minke whales in Icelandic waters was controlled by an index of sandeel. Parameter estimates are obtained through a weighted likelihood function comparing the simulated results to the various datasets.

Future work will mainly focus on the link between cod and minke whales using information obtained in SC/F13/SP2, in particular prey frequency of occurrence and length distributions. The effect of minke whale consumption will be estimated. The uncertainty of that estimate would then be assessed using a newly developed bootstrap approach based on independent geographical units. The single species model of the common minke whale will also require further work; in particular processes that affect the prey species abundance, such as temperature, could potentially be incorporated into the model.

7.2 Panel discussion, conclusion and recommendations

The Panel appreciated the notable amount of effort undertaken and the generally thorough analyses of the stomach contents as documented in SC/F13/SP2. It also acknowledged the large effort invested in this study demonstrating spatial and temporal variation in the diet of common minke whales on the Icelandic continental shelf waters. The temporal changes observed as a result of the extension of the sampling period could be related to climate change or a regime shift in the waters around Iceland and this is an important issue for further research. As with the other studies, the general nature of the objectives made evaluation of the success of the feasibility study more complex. However it is clear that knowledge of the feeding ecology of common minke whales has been advanced through a variety of approaches including stomach contents, fatty acid and stable isotope analyses and the collection of data that can be used to inform a more systematic than usual examination of the results that can be obtained from lethal and non-lethal methods. While welcoming the individual papers presented, the Panel **strongly recommended** that an integrated analyses including comparison of the information from each approach (including consideration of uncertainty) be developed and submitted to the Scientific Committee.

With respect to more detailed comments on the papers presented, the Panel initially focussed on the analyses of the stomach contents data; such data were collected for all the catch. However, with respect to the stable isotope (n=36) and fatty acid analyses (n=23), not all of the animals were chosen for analysis. The rational for the choice of the animals was explained by the proponents to have been to try to cover the variability of sex, length classes and areas in the former and to try to cover each of the BORMICON areas equally in the latter with animals within each area selected randomly. It was also explained that samples from all whales were stored and could be analysed if funding become available. The Panel **advised** that clearer research questions are required to elaborate on appropriate selection of tissue e.g. because the turnover rates of carbon and nitrogen differ among tissue types the tissue targeted for isotope analysis will depend on the question being asked.

As a result of its discussions of the papers presented by the 1 December deadline, the Panel **recommended** that the following issues be considered further in a revised paper or papers for the Scientific Committee[4].

(1) It was reported that because during the first two years of the programme very low diversity (almost entirely sandeel) was found in the diet of animals taken in the southern area, it was decided to increase the sample size in the northern areas where diet had been more diverse, to better characterise that diversity. While there is logic in that approach (and for modelling purposes data will be weighted by estimated abundance in the various areas), the change in sampling design renders the analyses of the aggregate diet in the analyses (rather than by southern and northern areas) to be biased.
(2) The spatial diversity in diet sampling complicates how the data can be used to compare between studies. This needs to be considered in comparisons with earlier work in the same area and other areas, when estimating a general minke whale diet around Iceland and when incorporating the data into multi-species models.
(3) For all studies, the sampling design and choice of samples needs to be more fully explained and the inferences of the various choices for the analyses conducted be examined.
(4) The stomach content data were analysed using some parameters not commonly used and the Panel recommends that the revised paper include full specifications of the equations used.

[4]The Panel was pleased to note that the published version of the paper on diet that became available after the deadline had addressed several of the recommendations made here, e.g. with respect to taking spatial diversity into account when comparing with past studies and using statistical methods to account for variability in the diet composition data.

(5) The Panel noted that there is a possibility of invertebrates being underestimated in the stomach content study. The proponents explained why they believed that this was unlikely to be a major problem and the Panel agrees that further justification should be incorporated into the paper to demonstrate that invertebrates are correctly represented in the data.
(6) As presented, the analyses suggest that diet composition is known with certainty whereas this probably reflects a time constraint of the data. Statistical approaches such as bootstrapping should be used to provide some measure of the variability around diet composition.
(7) For all animals for which data are available, blood and skin should be analysed for stable isotopes to compare with stomach content analyses.
(8) The stable isotope data should be further explored using alternative approaches (e.g. Bayesian mixing models) and taking into account the time lag between food ingestion and the stable isotope ratios in different tissues.
(9) Full account must be taken of the influence of sampling date (within and between seasons) on specific analyses. As an example, fatty acids were sampled in 2003, 2004 and 2006 but the whales sampled in 2003 were taken in August-September as compared to earlier in the season the two other years.
(10) Variation in C stable isotope values between geographical areas is relatively complex and does not only depend on whether the species is feeding on coastal or in oceanic waters as there is also a latitudinal gradient. This must better be taken into account when comparing results across and within areas.
(11) Further information should be provided on how the isotope and fatty acid data were obtained for the prey (e.g. from Icelandic waters or elsewhere) and any implications of this for the resultant analyses.
(12) A more thorough evaluation of the information available from before the moratorium should be incorporated including examination of the data available on prey and other environmental factors to try to examine further the possible changes in diet and prey availability (including capelin and krill) over time.
(13) The fatty acid and stable isotope techniques and stomach content material all provide insights into diet composition, but each approach represents diet composition over different time scales related to specific turnover of the material being examined. This lag needs to be explored further when comparing between the different methods that were used. The Panel acknowledges that the fatty acid technique cannot be used as a quantitative method because no fatty acid calibration factors are available for cetaceans.
(14) Given the north/south differences identified during the programme, a revised paper should try to incorporate as much fishery and environmental data available from outside sources as possible and at the same temporal and geographical scale. It must also incorporate information from the fatty acid and stable isotope analyses discussed below.

In the longer term and if any future studies occur, the Panel makes the following comments.

A weakness of the programme was that it did not examine the prey availability simultaneously to the whale sampling, as had been done for example in Norwegian studies (e.g. Haug *et al.*, 1995; Skaug *et al.*, 1997). Therefore it is not possible to explore prey preferences in a detailed manner or potentially examine functional responses. The Panel **recommended** that simultaneous studies of prey availability should occur. In this context, it notes the value of using telemetry to obtain information on fine scale movements and dive profiles if conducted simultaneously with prey resource surveys (e.g. IWC, 2000). In principle, if a tagged (and biopsied) animal could be biopsied again several months later while it is still in Icelandic waters, this could provide valuable insights into a number of feeding ecology issues, although the feasibility of achieving double biopsies may be low.

The Panel **agreed** that some of the most relevant questions, such as the representativeness of stomach contents to overall diet within a season or whether the observed differences between areas are real or artifactual, could be addressed by analysing baleen plates either already available or collected in the future from the commercial catch and **recommended** that this should be done. Baleen plates are composed of inert tissue with no isotopic turnover and therefore keep a permanent and chronologically-sequenced record of isotopic values of body circulating fluids, thus allowing reconstruction of time-related variation in diet and in migratory movements. Baleen plates in common minke whales in the western North Pacific grow at an average rate of about 12.9cm per year and therefore integrate the stable isotopes for several years (Mitani *et al.*, 2006). Such studies are also of relevance to a better understanding of stock structure.

7.2.1 Modelling

The key component of the long-term objective of the feeding ecology component of the programme is the development of a multi-species modelling approach to inform management of whales and fish within Icelandic waters. The Panel recognised the practical difficulties explained by the proponents but **concluded** that this important part of the programme is as yet poorly developed. In particular, a simple preliminary model should ideally have been developed at an early stage to inform discussions of which are key parameters with respect to obtaining robust results, evaluating how sensitive results are to different levels of uncertainty and determining appropriate sample sizes. This was a major weakness in the programme. However, the Panel **welcomed** the work presented in SC/F13/SP7 that was extended in the presentation to the Workshop. The author had emphasised the exploratory and preliminary nature of the work he had been able to conduct thus far. It was recognised as a small but valuable initial step toward the programme's overall objective. The Panel made the following **recommendations** for the continuation of this work:

(1) develop clear staged objectives for the work based on addressing specific questions;
(2) do not rely on a single modelling approach;
(3) consider the merits and weaknesses of using the 'inside Icelandic waters' and the 'rest' approach compared to attempting a broader modelling approach similar to that within the RMP with respect to the developed objectives;
(4) consider a broad range of possible explanatory drivers for minke whale density and abundance not simply sandeels;
(5) use the model development process to explore key parameters, the sensitivity of each type of input data and data needs to improve modelling in the future (for all aspects of the ecosystem);
(6) the model employed different sources of data (e.g. abundance, length composition, maturity, etc.) but

the weights were defined in an *adhoc* manner - where weighting procedures are used to determine likelihood contributions from different data sources to a total likelihood function then the method should be clearly documented and sensitivity examined to different weights; and

(7) the author should participate in and report progress to the Scientific Committee and its ecosystem modelling group.

8. ENERGETICS

8.1 Proponents' summary

SC/F13/SP8 investigates seasonal trends in energy storage of the minke whale in Icelandic waters, a feeding ground. The aim was to quantify the total amount of blubber that minke whale deposits through the feeding season and to compare this between immature and mature/pregnant whales to infer the use of blubber energy in reproduction. The authors modelled total blubber volume using blubber thickness and morphometric measurements of individual whales. Blubber volume was influenced by body length, and was higher for pregnant females than for mature whales. It increased linearly through the feeding season at the same rate for mature and pregnant whales, suggesting that minke whales aim to maximise energy storage while on the feeding grounds. The total amount of blubber accumulated over the feeding season (0.51±0.119m^3 for mature and 0.43±0.112m^3 for pregnant whales), together with energy stored as muscle and intra-abdominal fats, constitutes the total amount of energy available for reproduction (foetus development and lactation) on the breeding grounds, as well as migration, daily field metabolic rates, growth and body maintenance. No seasonal variation was observed for immature whales (n=4 male, 12 female), suggesting that they are investing most of their excess energy into growth in order to reach the (length at) attainment of sexual maturity faster and start reproducing earlier. This novel modelling approach provides insight into large whale bioenergetics and life history strategies, as well as the relationship between single-site measurement of blubber thickness and total blubber volume. Knowledge of this relationship can be used to develop models to quantify total blubber volume using non-invasive ultra-sound measurements, which together with photogrammetric methods (to estimate body length) can be used to predict blubber volume with up to 80% accuracy. The estimated volume of deposited blubber could be used together with information on lipid concentration (SC/F13/SP10) and rate of deposition in blubber tissue to better inform the total amount of energy deposited into the blubber layer of minke whales through the feeding season. This information, together with information on seasonal variation in muscle fats, visceral fats and other tissue (SC/F13/SP11) could then be used together to quantify the overall amount of energy that minke whale accumulate through the feeding season.

SC/F13/SP5 investigated potential influence in minke whales of female body condition (FBC) on foetal development, and hence on offspring production. Pregnant minke whales were sampled during the summer 2003-07 feeding seasons and the length and weight of their foetuses measured. FBC was calculated after modelling the relative difference between measured blubber volume and the average expected blubber volume of individual whales. Linear models were used to test the effect of FBC on foetus length, while accounting for the daily growth in foetus size through gestation, as well as other covariates. Foetus length increased linearly through the study period at a rate of 0.918cm day^{-1} (SE=0.111). The effect of FBC on foetal length was nonlinear, showing an almost linear positive relationship for females in poorer body condition (FBC<0), which levelled off at better body conditions (FBC>0). The curvilinear relationship between FBC and foetus growth was confirmed by fitting a generalised additive model and by running separate analyses on two subsets of data separating females in poorer and better condition. Findings suggest that females that are in poorer body condition reduce their energetic investment in their foetus proportionately to their condition in order to maintain their survival probability. That foetus length did not increase for females in better body condition suggests that females in good condition cannot invest more than expected in their foetus. Reducing the size at birth by reducing the gestation period is also unlikely, since the reproductive cycle of balaenopterids is strongly linked to their seasonal migration between feeding and breeding grounds. This study is the first to demonstrate that FBC can affect foetus growth in minke whales, a capital breeder. Further analyses can be done on the females carrying smaller foetuses to see if the fatty acids of these females tell a different story from that from females in better condition. Further, the ovaries of non-pregnant females (n=5) could be analysed to see if these females could potentially have aborted their foetus earlier in the feeding season.

SC/F13/SP9 presented a report on predicted urine production and food ingestion rate and salt balance in the common minke whale off Iceland. Blood and urine samples were initially obtained from 30 individuals but only 16 were eventually used in the study (four non-pregnant females and 12 males). With the model used, average urine production was estimated at 214L/day and the daily food ingestion at about 280kg, a value which is considerably higher than reported by previous research. Electrolyte concentrations in urine were compatible with a piscivorous animal and are quite different from that from whales eating krill, like the fin whale. The high levels of sodium and magnesium in the urine suggest some ingestion of sea water.

SC/F13/SP10 reported on studies on chemical composition (total lipids, protein and water) of various tissues in Icelandic minke whales. Energy deposition was demonstrated by an increase in the lipid content in blubber, muscle, visceral fat and bones. The study confirmed that, as in other balaenopterids, in minke whales the dorsal region behind the dorsal fin is a main location for lipid deposition. In addition, large amounts of energy are apparently stored as visceral fat and in bone. The highest levels of lipids in muscle, blubber and visceral fat were found in pregnant females. Spatial variation within the Icelandic continental shelf area might be explained by corresponding variation in diet composition. Thus, higher lipid levels were found in animals from southern and southeastern Icelandic waters where the diet was dominated by the energy rich species sandeel and herring (SC/F13/SP2). The lipid content of muscle and blubber at position D5 increased significantly over the feeding season. The daily increase in percentage lipid content at D5 was estimated as 0.09 for muscle and 0.23 for blubber with no significant differences between reproductive classes. The significant decrease observed in lipid content of posterior dorsal muscle over the research period 2003-07 could be a result of a decrease in prey availability, particularly sandeel and capelin, which again might explain the decrease in abundance of minke whales in Icelandic coastal waters during the period. This study demonstrated the feasibility of using carcass analysis for estimating total energy storage throughout the season, which constitutes an important parameter for estimating food requirements as an input for multispecies modelling. Larger sample sizes (e.g. in connection with the commercial minke whaling operations) are however obviously required to increase the precision of such estimates.

SC/F13/SP11 presented results on spatial and temporal variation in body mass and the blubber, meat and visceral fat (visceral and thoracic) content of North Atlantic minke whales. A log-linear length-weight regression found in all cases a significant increase in weight (for a given length) over the season, in particular for the mature animals. Similar results were found in the girth measurements, more so towards the caudal part of the body, but the girth measurements did not fully capture the increase in weight. This fattening (increased weight for a given length) is in addition to any increase in weight due to growth (lengthening) or maturation of the animals. The increased energy content found in other studies comes on top of this increased mass/volume. Pregnant females were found to be fattier already at the start of the season and overall had significantly more blubber than other reproductive categories. Some differences were found between the areas in the North Atlantic, but there is a clear segregation in the samples that should be investigated in relation to the segregation in catches. The results agree with parallel studies on blubber thickness measurements and tissue energy content in the same population and are in time and space in line with observed changes in the ecosystem in the North Atlantic during the sampling period.

8.2 Panel discussion, conclusion and recommendations

The Panel **welcomed** the work presented on energetics which involved considerable field, laboratory and analytical effort. Many of the studies provided valuable insights into aspects of the energetics of common minke whales around Iceland. However, as elsewhere in the programme, the Panel noted that further effort is required to integrate the various analyses to provide a more coherent and valuable picture that properly addressed uncertainty (and see IWC, 2010b). This can be used to develop quantitative input to energetics models and multispecies modelling.

For example, SC/F13/SP8 *inter alia* provided a well-structured and relatively novel way of estimating blubber volume. This was then used to undertake a number of analyses with respect to various reproductive classes. This is valuable but as noted in other studies presented here and elsewhere, blubber is a dynamic tissue with multiple functions: when liberating energy it liberates lipids while incorporating water in the tissue to keep a minimum thickness for insulation. Therefore its thickness or volume only partially reflects lipid mobilisation, which is the main clue to energy. As a consequence, the value of blubber volume *alone* can be limited. It is likely that the apparent lack of differences in fattening rates observed in this study between some reproductive classes (mature *vs* pregnant females) indeed reflects this. The Panel **stressed** the need to combine these results with the results of blubber lipid content (SC/F13/SP10 and SC/F13/SP11) to obtain an integrated approach to variation in energy stores. The Panel noted the aspect of the study that revealed that the two most informative measures for this aspect of the work, D1 and total body length, were sufficient for assessing body condition with appropriate sampling for lipids. This can inform and simplify any future work, and, after validation potentially be applied to other species/populations (e.g. see Konishi, 2006) and Antarctic minke whales.

SC/F13/SP10 examined the chemical composition of various tissues, an important component of aspects of energetics studies. The Panel referred to its earlier discussions on biological parameters and the need to use all of the information available to check reproductive status. For example, the anoestrus female category is likely to include different types of females (resting, females that have recently aborted, etc.). The Panel **recommended** that in a revised paper the authors:

(1) revise the analyses if any changes in reproductive category are identified;
(2) given the small sample size and above issues related to the 'anoestrus' group, consider the use of mature males as the reference group because it is less subject to varying energetic demands than females;
(3) consider producing a single integrated paper (see above); and
(4) further consider any patterns of seasonal variation.

SC/F13/SP11 examined spatial and temporal variation in body mass and the blubber, muscle and visceral fat. Most of its findings confirmed expected increases in these as the season progressed, especially for mature animals. The Panel noted that the small sample sizes and pooling of all ages may be the reason for an apparent lack of difference between sexes. From a logistical point of view it was clarified that the term visceral fat only applied to the discrete accumulations of fat that occur both in the thoracic and abdominal cavities that are easy to identify and isolate.

SC/F13/SP5 examined the influence of body condition of the females on foetal development. In discussing this paper the Panel referred to its earlier discussion of abortions and the possibility that there may be a negative bias towards larger foetuses in the last stages of gestation. The Panel **recommended** that a revised paper should:

(1) reanalyse the data if new information is obtained on abortions;
(2) examine those individuals that compose the smaller secondary peak in conception date to examine whether a cause can be attributed (e.g. poor nutritive condition, delayed ovulation, etc.);
(3) examine, where possible, stable isotope or fatty acid signals of the mothers in poor body condition to see if this provides insight as to the cause; and
(4) consider the use of AICc rather than AIC which is more appropriate for small sample sizes.

SC/F13/SP9 presented a novel and independent approach to examining food ingestion rate from analysis of urine. The Panel agreed that the approach was interesting and warranted further consideration. However, it **recommended** that any future work should:

(1) fully examine the uncertainties involved in the extrapolations and assumptions inherent in the approach, especially where these area based on non-cetacean data;
(2) incorporate consideration of factors known to affect creatinine values including body size, age and stress; and
(3) if further sampling was envisaged, use new and more precise creatinine analytical techniques.

9. POLLUTION

9.1 Proponents' summary

Documents on pollution included papers presented at the workshop that contained results on persistent organic pollutants including PBDEs (SC/F13/SP22), trace elements

(SC/F13/SP23), and Cs-137 (SC/F13/SP30). Also presented were papers previously published by Dam *et al.* (2013) on novel contaminants such as brominated flame retardants including PBDEs, methoxylated PBDEs, perfluorinated compounds including PFOS, polychlorinated naphthalenes, and brominated dioxins and dibenzofurans (SC/F13/SP26). Finally, papers on polybrominated diphenylethers and methoxylated polybrominated diphenylethers (SC/F13/SP21 and SC/F13/SP24)[5] as well as on polychlorinated naphthalenes (SC/F13/SP25)[6] were described.

Initially, the core objectives of these studies were to:

(a) characterise the pollutant load of common minke whales in Icelandic waters as compared to neighbouring and distant stocks;
(b) establish whether biopsies provide reliable information on such loads; and
(c) investigate whether the pollutant levels found were detrimental to the health of the animals.

However, since the levels found were low and unlikely to affect the health of the whales, and the latter were overall considered to be in good health conditions (SC/F13/SP29), the emphasis of the work focused on the first two aspects. Besides, two secondary objectives were also considered:

(a) whether contaminants can inform on the prey species consumed by minke whales; and
(b) whether minke whale products are acceptable for human consumption.

SC/F13/SP22 presents the results on persistent organic pollutants. The 25 whales selected for this study were collected both north and south of Iceland, in equal sex ratios in both areas and covering as large a length span as was possible. The samples were all from 2003 and 2004. The following compounds were analysed PCBs (#28, 31, 52, 101, 105, 118, 138, 153, 156, 170 and 180), DDTs (p,p'-DDE, p,p'-DDD, p,p'-DDT, and o,p'-DDT), HCHs (α-, β-, and γ-HCH), HCB, Chlordanes (trans-nonachlor, α-chlordane, γ-chlordane, and oxychlordane), toxaphenes (26, 50, and 62), dieldrin and PBDEs (47, 99 and 100) were analysed in blubber, biopsies, muscle and liver. Moreover, a sample of blubber from the ventral grooves was collected from five males caught in 2003 (body length interval 5.08-8.45m) for dioxins and dioxinlike PCB determination.

The relative contribution of the various organic contaminants was found to be similar in blubber and muscle. The liver concentration of Toxaphenes was found to be lower than that in blubber or muscle, while the opposite occurred with HCB, Dieldrin and HCHs. The DDE/tDDT and the oxychlordane /tChlordanes ratios in biopsies correlated with those in the liver but not those in the blubber or in the muscle. Conversely, the DDTs/PCB7 ratio in biopsies did not correlate with that ratio in blubber, liver or muscle. γ-HCH/tHCHs and Tox-26/tToxaphenes ratios in biopsies correlated with those in blubber and muscle but not in the liver. No significant difference was found in the pattern of PCBs between the four tissues examined. It may be concluded that biopsies are only useful to monitoring blubber concentrations of five compounds: HCB, β-HCH, p,p'-DDT, o,p'-DDT, and Tox-26 but are not adequate to predict levels in muscle or liver, with the exception of p,p'-DDT in muscle.

No difference in pollutant loads was found between north and south of Iceland for muscle and blubber nor between sexes or body lengths. However, β-HCH, PCB52, PCB138, and PCB153 levels in liver were higher in males than in females and hepatic concentrations of Tox-62, α-chlordane, PCB138, and PCB153 increased with body length. Substantial differences were found between the concentrations of POPs in the blubber of Icelandic minke whales in relation to other populations of the same species elsewhere in the North Atlantic, North Pacific and Antarctic.

SC/F13/SP21 describes the results of analysis made on a selection of MeO-BDEs in pooled blubber samples of pilot whales, ringed seals, minke whales, fin whales, harbour porpoises, hooded seals, and Atlantic white-sided dolphins, covering a time period of more than 20 years (1986-2009). The highest MeO-PBDE levels were found in the toothed whale species pilot whale and white-sided dolphin, often exceeding the concentration of the most abundant PBDE, BDE-47. The lowest MeO-PBDE levels were found in fin whales (Iceland) and ringed seals (SW Greenland). The main MeO-BDE congeners were 6-MeO-BDE47 and 2'-MeO-BDE68. A weak correlation only between BDE47 and its methoxylated analog, 6-MeO-BDE47, was found and considered as indicative of a natural source for MeO-PBDEs. The concentration of MeO-BDEs in minke whale off Norway was noticeably lower than the MeO-BDEs levels in minke whales sampled off SW-Greenland and W-Iceland.

In SC/F13/SP24, Rotander *et al.* (2012c) present the results of the analysis of a selection of PBDE congeners analysed in the same samples as the MeO-BDEs. The highest PBDE levels were found in toothed whale species such as pilot whales and white-sided dolphins, and the lowest levels in fin whales and ringed seals. One-sided analyses of variance (ANOVA) followed by Tukey comparisons of means were applied to test for differences between years and sampling areas. Due to inter-year sampling variability, only general comparisons of PBDE concentrations between different sampling areas could be made. Differences in PBDE concentrations between three sampling periods, from 1986 to 2007, were evaluated in samples of pilot whales, ringed seals, white-sided dolphins and hooded seals. The highest PBDE levels were found in samples from the late 1990s or beginning of 2000, possibly reflecting the increase in the global production of technical PBDE mixtures in the 1990s. The levels of BDE #153 and #154 increased relative to the total PBDE concentration in some of the species in recent years, which may indicate an increased relative exposure to higher brominated congeners. In order to assess the effect of measures taken in legally binding international agreements, the authors recommended to continuously monitor POPs such as PBDEs in sub-Arctic and Arctic environments. No significant difference was found in total PBDE concentrations between the pools of minke whales from Iceland, Norway and Greenland.

SC/F13/SP25 descibes analytical findings on a selection of 14 polychlorinated naphthalenes, PCNs, in the same pooled blubber samples as for MeO-BDEs and PBDEs. The levels of PCN congeners 48, 52, 53, 66, and 69 in all samples ranged between 0.03 and 5.39 ng/g lipid weight. A very large area of the North-Atlantic and the Arctic is covered but the sum of PCNs in minke whales, the only species sampled at several locations, the levels off Norway, SW Greenland and W-Iceland were not significantly different. However, a different pattern of the PCNs were found in the three minke whale stocks ascribed to spatial difference and not temporal effects although sampling of minke whales were from different time periods (2003-06 in Iceland, 1998 in Greenland, and 1993 and 1999 off Norway). 25 non-planar

[5]Published as Rotander *et al.*, 2012a and Rotander *et al.*, 2012c.
[6]Published as Rotander *et al.*, 2012b.

PCBs including PCB7 were also analysed in blubbers of fin whales and minke whales from W-Icelandic waters and the sum of PCNs was found to be about 0.2 % of the PCB-content of the samples. No statistically significant temporal trend could be discerned in the studied areas but in all species except minke whales caught off Norway, the lowest levels of PCNs were found in the most recent sampling period.

In SC/F13/SP26, Dam *et al.* (2013) describe a Nordic study on concentrations of 'new' contaminants in minke whales and five other marine mammal species in North Atlantic and Arctic regions over a period of three decades. Analyses included several types of BFRs including the PBDEs, methoxylated PBDEs, PBDD/PBDFs, PFCs including PFOS, and PCNs. Many of the 'new' contaminants, i.e. PCNs, PBDEs, and PFOS, appear to have declined during the time period studied, while the larger PFCs were found to increase. The temporal trend analysis of BFRs showed that the levels of Σ10 PBDEs increased from the 1980s to the late 1990s but thereafter declined during the first part of the 2000s. This trend was seen in all the marine mammals studied and was significant for fin whales (Iceland) and white side dolphins (Faroe Islands). A decline of Σ10 PBDEs during the period 2000-06 was observed in all species. In the species that could be sampled at more than one location, i.e. common minke whales (southwest Greenland, west Iceland, and Norway) and harbour porpoises (west Iceland and Norway), no regional differences were observed in these 'new' contaminant concentrations except for the MeO-BDEs, see SC/F13/SP21 above.

SC/F13/SP23 presented results on trace elements: As, Se, Hg, Cd, Pb, Cu, Cr, Ni, Mn, Fe and Zn were analysed in skin, muscle tissue, kidneys, and liver of 25 common minke whales. Additionally, Cd was analysed in the ovaries and testes of the same individuals. Ni levels were below detection limits in most of the samples. In the muscle, a number of differences were found between different sampling locations. Thus, significantly higher concentrations of Se, Mn, Zn, Cu, Hg, Pb, and Fe were found in the anterior (D1) than in the posterior (D4) dorsal muscle. In the case of As, however, D4 levels were found to be much higher than those in D1. Levels were indistinguishable between D1 and M4.5 for most elements except for Mn, the levels of which were two times higher at M4.5 than at D1. These findings need to be taken into consideration in future work.

No element was found to vary in any tissue with either area or sex. Hg levels increased with length in all tissues, and those of Se increased in liver but decreased in skin. Cd levels increased in both liver and kidney but showed no length-related variation in gonads. Minke whales from Iceland were found to differ from other North Atlantic stocks in their Cd and Hg levels. Thus, although no differences were found in Cd levels in liver and kidney, Cd levels in muscle and Hg levels in liver and kidney were lower in individuals from Iceland than in those from southeastern Greenland. Also, Cd, Se and Hg levels in liver, and Cu levels in liver and skin were significantly different from corresponding values in minke whales from the Antarctic.

When comparing levels between skin and other tissues, no correlation was found for any of the trace elements except for Hg in muscle, liver, and kidney and for Se in muscle. Hg levels in skin were in a relationship close to 1:1 when levels in skin were expressed on a dry weight basis and those in muscle on a wet weight basis. There was also a good correlation between Hg levels in skin and those in liver and kidney albeit the relationship was not 1:1. Whether these relationships hold for other stocks of minke whales warrants further studies. Se levels in muscle (wet weight) correlated linearly with levels in skin (wet weight) but the intercept and the slope are large. It may therefore be concluded that, for the Icelandic minke whales at least, skin biopsies are generally not valid for predicting trace element concentrations in internal organs except in the case of total Hg in muscle tissue.

SC/F13/SP30 presented the results of a study on the radioactive Cs-137. Levels of Cs-137 in muscle of Icelandic minke whales from 2003-04 were found to be significantly lower than those found in muscle in most minke whale stocks from the North Atlantic in 1998 (E-Greenland, W-Greenland, Jan Mayen, Barents Sea, Vestfjorden/Lofoten, and the North Sea). However, the levels found in minke whales from Svalbard were not significantly different from those in Icelandic minke whales. Additionally, the muscular levels of Cs-137 in all the common minke whale stocks of the North Atlantic are far below the stipulated maximum limits for food.

9.2 Panel discussion, conclusion and recommendations

The Panel noted that the overall objective of the pollutant studies had been to investigate contaminant burden and health status in individuals and at the population level. In terms of sub-objectives, it included characterising the relative pollutant loads in Iceland and comparing these with other areas, establishing the ability of biopsy samples to characterise such loads and examining the health implications of the identified loads. Even recognising that this is a feasibility study, the Panel noted the ambitious nature of such a study. For example the overall objective is similar to the long-term objective of the IWC's POLLUTION 2000+ programme which is still underway one decade later (Aguilar *et al.*, 1999; IWC, 2008a; 2011a; Reijnders *et al.*, 2006).

The Panel **acknowledged** the considerable field, laboratory and analytical work included in the papers presented and in a number of published papers (Dam *et al.*, 2013; Rotander *et al.*, 2012a; 2012b; 2012c). It also appreciated the effort made to compare and contrast results across the North Atlantic with the potential for this to inform stock structure discussions as noted elsewhere, as well as the efforts to examine relationships between concentration levels in different tissues including 'pseudo' biopsy samples. However, it agreed that the objective of assessing health status had not been fully addressed. The proponents had referred to the conclusions of the post-mortem studies of 14 animals that had broadly considered that the animals had been healthy and had noted the relatively low levels of the trace metals; from this they had given low priority to assessing health implications. While the Panel **agreed** that this may be indicative, it noted that low levels *per se* do not indicate no effect. The Panel **recognised** that the sample size of the feasibility study was insufficient to properly address any toxic-related cause-effect relationships but **agreed** that, should further studies take place, the design of the research should include a more robust sample size to sufficiently address health-related specific questions.

In welcoming the comparisons of pollutant levels found across the North Atlantic, the Panel made some general **recommendations** for a revised paper:

(1) indicate the period of sampling for each study presented since significant time-related variations in environmental pollution levels are well known, e.g. DDTs, PCBs and many organochlorine compounds have shown a decreasing trend in most locations of the North Atlantic over the last four decades (Aguilar *et al.*, 2002);

(2) avoid including areas in the comparisons for which sample sizes are very low; and
(3) with respect to comparisons within Iceland (e.g. north and south) do not pool results for factors (e.g. sex and body length) that are well-known to be important, even if no significant differences are found within the very limited sample size from the permit programme.

Within the analysis of trace metals, the Panel was surprised by the finding that cadmium levels in common minke whale liver were much higher than those in other areas of the North Atlantic while the opposite was true for muscle. The physiological reasons for this are unclear and the Panel **recommended** that this be further investigated to determine if the differences were real or the result of laboratory or analytical errors.

The Panel **appreciated** the considerable effort expended in examining the levels in different organs in comparison with those from skin biopsies to determine whether predictive relationships exist. This is valuable information for future studies attempting to use biopsies for monitoring cetacean pollutant loads. In response to a request from the Panel, the proponents developed a summary table of their results. The Panel noted that determination of the most 'representative' tissue for consideration of pollutant impact on an individual depends on its physiology and the physical-chemical properties of the pollutants.

Given the comprehensive sampling conducted of biological information on individuals including corpora counts, the Panel **recommended** that the dataset be examined to see whether it is possible to investigate the mother-foetus transfer of organochlorine compounds and possible effects on the offspring. For example, it would be interesting to establish whether the first foetus born to a female has a higher pollutant load, and therefore is at higher toxicological risk, than descendants from females that have previously had several pregnancies (given the high percentage of annual breeders, corpora counts in common minke whales will almost always represent pregnancy) as has been found in odontocetes subject to higher pollution levels (Hall *et al.*, 2006).

10. PARASITES AND PATHOLOGY

10.1 Proponents' summary

In SC/F13/SP27, the epibiotic macrofauna and skin lesions on 185 common minke whales landed in Icelandic waters between April to September 2003-07 were determined. For each whale, the fluke and one lateral side was examined. A total of seven epibiotic species were found, namely: the caligid copepod *Caligus elongatus* (prevalence (P)=11.9%, mean intensity (M.I)=95.5); the pennellid copepod *Pennella balaenopterae* (P=10.3%, M.I=1.6); the cyamid amphipod *Cyamus balaenopterae* (P=6.5%, M.I=37.0); the lepadid cirripeds *Conchoderma virgatum* (P=0.5%, M.I=4.0) and *Conchoderma auritum* (P=0.5%, M.I=1,0), the balanid cirriped *Xenobalanus globicipitis* (P=1.6%, M.I=5.3) and the sea lamprey *Petromyzon marinus* (P=2.7%, M.I=1.0). In addition, the hyperparasitic monogenean *Udonella caligorum* was found on *C. elongatus* (P=10.4%, M.I=3.9) on 8 of the 22 whales infected with the copepod. No significant relationship was observed between parasite intensity and host body length for neither *C. balaenopterae* nor *C. elongatus* while the proportion of infected hosts was higher in August-September than earlier in the summer for *C. balaenopterae* ($\chi 2 = 13.69$; $p<0.01$: d.f.=1) and *C. elongatus* ($\chi 2=28.88$; $p<0.01$: d.f.=1). The prevalence of *C. balaenopterae* was significantly higher on male than on female hosts ($\chi 2=5.08$; $p<0.05$: d.f.=1) suggesting possible different migration routes by the sexes. A likely explanation of the occurrences of *P. marinus,* attached to the minke whales may be gradually rising sea temperature in the area in the recent years. This study represents the first known record of *C. elongatus* on a cetacean host.

The objective of SC/F13/SP28 was to determine prevalence and abundance of Anisakid nematodes (lethal sampling). Anisakid nematodes in the stomachs went through the same sampling and sub-sampling procedures as the food, however, in the special permit programme this aspect was given only secondary importance. The presence of Anisakids was detected in 176 animals from a total of 190 whales analysed (prevalence of 92.6%). Total enumeration of worm and sub-sampling of every whale for measuring overall prevalence, abundance and mean intensity, was not practical. There were also problems encountered during sub-sampling onboard the whaling boats, which made the first subsample not very representative, in case of the abundance and mean intensity of the nematodes. Assuming random sub-sampling total amount of nematode (M) larvae were estimated as $F\times m$ and standard error as $F\times s_m$, assuming Poisson distribution, where $m=s_m$, (m is the mean and F the reciprocal of the fraction sampled). Abundance of anisakid nematodes was estimated by multiplying the weight obtained by the worms/gram factor, of which mean and 90% confidence limits were estimated by bootstrapping 1,000 samples. Previous studies found only mature *A. simplex* worms in the stomachs of minke whales they investigated. They also found *Anisakis larvae* and larval stages of *Contracaecum, Phocascaris* and *Hysterothylacium.* The observed prevalence of 87.5% was not significantly different from the 78% observed in 1977-78.Calculated abundance and mean intensity of infection of anisakid nematodes were 88,994 and 1,423,903 respectively. Probably these estimates were underestimated, due to various sampling errors in the processing of samples and sub-sampling onboard of the whaling boats and in the laboratory. In the few worm samples analysed to species, *Anisakis simplex* was predominating.

It is quite feasible to study Anisakid infestations of whales in Icelandic waters further, in light of the experience from the research operations during the scientific whaling period. Routine sub-sampling onboard of the whaling boats should, however, be improved.

The aim of SC/F13/SP29 was to evaluate the of health status of minke whales in Icelandic waters by veterinary dissections, histopathological, haematological and bacteriological examinations of animals caught in the period 2003-05. Basic veterinary necropsy was performed on fourteen animals (eight males and six female) and a total of 49 organ tissue samples from these 14 animals and 95 tissue samples from other 48 animals caught in the same period were collected for histological examination. A total of 140 animals were blood sampled for analyses of hemoglobulin, hematocrit and total leukocyte, neutrophil, lymphocyte, eosinophil and monocyte counts. Bacteriological cultivation was made from a total of 135 swabs collected from 39 animals.

The gross pathological and histopathological findings in the studied animals were sporadic, usually mild and mainly due to parasites infestations. Importance of observed parasites and parasitic lesions found on the health status is unknown. However, it could be speculated that parasite cysts in *ductus deferens* or in the epididymitis of testis, that were found in the majority of the male animals dissected, could have an impact on male-fertility.

Novel information was gained in the programme on haematological values in minke whales. Large differences were found between animals in total white blood cells and in individual leukocyte populations (i.e. neutrophils, lymphocytes and eosinophils). A number of animals were found to be low in total white blood cell count, neutrophils, lymphocytes ($<10^3/\mu l$). The significance of this finding is unknown. High eosinophil count in many of the animals was probable due to parasite infections. No pathological lesions were observed that could reflect infections with bacteria or viruses nor could pathogenic bacteria be isolated from blood and major organs of these animals. Valuable material for future serological studies on infectious agents was collected in the programme.

In present study on the health status of common minke whales found in Icelandic waters, all animals examined were found to be in normal condition and with a healthy appearance. However, the few pathological observations made, reflect the high parasitic burden found in some of these animals.

10.2 Panel discussion, conclusion and recommendations

The Panel noted that the objective of this component of the programme was to investigate the feasibility of monitoring and evaluating the morbidity of potential pathogens. The Panel recognised the difficulty of conducting full post-mortems of animals and undertaking thorough examination for parasites and pathogens at sea. It welcomed the efforts of the scientists and the reports presented. It **agreed** that the study of the epibiotic macrofauna has resulted in a good baseline for future analyses in the light of the identified environmental changes which may be related to regime shift and/or climate change. With respect to the study of Anisakid nematodes, the Panel **agreed** with the authors that methodological problems in the sampling with respect to abundance were detected which could result in a bias in the standard parasitic descriptors. Overall, the Panel **concluded** that the approaches adopted in the feasibility study would be insufficient to achieve the ambitious objective outlined. The relationship between parasites and whale health parameters had not been thoroughly investigated.

The Panel **recommended** with respect to any future studies:

(1) more focused studies on the role of parasitic diseases on the health status of whales;
(2) a better sampling scheme and protocols adapted to the parasitological objectives and subsequent analysis techniques, ensuring an adequate sample size for each case considered;
(3) continued studies of epibionts in the light of water temperature changes;
(4) coordinated studies with other photo-ID work in Iceland to identify the presence of infectious lesions in the skin and determine the causative agents;
(5) studies of biomarkers using endoparasites (especially but not exclusively Anisakids) to explore differences in prevalence, abundance and intensity of parasites among whales present in the north and south of Iceland due to differences in diet; and
(6) the preservation and archiving of biological materials such as parasites, is essential as preserved serological samples can be used in future studies.

11. GENERAL OVERVIEW AND CONCLUSIONS ON THE PROGRAMME AS A WHOLE

In reaching its conclusions and recommendations, the Panel noted the statement from the proponents that no further special permit programme was envisaged by Iceland at present. With respect to consideration of the effect of the catches on stocks, it noted that the level of catches was considerably below the level for the CIC *Small Area* that would have been allowed under the RMP (IWC, 2011b, p.64). The Panel **emphasised** that its remit was to provide an objective scientific review of the results of the Icelandic programme; its task was not to provide either a general condemnation or approval of research under special permit. Consideration of that would require examination of some issues way beyond the purview of a scientific panel.

11.1 Achievement of the objectives

11.1.1 General comments

Before considering the individual components and papers presented in terms of objectives, the Panel made a number of general comments that are applicable to all aspects of the programme.

11.1.1.1 SPECIFICATION OF OBJECTIVES

The Panel noted several times in its discussions that the general nature of the objectives of the original proposal and its characterisation as a feasibility/pilot study made it difficult to fully review how well the programme could be said to have met its own objectives. While the Panel recognised that the general overall objective of multi-species modelling was extremely broad and that most information can be considered to be useful in helping establish the framework for such modelling exercises, it **agreed** that it is important that any special permit programme provides careful objectives and sub-objectives for which performance can more easily be assessed. The Panel noted that the guidelines for proposed permits in 'Annex P', developed since the Iceland permit was presented in 2003, make this factor clear and it **endorsed** the guidelines.

The Panel noted that the original special permit programme also covered fin and sei whales. Whilst it accepted the statement from Iceland that the common minke whale component could be seen to be stand alone, it believed that the proponents should have considered further and provided information on any implications for the overall multi-species modelling objective that might result from the other baleen whale species components of the original programme.

11.1.1.2 SAMPLING PROCEDURE

An important component of any research programme is to determine how representative the sampling procedure is temporally and geographically in terms of: (a) animals within the sampling area; and (b) the population as a whole. The proponents provided some information on this in their presentations and papers on the individual topics and these are reflected in this report. They also kindly provided the Panel with a detailed table summarising by whale the analyses undertaken. In addition, the Panel was provided with a summary of the instructions given to the cruise leaders which is provided as Annex E. However, the Panel **recommended** that an integrated overview paper fully explaining the sampling design, providing a final summary of sample sizes by area, season and topic be developed; that paper should evaluate and address the question of representativeness at the local and population level.

In **conclusion**, the Panel noted that the feasibility study had attempted to obtain an approximate balance in terms of numbers of animals by the BORMICON areas. This had been made more complex by the changes in distribution revealed by the aerial survey data. Although no selectivity in terms of length of the animals was allowed, the vessels did not follow randomly designed tracklines. The Panel **agreed** that while the method used was probably sufficient for a feasibility study, if future work is contemplated then more effort needs to be dedicated to geographical and temporal sample design and appropriate sample sizes.

11.1.1.3 INTEGRATION

Although it was a feasibility study, the Panel **agreed** that the programme would have benefitted considerably from better integration of all aspects of the programme with modelling work. Given the ultimate objective of developing multi-species modelling to improve management of key species in the Icelandic ecosystem, this would have allowed better identification of key parameters and the degree of accuracy and precision that would allow for robust conclusions to be drawn. This should be done and a more complete evaluation of uncertainty undertaken.

The Panel **welcomed** the considerable new information that was presented in the available papers on a large number of topics. However, as is apparent from a number of its recommendations, it **recommended** that further analytical work integrating the information available from the various aspects of the programme is essential. This will strengthen conclusions that can be drawn and make better use of the extensive data set collected. In particular, the Panel noted that the results of the work on segregation and ageing are important to many of the studies and this should be taken more fully into account in revised papers and analyses.

The Panel **stressed** the importance of trying to obtain as much information as possible on the environment (oceanographic, fishery related, etc.) at appropriate geographical and temporal scales. Such information may be of great value in interpreting annual and seasonal changes in the abundance and distribution of common minke whales, as well as interpreting the data on feeding ecology.

11.1.1.4 ARCHIVING

The Panel noted the recommendation from the previous JARPN II review that *if* whales are killed for scientific purposes, then every effort must be made to maximise the information from them. It **agreed** that the Icelandic programme had tried to do this and that this may have been part of the reason for the many research components and the rather general objectives. An important component of such a programme relates to archiving. It is essential that a proper tissue archiving system is in place that will allow: (a) analytical sample sizes to be increased for studies that were carried out on only a subset of the animals killed; and/or (b) new analyses to be carried out as techniques improve. Similarly, it is important to compile a relational database that links all components and results of analyses for each animal with the tissue archive.

11.1.2 Abundance

The Panel **welcomed** the information on the Icelandic surveys, recognising the work involved in undertaking them and analysing the data. In particular, it recognised the logistical difficulties in undertaking surveys outside the summer period given the prevailing weather conditions around Iceland and appreciated the efforts made.

Overall, the Panel **agreed** that the Icelandic survey data has improved knowledge about the abundance and distribution of the common minke whale in Icelandic waters both for use in the RMP (many of the summer surveys have already been accepted by the Scientific Committee) and for input to potential multispecies modelling. It noted that survey data were integral to the study design; earlier survey data were used to develop the original sampling programme and later data in part the modified programme. Despite the logistical difficulties, the off-summer surveys provided valuable new information, especially in the context of any future multi-species modelling. It **agreed** that the research has demonstrated the feasibility of undertaking surveys outside the summer season and **recommended** that these continue.

The Panel made a number of specific recommendations for improved analyses and additional field work (see Item 12.1.1).

11.1.3 Stock structure

The Panel **agreed** that the proponents conducted and reported research that addresses the objectives related to stock structure. The data collected and the analyses presented will provide valuable information for the forthcoming RMP *Implementation Review* of North Atlantic common minke whales and the planned joint AWMP/RMP workshop on the stock structure of this species in the region. With respect to the feasibility component, it was of course already well-known that it is possible to collect samples for a number of techniques to better understand stock structure from carcases (as well as from biopsy samples for some aspects of the study as the proponents' note).

The Panel **welcomed** the analyses presented, recognising the considerable amount of field and laboratory work they represented. It appreciated the effort that had been expended in comparing the data obtained from the programme with data from elsewhere, as is critical for such studies. However, it **recommended** further effort to integrate information regarding stock structure from the variety of genetic and non-genetic sources. One step in this direction has been achieved in the summary presented in Annex D, developed by the proponents in response to a request from the Panel. A full integrated analysis will be of considerable value to the forthcoming IWC Workshop.

The Panel made a number of recommendations for improved analyses and additional field work (see Item 12.1.2).

11.1.4 Biological parameters

The Panel **recognised** the extensive amount of field and laboratory work that had been undertaken and presented, noting that the procedures followed were standard good practice as discussed at previous IWC meetings (e.g. Perrin and Donovan, 1984). However, it noted that the general nature of the objectives made it difficult to fully evaluate whether they had been satisfactorily met, although more information is certainly available now for Icelandic waters than prior to the programme. Evaluating the feasibility of collecting information on biological parameters of sufficient precision and accuracy to inform multi-species modelling requires examining the sensitivity of model results to the parameters concerned (which can be an iterative process). As the modelling (see below) was not as advanced as had been originally planned in the programme, this evaluation cannot yet be conducted. It was noted that the *CLA* development process had shown that it was relatively insensitive to the values of biological parameters; such values are not essential input for the *CLA* although they can contribute to and improve the *Implementation* and *Implementation Review* process.

One of the most important feasibility questions relates to the issue of ageing common minke whales. The Panel **commended** the work to examine a new approach for common minke whales where the 'traditional' approach of using earplugs is not feasible for the North Atlantic given the fragility of the earplugs, recognising that further work needs to be undertaken.

The Panel made a number of specific recommendations for improved analyses (see Item 12.1.3).

11.1.5 Feeding ecology

This was an important component of the primary objective of the feasibility study. The proponents had noted that the primary objective was to increase knowledge on the feeding ecology of minke whales in Icelandic waters by studies of diet composition, energetics, seasonal variation in distribution and abundance, estimation of consumption rates and multispecies modelling.

The Panel **appreciated** the notable amount of effort undertaken and the generally thorough analyses of stomach contents as documented in SC/F13/SP2. It also **acknowledged** the large effort invested in this study demonstrating spatial and temporal variation in the diet of common minke whales on the Icelandic continental shelf waters. The temporal changes observed as a result of the extension of the sampling period could be related to climate change or a regime shift in the waters around Iceland and this is an important issue for further research. As with the other studies, the general nature of the objectives made evaluation of the success of the feasibility study more complex. However, the Panel **agreed** that it is clear that knowledge of the feeding ecology of common minke whales around Iceland has been advanced through a variety of approaches including stomach contents, fatty acid and stable isotope analyses and the collection of data that can be used to inform a more systematic than usual examination of the results that can be obtained from lethal and non-lethal methods. While welcoming the individual papers presented, the Panel **strongly recommended** that an integrated analyses including comparison of the information from each approach be developed and submitted to the Scientific Committee.

The Panel made a number of other specific recommendations for improved analyses (see Item 12.1.4).

11.1.6 Modelling

The key component of the long-term objective of the feeding ecology component of the programme is the development of a multi-species modelling approach to inform management of whales and fish within Icelandic waters. The Panel recognised the practical difficulties explained by the proponents but **concluded** that this important part of the programme is as yet poorly developed. In particular, a simple preliminary model should ideally have been developed at an early stage to inform discussions of which are key parameters with respect to obtaining robust results, evaluating how sensitive results are to different levels of uncertainty and determining appropriate sample sizes. This was a major weakness in the programme. However, the Panel welcomed the work presented in SC/F13/SP7 that was extended in the presentation to the Workshop as an important first step. The author emphasised the exploratory and preliminary nature of the work he has been able to conduct thus far. It was recognised as a small but valuable initial step toward the programme's overall objective.

The Panel made a number of specific recommendations for taking this work forward (see Item 12.1.4).

11.1.7 Energetics

The Panel **welcomed** the work presented on energetics which involved considerable field, laboratory and analytical effort. The Panel **agreed** that many of the studies provided valuable insights into aspects of the energetics of common minke whales around Iceland. However, as elsewhere in the programme, the Panel noted that further effort is required to integrate the various analyses to provide a more coherent and valuable picture that can be used to obtain quantitative input to energetics models and multispecies modelling. This will allow better evaluation of the sensitivity of the results to the inevitable uncertainty.

The Panel made a number of specific recommendations with respect to further work (see Item 12.1.5).

11.1.8 Pollution

The Panel **acknowledged** the considerable field, laboratory and analytical work included in the papers presented and in a number of published papers (Dam *et al.*, 2013; Rotander *et al.*, 2012a; 2012b; 2012c). It also appreciated the effort made to compare and contrast results across the North Atlantic with the potential for this to inform stock structure discussions as noted elsewhere, as well as the efforts to examine relationships between concentration levels in different tissues including 'pseudo' biopsy samples. However, it agreed that the objective of assessing health status had not been fully addressed. The proponents had referred to the conclusions of the post-mortem studies of 14 animals that had broadly considered that the animals were healthy and had noted the relatively low levels of the trace metals; from this they had given low priority to assessing health implications. While the Panel **agreed** that this may be indicative, it noted that low levels *per se* do not indicate no effect. The Panel **recognised** that the sample size of the feasibility study was insufficient to properly address any toxic-related cause-effect relationships but **agreed** that, should further studies take place, the design of the research should include a more robust sample size to sufficiently address health-related specific questions.

The Panel made a number of specific recommendations with respect to further work (see Item 12).

11.1.9 Parasites and pathology

The Panel noted that the objective of this component of the programme was to investigate the feasibility of monitoring and evaluating the morbidity of potential pathogens. The Panel recognised the difficulty of conducting full post-mortems of animals and undertaking thorough examination for parasites and pathogens at sea. It welcomed the efforts of the scientists and the reports presented. It **agreed** that the study of the epibiotic macro fauna has resulted in a good baseline for future analyses in the light of the identified environmental changes which may be related to regime shift and/or climate change. With respect to the study of Anisakid nematodes, the Panel **agreed** with the authors that methodological problems in the sampling with respect to abundance were detected which could result in a bias in the standard parasitic descriptors. Overall, the Panel **concluded** that the approaches adopted in the feasibility study would be insufficient to achieve the objective outlined. The relationship between parasites and whale health parameters had not been thoroughly investigated.

The Panel made a number of specific recommendations with respect to further work (see Item 12).

11.2 Other contributions to important research needs

The Panel noted that the papers presented were all relevant to the objectives of the proposal and that this item was therefore not applicable to the review.

11.3 The relationship of the research to IWC Resolutions and discussions

11.3.1 Research on the ecosystem and environmental change

The Commission has passed a number of Resolutions (see summary in IWC, 2010c) on matters related to ecosystem research and climate change. Resolution 1994-13 (IWC, 1995) encouraged Contracting Governments and the Scientific Committee to study environmental changes and impact on cetaceans. Resolution 1995-10 (IWC, 1996b) encouraged Contracting Governments to study the effects of pollutants on cetaceans as recommended by the Scientific Committee's workshop on the topic (Reijnders *et al.*, 1999). Resolution 1997-7 (IWC, 1998) encouraged Contracting Governments to continue to provide information on environmental changes and potential effects on cetaceans. Resolution 1999-4 (IWC, 2000) requested Contracting Governments to provide the Scientific Committee with data on contaminants in cetaceans.

The Panel **agreed** that many aspects of the programme were directly relevant to these resolutions and noted that this information has been made available to the Scientific Committee in papers presented at Annual Meetings as well as the present Workshop.

11.3.2 Work of the Scientific Committee

In addition to the work related to ecosystems and environmental change discussed above, the Panel **agreed** that the work on stock structure and abundance was directly relevant to the Scientific Committee's work on the Revised Management Procedure, in particular with respect to the forthcoming *Implementation Review* for North Atlantic common minke whales and the joint RMP/AWMP workshop on stock structure of common minke whales throughout the North Atlantic.

11.4 Utility of lethal and non-lethal techniques

The Panel noted the full discussion of this issue at the Workshop to review the JARPN II programme (IWC, 2010a, pp. 423-6). That report provided a good review of the strengths and weaknesses of the then available non-lethal techniques for studies on the following topics that are also relevant to the Icelandic Research Programme: feeding ecology; pollutant studies; and stock structure including genetic studies. The Panel also noted the more recent extensive review (Baker *et al.*, 2012) undertaken as part of the SORP (Southern Ocean Research Partnership) programme. The Panel has not repeated the information from those two reviews again here but took them into account during its deliberations.

The Panel **welcomed** the efforts of the Icelandic programme to provide data to allow a more thorough and quantitative comparison of some lethal and non-lethal techniques than has previously been possible (see recommendation in IWC, 2010a). It **agreed** that this work is valuable and informative not only for future studies on North Atlantic common minke whales but also for other populations and species. The Panel developed Table 4 that summarised the situation for North Atlantic common minke

Table 4

A simple summary of the actual and potential contribution of various lethal and non-lethal techniques for the programme's research objectives. The Panel emphasises that not all techniques provide identical information or the same level of insights into the topic and some techniques provide insights into several objectives. See the text for further explanation. The categories under 'Practicality' are qualitative assessments of high (H), medium (M), low (L) and not applicable (-) and include consideration of *inter alia* obtaining sufficient sample size.

	'Practicality'			
	In principle		In this species/area	
Research objective	Lethal	Non-lethal	Lethal	Non-lethal
1. Feeding ecology				
Diet composition through stomach content analysis (most recent feeding)	H	-	H	-
Diet composition through stable isotopes in blood (scale of few days)	H	-	H	-
Diet composition through stable isotopes in skin (scale of up to 2-3 months)	H	H	H	H
Diet composition through fatty acid analysis	M	L	L	-
Diet composition in faeces (DNA analyses)	M	M	M	L
Energetics through lipid mass reserves	H	L	H	-
Feeding rates through creatinine	M	-	L	-
Seasonal abundance	-	H	-	H
2. Stock structure				
Genetics	H	H	H	H
Movements through satellite tracking	-	M	-	M
Morphology	M	L	M	L
Stable isotopes	M	M	M	M
Biological parameters	M	-	M	-
Pollutant levels	M	M	M	M
Parasites	H	-	M	-
3. Health status				
Pathogens and pathology	H	M	M	L
External morphology	H	M	H	L
4. Biological parameters				
Age determination	H	-	M	-
Length at physical maturity	H	L	H	L
Reproductive parameters through examination of reproductive tracts	H	-	H	-
Reproductive parameters through hormones	M	L	L	L
5. Pollutants				
Organic pollutants (lipophilic)	H	H	H	M
Trace elements	H	H	H	M

whales in the light of the information presented during the Workshop (note that this is not identical to Table 3 produced by the proponents). It **stresses** that this Table is **not** intended to represent a complete or comprehensive evaluation of lethal or non-lethal techniques, either in general or for this specific programme. It has for example listed the applicable techniques by programme objective but **emphasises** that not all of them are equally informative or valuable to that topic (e.g. genetics may be more central to stock structure than other types of information) or that different techniques they may provide complementary rather than identical insights into an issue (e.g. stomach content data versus chemical analyses of biopsy samples). The Panel **emphasises** that this is a qualitative summary. For example it is **not** appropriate to try to sum up the rows/columns and say that either lethal or non-lethal techniques are superior overall.

The Panel noted that a full evaluation of 'practicality' requires a more detailed overview of the practicalities, logistics (including costs) of the field and laboratory techniques in the context of the *integrated* objectives, sub-objectives and analyses proposed. Such an overview must be undertaken if there is any proposal to carry out this as a full programme in the future. The Panel also noted that a full evaluation for any programme requires a more detailed review of the available techniques at the time (some techniques are rapidly evolving) in the light of the programme's specific objectives, taking uncertainty in the results provided by such methods fully into account.

12. SUMMARY OF RECOMMENDATIONS

12.1 Short-term recommendations that could be undertaken 40 days prior to the 2013 Meeting of the Scientific Committee (or in time for expected intersessional Workshops)

12.1.1 Abundance

(1) Present a revised abundance paper that summarises the overall results for the period up to 2009 (inside and outside the peak summer surveys) including a fuller investigation of the available data and use covariates to model the detection function and encounter rates for use in the surveys with few sightings/low effort. This paper should also present information and results at the spatial and temporal level to be used in multispecies modelling. For more details see Item 4.2.

12.1.2 Stock structure (before the joint RMP/AWMP Workshop prior to the 2014 meeting)

(1) Produce a fully integrated paper incorporating the information from genetics, morphometrics, telemetry, biological parameters, stable isotopes, fatty acids and pollutants.
(2) For the genetics papers provide details of the analyses undertaken to demonstrate that IWC data quality standards were met.
(3) Present a revised version of SC/F13/SP17 that discusses its relationship with SC/F13/SP16 including: (a) differences in objectives; (b) the rationale for and effect of using partially overlapping but substantially different sets of geographic samples; and (c) a better integration of the results of both studies.
(4) Request a paper from the authors of SC/F13/SP16 that considers further the question of circularity referred to under Item 5.2.
(5) Present a revised morphometrics paper taking into account the detailed comments given under Item 5.2.

12.1.3 Biological parameters (for details see Item 6.2)

(1) Present a revised paper on ageing that takes into account the results of the IWC research project by Lockyer (2010) and Kitakado and Punt (2010) on ageing errors in Antarctic minke whales (and see the recommendation under Item 12.2.3).
(2) Examine the available suite of data to re-examine the reproductive status of whales (especially those considered to be anoestrus) and if necessary incorporate this information into revised paper(s) and associated parameter estimates.
(3) Examine the length data for 'very small' common minke whales in the Vestfjord area of Norway to see whether this provides insights into the apparent absence of calves/yearlings off Iceland (and indeed elsewhere).

12.1.4 Feeding ecology (for details see Item 7.2)

(1) Provide a paper that integrates all of the information obtained from a variety of techniques to summarise the overall findings of the programme on this issue.
(2) Revise the existing papers taking into account the 14 detailed comments provided under Item 7.2.
(3) Present a revised paper on the multispecies modelling work that incorporates all of the work undertaken so far and presents a roadmap for future work; ensure participation of the author in the ecosystem modelling group of the Scientific Committee.

12.1.5 Energetics

(1) Provide a paper that integrates the results of *inter alia* SC/F13/SP8, 10 and 11.
(2) Provide a revised SC/F13/SP10 that *inter alia* takes into account any changes in the female reproductive category classification (see Item 6.2), uses mature males as a reference group and considers further any patterns of seasonal variation.
(3) Provide a revised SC/F13/SP5 that *inter alia* takes into account any changes in reproductive category classification (see Item 6.2), examines individuals comprising the secondary peak in conception date, examines stable isotope and fatty acid data for mothers in poor body condition and considers use of AICc.

12.1.6 Pollution (for further details see Item 9.2)

(1) Present revised papers that *inter alia* take into account time of sampling of comparative studies and take into account significant time-related variation in certain pollutant levels; avoid comparisons where the sample sizes are very low; for within Iceland comparisons do not pool results for factors known to be important (e.g. sex and body length) even if low sample sizes preclude significant differences being detected.
(2) Further investigate the unusual findings with respect to cadmium to ensure that they are real.

12.2 Medium to long-term recommendations

12.2.1 Abundance (for details see Item 4.2)

(1) Conduct additional spring and autumn surveys, especially in years when a full midsummer survey will be conducted. Additional coverage outside coastal waters is required (including to the north and to East Greenland) to determine whether this is where the 'missing' common minke whales are to be found. It would be valuable if future surveys are conducted in conjunction with prey species surveys to more fully explore possible correlations and spatial-temporal overlaps.

12.2.2 Stock structure (for details see Item 5.2)

(1) Develop an experimental design for future studies that maximises the amount of stock-structure information that can be obtained, in the context of existing samples of the species from around the North Atlantic (this should be referred to the joint workshop).

(2) Conduct further satellite tagging with additional emphasis on trying to obtain a biopsy sample and photo-ID photographs of the tagged animals.

(3) Conduct joint studies to improve telemetry delivery and attachment systems.

12.2.3 Biological parameters (for details see Item 6.2)

(1) Expand the ageing study to include:
  (a) animals and foetuses from the common minke whale in the North Pacific
  (b) provide a much fuller consideration of the several sources of uncertainty in the 'correct' ages used for comparisons and the racemisation process itself; and
  (c) provide a range of the uncertainty in ageing for incorporation into the modelling exercise.

(2) Examine the modelling results to identify which biological parameter information is required and to what level of accuracy and precision to produce robust model conclusions.

12.2.4 Feeding ecology (for details see Item 7.2)

(1) Examine stable isotope data in baleen plates to provide information on the representativeness of stomach contents to overall diet within a season as well as on seasonal variation in diet composition, and to discern whether the observed differences between areas are real or an artefact (using baleen plates from individuals of known sex, body length and date of capture already available or collected from any future commercial catches should they occur).

(2) Increase the resources available for ecosystem modelling and follow the detailed comments and suggestions provided under Item 7.2.1.

12.2.5 Energetics (for further details see Item 8.2)

(1) Further investigate the approach to examining food ingestion rate from analysis of urine, focussing on a full examination of the uncertainties involved, consideration of factors known to affect creatinine values and, *if* further sampling was envisaged, use new and more precise creatinine analytical techniques.

12.2.6 Pollution (for further details see Item 9.2)

(1) If further studies on pollutants occur, the research should be carefully designed to focus on priority pollutants and include a sufficient sample size to address health-related specific questions.

(2) Examine the full dataset of the programme to see whether it is possible to investigate the mother-foetus transfer of organochlorine compounds and its possible effects on the offspring.

12.2.7 Parasites and pathology (for details see Item 10.2)

(1) If future studies are envisaged, they should:
  (a) incorporate an appropriate sampling design and sample size to meet parasite-related objectives with a focus on the role of parasitic diseases on the health status of whales;
  (b) incorporate epibiont studies in association with water temperature changes;
  (c) be coordinated with photo-identification work in Iceland with respect to infectious lesions in the skin and causative agents;
  (d) incorporate biomarker studies using endoparasites (e.g. Anisakids) to explore differences in prevalence, abundance and intensity of parasites among whales present in the north and south of Iceland given differences in diet; and
  (e) include the preservation and archiving of biological materials such as parasites; preserved serological samples can be used in future studies.

13. ADOPTION OF REPORT

The report was adopted by email on 10 March 2013. The Chair thanked the Panel, the proponent scientists and the observers for their constructive and patient approach to the Workshop. He particularly thanked the Marine Research Institute for providing excellent facilities.

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Annex A

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Annex B

List of Documents

SC/F13/SP

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2. Pastene, L. and Murase, H. Japanese Observers' comments on the scientific outputs of the Icelandic feasibility research study on common minke whale. 2pp
3. Rael, B.A. UK review comments to the Icelandic Special Permit Review Workshop. 3pp.

Annex C

Agenda

1. Introductory items
   - 1.1 Chair's opening remarks
   - 1.2 Terms of reference
   - 1.3 Overview of the process for developing advice for the Commission
   - 1.4 Meeting arrangements and work schedule
   - 1.5 Review of documents and data
2. Adoption of Agenda
3. Proponents' overview of the research objectives and results
4. Abundance
   - 4.1 Proponents' summary
   - 4.2 Panel discussion, conclusion and recommendations
5. Stock structure
   - 5.1 Proponents' summary
     - 5.1.1 Genetics
     - 5.1.2 Morphometrics
     - 5.1.3 Satellite telemetry
   - 5.2 Panel discussion, conclusion and recommendations
6. Biological parameters
   - 6.1 Proponents' summary
   - 6.2 Panel discussion, conclusion and recommendations
7. Feeding ecology
   - 7.1 Proponents' summary
   - 7.2 Panel discussion, conclusion and recommendations
     - 7.2.1 Modelling
8. Energetics
   - 8.1 Proponents' summary
   - 8.2 Panel discussion, conclusion and recommendations
9. Pollution
   - 9.1 Proponents' summary
   - 9.2 Panel discussion, conclusion and recommendations
10. Parasites and pathology
    - 10.1 Proponents' summary
    - 10.2 Panel discussion, conclusion and recommendations
11. General overview and conclusions on the programme as a whole
    - 11.1 Achievement of the objectives
      - 11.1.1 General comments
      - 11.1.2 Abundance
      - 11.1.3 Stock structure
      - 11.1.4 Biological parameters
      - 11.1.5 Feeding ecology
      - 11.1.6 Modelling
      - 11.1.7 Energetics
      - 11.1.8 Pollution
      - 11.1.9 Parasites and pathology
    - 11.2 Other contributions to important research needs
    - 11.3 The relationship of the research to IWC resolutions and discussions
      - 11.3.1 Research on the ecosystem and environmental change
      - 11.3.2 Work of the Scientific Committee
    - 11.4 Utility of lethal and non-lethal techniques
12. Summary of recommendations
    - 12.1 Short-term recommendations that could be undertaken prior to the 2013 Meeting of the Scientific Committee
    - 12.2 Medium to long-term recommendations
13. Adoption of Report

Annex D

Summary of potential indicators of structure developed by proponents

The Table considers structure at two levels, i.e. indication of structure at breeding grounds and of structure in the IWC Schedule stock boundaries for the Central North Atlantic stock (feeding ground). In the latter, the table considers local structure (north *vs* south Iceland) and at larger scale (North Atlantic). Explanatory comments are indicated to clarify the observed results.

Methods	Breeding	Feeding local	Feeding large	Comments
Feeding ecology				
Diet: SC/F13/SP2	N/A	3	N/A	
Energetics				
Energy storage: SC/F13/SP10	N/A	2	N/A	Differences related to change in diet composition north *vs* south.
Genetics				
Microsatellite: SC/F13/SP16	1	N/A	1	Possible indication of two breeding populations, distribution of these two groups across the North Atlantic shows differences in IWC stock boundaries areas.
Microsatellite: SC/F13/SP17	0	0	0	No genetic pattern observed (different loci than SC/F13/SP16).
mtDNA: SC/F13/SP16	0	N/A	0	
mtDNA: SC/F13/SP17	1	0	0	Two groups of haplotype detected with no geographical partitioning.
Relatedness: SC/F13/SP20	0	0	0	High rate of related individuals across the North Atlantic. Age and geographical location information are crucial.
Morphometry				
SC/F13/SP19	N/A	1	1	But non-significant pattern due to too large variance in estimates.
Telemetry				
SC/F13/SP18	0[§]	1[†]	*	Five[†] individuals tagged in the north exhibited site fidelity during all the period. [§]All individuals migrating south stayed within the Central North Atlantic area (370 days of tracking for eight whales).
Stable isotopes				
SC/F13/SP3	1	2	3	Reflects feeding in the past.
Fatty acids				
SC/F13/SP4	1	0	2	Reflects feeding in the last 3-6 months.
Pollutants				
SC/F13/SP21-SP23, SC/F13/SP25-SP30				
Cadmium and mercury	2	0	3	Differences in concentration in Iceland and other areas.
Toxaphene	2	0	3	Differences in concentration in Iceland and other areas.
Methoxylated PBDEs	2	0	3	Differences in concentration in Iceland and other areas.
Cs-137	2	0	3	Differences in concentration in Iceland and other areas.
Biological parameters				
Reproductive seasonality: SC/F13/ SP13	1	0	2	Differences between the rise in the serum testosterone measurements in Norway and Iceland.
Variation in body mass: SC/F13/SP11	N/A	0	2	Differences between Norway and Iceland.
Sex segregation: SC/F13/SP14	0	2	0	Sex segregation in Iceland is similar to what is known in other areas.
Parasites (anisakids)				
SC/F13/SP28	N/A	0	N/A*	

N/A: information not available. *Promising methods despite the current absence of relevant information related to stock structure. '0' denotes the absence of detected structure; '1' = low indication of structure; '2' = medium indication of structure; and '3' = strong indication of structure.

Annex E

Specific catch rules applied in the Icelandic minke whale research programme 2003-07 for representative sampling

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All operative decisions related to sampling, *inter alia* the selection of search areas, choice of animals to target and judgement of when targeted animals were lost were taken by cruise leaders from the Marine Research Insitute. The general rules for securing representative sampling were outlined in the original proposal. Instead of searching along pre-determined tracklines, the sample was allocated to fine scale spatio-temporal units (nine areas, five seasonal units) according to the previously known distribution of the species. In addition, the following more detailed rules were applied.

The first sighted animal should be the target and exhaustive attempts made to catch that animal for a minimum of 45 minutes, unless the animal had been lost i.e. not seen for 20 minutes.

In 2004 the following clarifications were added.

(1) When a group (n>1) was sighted and chased simultaneously, attempt should be made to make the selection of animals from group as close to random as possible by prohibiting a selection by size. In such cases the gunner had to consult with the cruise leader.
(2) To further distribute sampling within sub-areas (the nine BORMICON areas), it was forbidden to take another animal within 10 n.miles of a previously caught animal in the same month.
(3) Special rules intending to minimise interference with whalewatching activities were applied. Thus, small inshore areas in Faxaflói and Skjálfandi bays were closed for this purpose and cruise leaders were instructed to be in daily contact with the companies, to prevent conflicts.

From 2006, the BORMICON areas 1, 2, 9 and 10 were split up into coastal (<100m deep) and offshore (>100m) sub-areas with increased relative effort in the offshore parts of these areas. In addition, the above mentioned 10n. miles protection rule around a previous catching site was not applied in the offshore areas if densities were low and previous sampling limited in the area.

Report of the 'Second' Intersessional Workshop on the *Implementation Review* for Western North Pacific Common Minke Whales

Report of the 'Second' Intersessional Workshop on the *Implementation Review* for Western North Pacific Common Minke Whales[1,2]

The Workshop took place at the Southwest Fisheries Science Center, La Jolla, USA, from 19-23 March 2013. The list of participants is given as Annex A.

1. INTRODUCTORY ITEMS

1.1 Welcoming remarks
Butterworth (Convenor) welcomed participants to the Workshop and thanked the hosts, the National Marine Fisheries Service and particularly Weller for making their facilities available and assisting in the meeting organisation. Weller explained the logistical arrangements for the Workshop.

1.2 Election of Chair
Donovan was elected Chair. He reminded the participants that this was primarily a technical workshop whose objectives (IWC, 2005, p.87) were to review the results of work agreed at the 2012 Annual Meeting (IWC, 2013) and consider the results of the final trials using the agreed approach that forms part of the *Implementation* process (IWC, 2012b), and then to develop recommendations for consideration by the full Committee on:

(1) management areas;
(2) RMP variants (e.g. catch-cascading, catch-capping);
(3) suggestions for future research (either within or outside whaling operations) to narrow the range of plausible hypotheses/ eliminate some hypotheses; and
(4) 'less conservative' variants(s) with their associated required research programmes and associated duration.

1.3 Appointment of rapporteurs
Allison, Butterworth and Punt served as rapporteurs with the assistance of the Chair.

1.4 Adoption of Agenda
The adopted Agenda is given as Annex B.

1.5 Review of documents
A list of the documents prepared for the Workshop is given as Annex C.

2. PROGRESS SINCE ANNUAL MEETING IN RELATION TO THE WORK PLAN

2.1 Updated trials specifications
SC/M13/NPM2 was an update of the document specifying the *Implementation Simulation Trials* process as developed at the previous meetings of the Scientific Committee. Since the 2012 meeting, a number of items had required amendment or addition, and these changes required confirmation from the Workshop. The final trial specifications can be found in Annex H.

Section B: Basic dynamics
Given the delay in completing the *ISTs*, the Workshop **agreed** that the first year in which catches would be set by the RMP variants being evaluated would be 2013 rather than 2012, but the actual catches for 2012 will not be used so that there is no need to recondition the trials. The Workshop **agreed** that the scientific permit catches for 2012 would be assumed to equal those for 2011, as this is the assumption on which the conditioning is based.

Section D: Catches
The Workshop noted that the existing specification for splitting of incidental catches in sub-area 7CS and 7CN (see Fig. 1) between the J/JE and O/OW stocks led to inconsistencies in projections, with proportions remaining the same despite changes in the abundances of the two stocks over time. The equations in question were modified so that projections would initially reflect the average proportions of the abundances of the two stocks present for the most recent five years, but these would change over time in line with changes in stock abundance. These modifications are given as Annex D, and have been incorporated into Annex H.

The Workshop **agreed** that the bycatch fishing proportions projected into the future would correspond to the average over the last five years for which incidental catch data were available for each of Japan and Korea when the conditioning was conducted. These two countries each provided updates on these and (in the case of Japan) the special permit catches to Allison. These values can be found in Annex H.

The Workshop **confirmed** that the RMP specification 3.5, which reduces the catch limit in a *Small Area* to the extent required to ensure that the intended catch of females is not exceeded, was only applicable to the commercial catch for the present trials (IWC, 2012b). The Workshop **recommended** that the generic issue of how to deal with imbalanced sex ratios in incidental catches under the RMP be examined by the Committee.

Section E: Generation of data
Amendments to specifications in regard to past and future survey estimates of abundance are detailed under Item 2.2 below.

The extent of observation error associated with future survey estimates of abundance differs among sub-areas. The CV for a future survey in a given sub-area depends on: (1) the average survey CV in the sub-area historically; and (2) the average 1+ population size during past years for which abundance estimates are available in the sub-area relative to the associated pre-exploitation population size. The initial results presented to the Workshop set the parameter which determines future survey CVs (τ; see Equation E.4 of Annex H and associated text) based on the CVs for the historical (pre-2012) surveys which were used when testing RMP variants. The Workshop **agreed** that the observation error associated with future surveys should not depend on which historical abundance estimates are used when testing these variants. Rather the size of this observation error should depend on sub-area and population size only. The Workshop discussed whether the observation error associated with

[1]Given the complexities of this particular *Implementation Review*, it has not been possible to keep to the normal two-year period. This is termed the 'second' Workshop as it is intended to achieve the objectives of the second Workshop specified under the Requirements and Guidelines (IWC, 2012b) even though it is in fact the third Workshop.
[2]Presented to the meeting as SC/65a/Rep04.

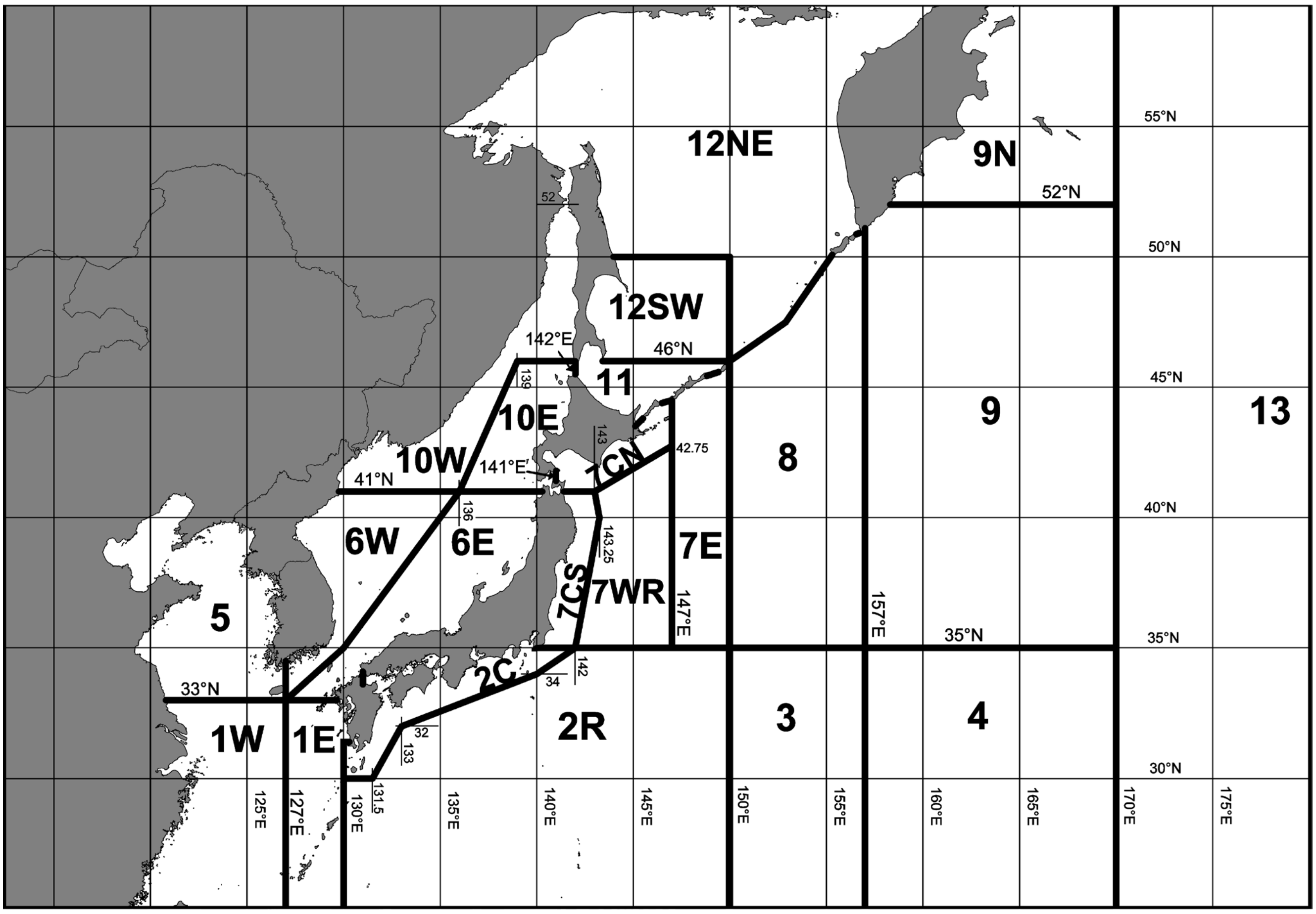

Fig. 1. The 22 sub-areas used for the *Implementation Simulation Trials* for North Pacific minke whales. Note that sub-area 7W is the combination of sub-areas 7CS, 7CN, and 7WR.

future surveys in a sub-area should be based on the average CV for all of the surveys in that sub-area, or on the CVs for only those surveys which were conducted during the period of the year when future surveys are planned to occur. Using all surveys will reduce the influence of outlying CVs, but will be inappropriate if CVs differ systematically among months. After reviewing the values of t with for both options, the Workshop **agreed** to use all of the past surveys in each sub-area for such computations (see Annex E).

Section F: Parameter values and conditioning
The biological parameter values used in the trials are based on North Atlantic common minke whales (as was the case during the initial *Implementation*). Japanese scientists advised that this was an appropriate approach given the well-known practical difficulties in using earplugs for age determination of North Pacific common minke whales. However, they also noted that technical advances meant that it may be possible to obtain age estimates in the future.

Section G: Trials
Trials ABC26-1 require a reduction in the number of age 1-4 O/OE whales predicted to occur in sub-areas 9 and 9N in spring and summer, as these seem rather large. However the Workshop noted that the number of whales aged 1-4 in these two sub-areas for the baseline C01-1 trial was already less than for trial B26-1. Accordingly the Workshop **agreed** to delete trials C26-1 and C26-4 (see SC/M13/NPM2). The Workshop **agreed** to add a new trial (C31) to test an alternative time invariant proportion of JE-stock whales in 7CN in Jan-Jun to be used to remove bycatch (see Table 2b of Annex H).The final list of agreed trials is given as Table 1.

Section H: Management options
Japan and Korea confirmed that the RMP variants listed in this section correctly reflected the options which they had requested to be examined. However, upon examination of the preliminary results, they requested modifications to those variants as discussed under Item 5.

The Workshop **agreed** that the frequency with which simulated future catch limit calculations are performed would change from every five to every six years in line with the Commission’s decision to move to biennial meetings. While the choice of 2013 as the first year for setting a catch limit may appear to be contradictory (the Commission next meets in 2014), the Workshop **agreed** that the purpose of the trials is to evaluate long-term performance, and the choice of 2013 avoids the need to make assumptions for removals in 2013. Actual calculation of catches using the *CLA* will occur only if the Commission requests it.

2.2 Choice of surveys to be used in trials and the months to which these surveys are to be taken to refer

2.2.1 Choice of surveys
The Workshop reviewed SC/M13/NPM1 which summarised the past sighting surveys of western North Pacific minke whales, and the work of the intersessional group established to examine in detail the decisions made at the 2012 Scientific Committee meeting on the status of estimates for use in the projections of the RMP variants under consideration. The Workshop **confirmed** that any updated survey estimates would not be used in the conditioning, which are consistently based on the set of estimates agreed earlier (as listed in Annex H, Table 6).

Table 1

The list of trials. Details of the trials are given in Annex H. Trial 24 is assigned low plausibility and so is crossed through.

Stock hypothesis	Trial no.	MSYR	Description
A	A01-1 and A01-4	1% and 4%	Baseline A: 2 stocks (‘J’ and ‘O’); *g*(0)=0.8; including Chinese bycatch.
B	B01-1 and B01-4	1% and 4%	Baseline B: 3 stocks (‘J’, ‘O’, and ‘Y’); *g*(0)=0.8; including Chinese bycatch.
C	C01-1 and C01-4	1% and 4%	Baseline C: 5 stocks (‘JW’, ‘JE’, ‘OW’, ‘OE’, and ‘Y’); *g*(0)=0.8; including Chinese bycatch.
AC	A02-1 etc.	1%/4%	With a ‘C’ stock.
ABC	A03-1 etc.	1%/4%	Assume *g*(0)=1.
ABC	A04-1 etc.	1%/4%	High direct catches + alternative Korean and Japanese bycatch level.
ABC	A05-1 etc.	1%/4%	Some ‘O’ or ‘OW’ animals in sub-area 10E. The mixing matrices will be modified such that the proportion of O/OW-stock in 10E is ~30% of that in 7CN in all months.
ABC	A06-1 etc.	1%/4%	Mixing proportion in 7CS and 7CN calculated using 2/60 weight for bycatch.
ABC	A07-1 etc.	1%/4%	Mixing proportion in 7CS and 7CN calculated using 10/60 weight for bycatch.
ABC	A08-1 etc.	1%/4%	More Korean catches in sub-area 5 (and fewer in 6W).
ABC	A09-1 etc.	1%/4%	More Korean catches in sub-area 6W (and fewer in 5).
ABC	A10-1 etc.	1%/4%	10% J (/JW) -stock in sub-area 12SW in June (base case value=25%).
ABC	A11-1 etc.	1%/4%	30% J (/JW) -stock in sub-area 12SW in June (base case value=25%).
C	C12-1 and 4	1%/4%	No ‘C’ animals in sub-area 12NE.
C	C13-1 and 4	1%/4%	No ‘OW’ in 11 or 12 SW (OW and OE whales mix with JW in 11 and 12 SW in the baseline C trials).
C	C14-1 and 4	1%/4%	No ‘OE’ in 11 or 12 SW.
C	C15-1 and 4	1%/4%	No ‘OE’ in 7WR. (OE and OW whales mix in 7WR from Apr.-Sep., while OW whales are present year round in the baseline C trials).
C	C16-1 and 4	1%/4%	Dispersal rate of 0.005 between the OW and OE and the JW and JE stocks.
C	C17-1 and 4	1%/4%	Dispersal rate of 0.02 between the OW and OE and the JW and JE stocks.
ABC	A18-1 etc.	1%/4%	Chinese incidental catch=0 (the base case value=twice that of Korea in sub-area 5).
ABC	A19-1 etc.	1%/4%	Alternative abundance estimates in 6E (see table 6a of Annex H).
ABC	A20-1 etc.	1%/4%	Additional abundance estimate in 10E in 2007 (see table 6a of Annex H).
ABC	A21-1 etc.	1%/4%	Abundance estimate in 5=‘minimum’ value listed in Table 6b of Annex H, with a CV=0.1.
ABC	A22-1 etc.	1%/4%	Abundance estimate in 5=‘maximum’ value listed in Table 6b of Annex H (=5* baseline value), with a CV=0.1.
C	C23-1 and 4	1%/4%	Single ‘J’ stock (with pure ‘J’ stock definition using 6E (all months)).
~~C~~	~~C24-1 and 4~~	~~1%/4%~~	~~Single O-stock (with pure O-stock definition using 7WR, 7E and 8 (all months)).~~
ABC	A25-1 etc.	1%/4%	The number of bycaught animals is proportional to the square-root of abundance rather than to abundance (in order to examine the impact of possible saturation effects).
AB	A26-1 etc.	1%/4%	A substantially larger fraction of whales ages 1-4 from ‘O’ stock are found in sub-areas 2R, 3 and 4 year-round (so the proportion of 1-4 whales in sub-area 9 is closer to expectations given the length-frequencies of catches from sub-area 9). The mixing matrices are adjusted such that the numbers of age 1-4 of ‘O’ stock animals in sub-area 9 and 9N are no more than half the base case numbers; juveniles will be allowed into subareas 2R, 3 and 4 in the corresponding months.
ABC	A27-1 etc.	1%/4%	Set the proportion of O/OE animals of ages 1-4 in sub-area 9 and 9N to zero and allow the abundance in sub-areas 7CS and 7CN to exceed the abundance estimates for these sub-areas. Projections for this sub-area will need to account for the implied survey bias.
ABC	A28-1 etc.	1%/4%	The number of 1+ whales in 2009 in sub-area 2C in any month < 200 (if large numbers of whales were found in 2C, the historical catch would be expected to be much greater).
ABC	A29-1 etc.	1%/4%	Abundance estimate in 6W=‘minimum’ value listed in Table 6b of Annex H, with a CV=0.1.
ABC	A30-1 etc.	1%/4%	Abundance estimate in 6W=‘maximum’ value listed in Table 6b of Annex H (=5* baseline value), with a CV=0.1.
C	C31-1 etc.	1%/4%	Alternative time invariant proportion of JE-stock whales in 7CN in Jan.-Jun. used to remove bycatch.

The Workshop first considered cases where the 2012 Scientific Committee meeting had indicated acceptability for use in the trials, but only after some further work or checks had been requested. The Workshop **confirmed** the following estimates to be acceptable for use in projections:

(1) sub-area 10E in 2002 - coverage of the planned trackline was sufficient to retain the estimate;
(2) sub-area 7CS in 2004 - the estimate pertained to the northern part of the survey only (sightings from outside this area had been used in estimating mean school size and effective search half-width to increase estimation precision);
(3) sub-area 7WR in 2003 - the estimate pertained to a northern part of the sub-area only, for which adequate survey coverage had been obtained;
(4) sub-area 11 in 2007 - only survey transect lines were used in calculating the estimate; and
(5) sub-area 12NE in 1999 - areas used in the abundance computations corresponded to only those parts of the various strata which had been covered effectively by the survey transects achieved.

In one case, sub-area 7W in 1991 (actually an estimate developed from the combination of results of surveys in 1990, 1991 and 1992), the work conducted, which involved splitting of the estimate proportional to sub-area size amongst 7CN, 7CS and 7WR, was not considered acceptable. This was because the sighting rates in the three sub-areas had been very different. These data were re-analysed in a manner that took account of this difference (see Annex F), and the resultant alternative for splitting the overall abundance estimate between the three sub-areas was **agreed** for use in projections for the *ISTs*. This process led to a zero estimate of abundance for 7CS.

In discussing how to incorporate this zero estimate, the Workshop referred to Annotation (29) of the RMP specification document (IWC, 2012b) which details how a Poisson likelihood component is developed in such situations. This is described in Annex F, with a final output of a negative log – likelihood component of $P/98.6$ where P is the true abundance present. This could not, however, be used directly when applying the *RMP* in the *IST*s as the program implementing the RMP does not make allowance for such terms. Accordingly the Workshop **agreed** to replace this form with a negative log-likelihood based on the assumption of a log-normally distributed pseudo estimate, which as with the Poisson form would yield a value of 1 when *P*=98.6. Since this is not sufficient to define this likelihood term unambiguously, the Workshop decided to fix the mean at 42 (Adams, 1995) which resulted in a standard deviation of 0.603. This approach was applied to other cases of zero abundance estimates as shown in Annex F, which also details how zero estimates should be dealt with in the projections.

Other sub-areas with zero abundances, either in the past or in future projections were accorded negative log-likelihoods with the same standard deviation, but a different mean depending on the what the population estimates would have been for recent surveys in those areas had there been only one minke whale sighting made. Specifically, with averages taken over such population estimates calculated separately for each of the surveys listed and then scaled by 42/98.6, the results were:

(1) 6E - 27.8 (based on the average of the 2002, 2003 and 2004 surveys);
(2) 10E - 29.3 (based on the average of the 2002, 2003 and 2005 surveys);
(3) 10W - 29.3 (based on the 2006 survey);
(4) 7CN - 44.8 (based on the average of the 1991 and 1992 surveys);
(5) 7WR - 86.3 (based on the average of the 1991 and 1992 surveys);
(6) 7E - 52.6 (based on the 2006 survey);
(7) 8 - 63.6 (based on the average of the 2006 and 2007 surveys); and
(8) 11 - 23.0 (based on the average of the 2003 and 2007 surveys).

The Workshop then reviewed those estimates for which there had been 'No agreement' during the 2012 Scientific Committee meeting regarding their acceptability for use in projections for the *ISTs*. The Workshop **agreed** that the following estimates were acceptable for use in the trials:

(1) sub-area 6E in 2002 - only the northern part where there was adequate survey coverage had been used for the estimate;
(2) sub-area 11 in 2003 - the estimate referred only to that part of the sub-area which had been surveyed, and sightings and effort on transit legs had not been included in computations;
(3) sub-area 12SW in 2003 - the estimate referred only to that part of the sub-area over which adequate survey coverage had been obtained; and
(4) sub-area 12NE in 2003 - the estimate included only blocks where survey coverage had been adequate, and for the northernmost block that only the area covered by the transects completed had been included in the computation.

In addition, the Workshop **agreed** that the estimates for sub-area 10E in 2004 and sub-area 7CN in 2003 should not to be used for projections under RMP variants because of poor coverage resulting from bad weather, although the formal status of the abundance estimates for these sub-areas could be reviewed in the future if further analyses were presented.

The Workshop received a working paper which after modification to account better for appropriate survey boundaries was upgraded to a full paper (SC/M13/NPM3). This provided minke whale abundance estimates from the most recent (2012) survey in the western North Pacific, following the Scientific Committee's Requirements and Guidelines for Surveys (IWC, 2012a). The Workshop **endorsed** the updated estimates in this paper for use in the *ISTs* in forward projections (but not conditioning as that was effectively already completed), and consequently these estimates are included in Table 3 in Annex H.

The Workshop noted particular difficulties arising in the past in such reviews because of confusion over which parts of areas had been included in the survey abundance computations, inclusion (or not) of transit legs and associated sightings in plots, and survey block boundaries not corresponding to sub-area boundaries (in part because some sub-areas had been defined by the Committee only after surveys had been carried out). Accordingly, in the interests of keeping a clear record, the Workshop **recommended** that Miyashita and An develop a document containing a set of plots covering all the western North Pacific minke whale surveys to present at the 2013 Scientific Committee meeting. These plots are to show survey transects with primary minke whale sighting positions (but excluding transit legs), together with survey block boundaries, sub-area boundaries, and those parts of the area surveyed which has been included when calculating the abundance estimate. Furthermore this document should contain a table summarising: the number of primary sightings made; the distance searched on primary effort; the size of the open-ocean area included in the survey design; the mean school size and the effective search half-width inputs, together with population estimates output on a block-by-block basis for these surveys. The Workshop further **recommended** that the Scientific Committee consider making this a standard requirement for all *Implementations/ Implementation Reviews*.

Annex G updates the summary of the status of abundance estimates in the context of the RMP developed at the 2012 Annual Meeting. It specifies "Yes*" next to any survey estimates of abundance considered acceptable for use in projections when testing RMP variants, but which merit further analysis before they might be used for input in using the *CLA* to calculate catch limits. The Workshop **agreed** that this annotation should be extended further to include the following surveys:

(1) sub-area 7CS in 2004;
(2) sub-areas 10E in 2004 and 7CN in 2003 (see above);
(3) sub-area 7W in 1991;
(4) sub-area 11 in 2003; and
(5) all surveys in sub-areas 12SW and 12NE.

One reason for this is that with different area coverage for successive surveys in the same region, it is possible that GLM methods could be used to 'fill in the holes' for certain surveys to provide time-series of abundance estimates with associated variance-covariance matrices for comparable portions (full extents where possible) of the sub-areas concerned.

2.2.2 Future surveys

Both Japan and Korea advised some changes to the plans specified in SC/M13/NPM1. These updates are reflected in Table 2.

The Workshop **agreed** that the trials would assume that proportional coverage of sub-areas by future surveys remained fixed and at its most recent level. Over the period of the past surveys, there have been instances where this proportional cover had decreased, but none where it has increased (see Table 2). Such decreases are not seen as a problem for the *ISTs* from a conservation perspective, as the effect will be that the trials (and future surveys) reflect an

Table 2

Summary of past and future surveys. 1=Agreed survey (% coverage). Estimates will be generated for surveys from 2011 in subareas 5 and 6W and from 2013 on in other subareas. They are assumed to continue in the future in the same pattern.

(a) Surveys to the west of Japan. All surveys are in April-May except past surveys in 6E, 10W and 10E which were in May-June.

	5	6W	6E	10W	10E
2000	-	1 (14.3%)	-	-	-
2001	1 (13%)	-	-	-	-
2002	-	1 (14.3%)	1 (79.1%)	-	1 (100%)
2003	-	1 (14.3%)	1(79.1%)	-	1 (100%)
2004	1 (13%)	-	1(79.1%)	-	-
2005	-	1 (14.3%)	-	-	1 (64.6%)
2006	-	1 (14.3%)	-	1 (59.9%)	-
2007	-	1 (14.3%)	-	-	-
2008	1 (13%)	-	-	-	-
2009	-	1 (14.3%)	-	-	-
2010	-	1 (14.3%)	-	-	-
2011	1	-	-	-	-
2012	-	1	-	-	-
2013	1	-	-	-	-
2014	1	-	-	-	-
2015	-	1	1(79.1%)	1(59.9%)	1(100%)
2016	-	1	-	-	-
2017	1	-	-	-	-
2018	1	-	-	-	-
2019	-	1	1(79.1%)	1(59.9%)	1(100%)
2020	-	1	-	-	-
2021	1	-	-	-	-
2022	1	-	-	-	-
2023	-	1	1(79.1%)	1(59.9%)	1(100%)

(b) Surveys to the north and east of Japan. Surveys are carried out in August-September unless otherwise noted.

	7CS	7CN	7WR	7E	8	9	11	12SW	12NE
1990	-	-	-	-	1 (61.8%)	1 (35.0%)	1 (100%)	1 (100%)	1 (100%)
1991	1*	1	1	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	1 (89.4%)
1999	-	-	-	-	-	-	1 (100%)	-	1 (63.8%)
2000	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-	-	-
2002	-	-	-	-	1 (Jun.-Jul. 65.0%)*	-	-	-	-
2003	-	-	1 (May-Jun. 26.7%)	-	-	1 (Jul.-Sep. 33.2%)	1 (33.9%)	1 (100%)	1 (46.0%)
2004	1 (May 36.7%)	-	1 (May-Jun. 88.8%)	1 (May-Jun. 57.1%)	1 (Jun. 40.5%)	-	-	-	-
2005	-	-	-	-	1 (May-Jul. 65.0%)	-	-	-	-
2006	1 (Jun.-Jul. 100%)	-	-	1 (May-Jun. 57.1%)	1 (May-Jul. 65.0%)	-	-	-	-
2007	-	-	1 (Jun.-Jul. 88.8%)	1 (Jun.-Jul. 65.0%)*	1 (Jun.-Jul. 65.0%)	-	1 (20.2%)	-	-
2008	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	-
2010	-	-	-	-	-	-	-	-	-
2011	-	-	-	-	-	-	-	-	-
2012	1 (May-Jun.)	1 (May-Jun.) 1 (Aug.-Sep.)	-	-	-	-	-	-	-
2013	-	-	1 (88.8%)	1 (57.1%)	1 (100%)	1 (100%)	-	-	-
2014	-	-	-	-	-	-	1 (30.1%)	1 (48.9%)	1 (46.4%)
2015	-	-	-	-	-	-	-	-	-
2016	1 (100%)	1 (75.4%)	0	0	0	0	-	-	-
2017	-	-	1 (88.8%)	1 (57.1%)	1 (100%)	1 (100%)	-	-	-
2018	-	-	-	-	-	-	1 (30.1%)	1 (48.9%)	1 (46.4%)
2019	-	-	-	-	-	-	-	-	-
2020	1 (100%)	1 (75.4%)	-	-	-	-	-	-	-
2021	-	-	1 (88.8%)	1 (57.1%)	1 (100%)	1 (100%)	-	-	-
2022	-	-	-	-	-	-	1 (30.1%)	1 (48.9%)	1 (46.4%)
2023	-	-	-	-	-	-	-	-	-

Notes: Future coverage in 7CN, 7WR and 7E is expected to be similar to above (because of territorial issues). Coverage in 8 and 9 assumes that future surveys include the Russian EEZ. Future coverage in subareas 11 and 12SW (of 30.1%, and 48.9% respectively) excludes areas in the Russian EEZ which cannot be surveyed until the resolution of territorial issues with Japan. Future coverage in sub-area 12NE (of 46.4) reflects the area which cannot be surveyed in the North and East because of Russian restrictions. *Abundance estimate=0.

overall abundance that is too low, and the *CLA* interprets the apparent past decline in abundance as low productivity. It is naturally conceivable (and considered likely in some cases) that proportional coverage might increase in some future surveys. The Workshop **agreed** that such circumstances would trigger an *Implementation Review*, as it would not be acceptable to input such estimates automatically into the RMP because they would give the *CLA* a false impression of resource productivity that was too large.

Further, given that the matter of changing proportions of survey coverage over time is one with potential relevance also to other populations to which the RMP might be applied in addition to western North Pacific minke whales, the Workshop **recommended** that the Scientific Committee should give further attention to this matter.

2.2.3 Acceptability of past surveys in relation to the months in which they took place

Future survey plans submitted by both Japan and Korea propose that future surveys in any one sub-area will be carried out in the same months. However, past surveys have not always kept to this pattern (see Table 2 and Annex G). The survey timing is taken into account explicitly in the conditioning process, as the underlying population model allows for changing proportions of the different stocks in each sub-area during the course of a year. However, the *CLA* does not include any mechanism to adjust for this, and in principle 'expects' that the series of abundance estimates input for a particular sub-area is comparable over time.

The Workshop considered carefully whether the projections under the RMP variants for the various trials should include or exclude past surveys that had taken place in different months of the year compared to what is planned for the future. The Workshop **decided** to include these surveys in simulated applications of the candidate RMP variants. The rationale was that their inclusion will most probably lead to larger catches, and therefore provide a more stringent test of the conservation performance on the RMP variants considered; if a variant is acceptable with these surveys included, it would be acceptable had they been excluded, and the purpose of the trials is purely to determine whether or not different variants are acceptable. The Workshop **emphasised** that this decision did not imply that such survey results would be acceptable for input in an actual application of the RMP, and **recommended** that the generic aspects of this matter be discussed by the Scientific Committee.

In some instances where RMP variants involving *Combination Areas* are being tested, in the past not every sub-area within that *Combination Area* has been surveyed in a given block of years. The approach adopted in such circumstances is that if the sub-areas without surveys would have made only a relatively small contribution to the estimate for the *Combination Area*, then those sub-areas are treated having contributing zero abundance to the combined estimate which is accepted for input to the computations for the RMP variant concerned. However, if those sub-areas would have made the major contribution to the combined estimate, then computations assume that no abundance estimate is available for that *Combination Area* for the block of years in question (see Table 4 in Annex H).

2.3 Plans for trials not yet conditioned

Conditioning for trials 8 and 9 which had not been run before the Workshop and for the new trial C31 will be prioritised and the results will be available by the end of April via Dropbox.

3. REVIEW NEW CONDITIONING RESULTS

The Workshop noted that most of the conditioning had been completed and accepted by the Scientific Committee at the 2012 Annual Meeting. Conditioning runs take a considerable time to run and the Workshop **agreed** that the full set of conditioning results for all trials would be made available to the Steering Group as soon as each becomes available; all results will be available by the end of April via Dropbox. Allison and de Moor will review the results and draw the attention of the Steering Group to any issues, should they arise, in a timely fashion.

4. GUIDELINES ON THE REVIEW OF *IST*S

4.1 Overview and procedure to follow at the Workshop

The Workshop **agreed** that the RMP phase-out rule (Item 3.4, IWC, 2012c) would not be implemented for running the *ISTs* for western North Pacific minke whales. The reason is that this rule reduces catches, and consequently may give an inappropriately positive impression of the conservation performance of certain RMP variants. Of course, the phase-out rule will be invoked should the Commission decide to ask the Committee to develop actual catch limits in the future.

The Workshop reviewed past *Implementations*, notable the most recent undertaken (for North Atlantic fin whales) as well as the Requirements and Guidelines for *Implementations* (IWC, 2009; 2012b). It **agreed** that the following approach was appropriate for reviewing the trial results.

The procedure for defining 'acceptable' and 'borderline' performance agreed by the Committee involves conducting the following steps for each stock in an *IST* for which $MSYR_{(mat)}$=1%.

(1) Construct a single stock trial, which is 'equivalent' to the *IST*. For example, if a particular *IST* involved carrying capacity halving over the 100-year projection period, the 'equivalent single stock trial' will also involve carrying capacity halving over the next 100 years.

(2) Conduct two sets of 100 simulations based on this single stock trial in which future catch limits are set by the *CLA*. The two sets of simulations correspond to the 0.60 and 0.72 tunings of the *CLA*. Rather than basing these calculations on a single initial depletion, the simulations for each stock shall be conducted for the distribution of initial depletions for the stock concerned in the *IST* under consideration.

(3) The cumulative distributions for the final depletion and for the minimum depletion ratio (the minimum over each of the 100-year projections of a trial of the ratio of the population size to that when there are no future catches) shall be constructed for each of these two tunings of the *CLA*.

(4) The lower 5%-ile of these distributions shall form the basis for determining whether the performance of the RMP (i.e. the RMP variant under consideration) for the *IST* is 'acceptable - A', 'borderline - B' or 'unacceptable - U', as follows:
   (a) if the 5%-ile of the final depletion or the 5%-ile of the minimum depletion ratio for the *IST* (where the scalar used to compute the depletion ratio is based on projections where there are only incidental catches) is greater than for the equivalent single stock trial with 0.72 tuning of the *CLA* (or the 5%-ile of the minimum depletion ratio for the *IST* is greater than 0.999), the performance of the RMP shall be classified as 'acceptable';

(b) if performance is not 'acceptable', and either the 5%-ile of the final depletion or the 5%-ile of the minimum depletion ratio for the *IST* is greater than for the equivalent single stock trial with 0.60 tuning of the *CLA*, the performance of the RMP shall be classified as 'borderline'; and
(c) if performance is neither 'acceptable' nor 'borderline' then the 5%-ile of the final depletion and the 5%-ile of the minimum depletion ratio for the *IST* are less than those for the equivalent single stock trial with 0.60 tuning of the *CLA*, and the performance of the RMP shall be classified as 'unacceptable'.

If the performance for a small number of medium weight trials is 'borderline' but closer to 'acceptable' then performance of the variant can be considered 'acceptable' without research. A flow chart summarising the decision process to follow is given as Fig. 2.

4.4 Presentation style for results

The Workshop **agreed** to use the same tabular and graphical summaries as used in the equivalent Workshop for the North Atlantic fin whale *Implementation* (IWC, 2009). The purposes of the various plots and tables range from providing a quick graphical summary of conservation performance to listing the full set of performance statistics for each trial and RMP variant. The master set of plots and tables will be archived by the Secretariat, and be made available to members of the Committee on request.

(1) A plot for each of the $MSYR_{(mat)}$=1% trials showing the performance of each RMP variant and scenarios with: (i) only the incidental catch; and (ii) with no catches of any kind using the procedure for defining 'acceptable', 'borderline' and 'unacceptable' performance. This plot will have panels for the various stocks and the two performance statistics on which the thresholds are based (the lower 5^{th} percentile of the final depletion distribution and the lower 5^{th} percentile of the minimum depletion ratio distribution). The values for the performance statistics for each variant (and the no-catch scenario) are represented as dots, and horizontal lines indicate the thresholds (upper line: 'acceptable'; lower line: 'borderline'). The shaded area in this plot indicates 'unacceptable' performance.
(2) An example plot or plots showing the performance for one of the trials. This plot will consist of the following types of outputs:
    (a) the median population size trajectories by stock for all of the RMP variants and that for the scenario with only the incidental catch;
    (b) the 5%-ile, median and 95%-ile of the population size trajectories by stock under the specific RMP variant (1980 until the end of the projection period);
    (c) the 5%-ile of the population size trajectories by stock (1980 to the end of the projection period) for all of the RMP variants;
    (d) the median population size trajectories by stock (1980 to the end of the projection period) for all of the RMP variants;

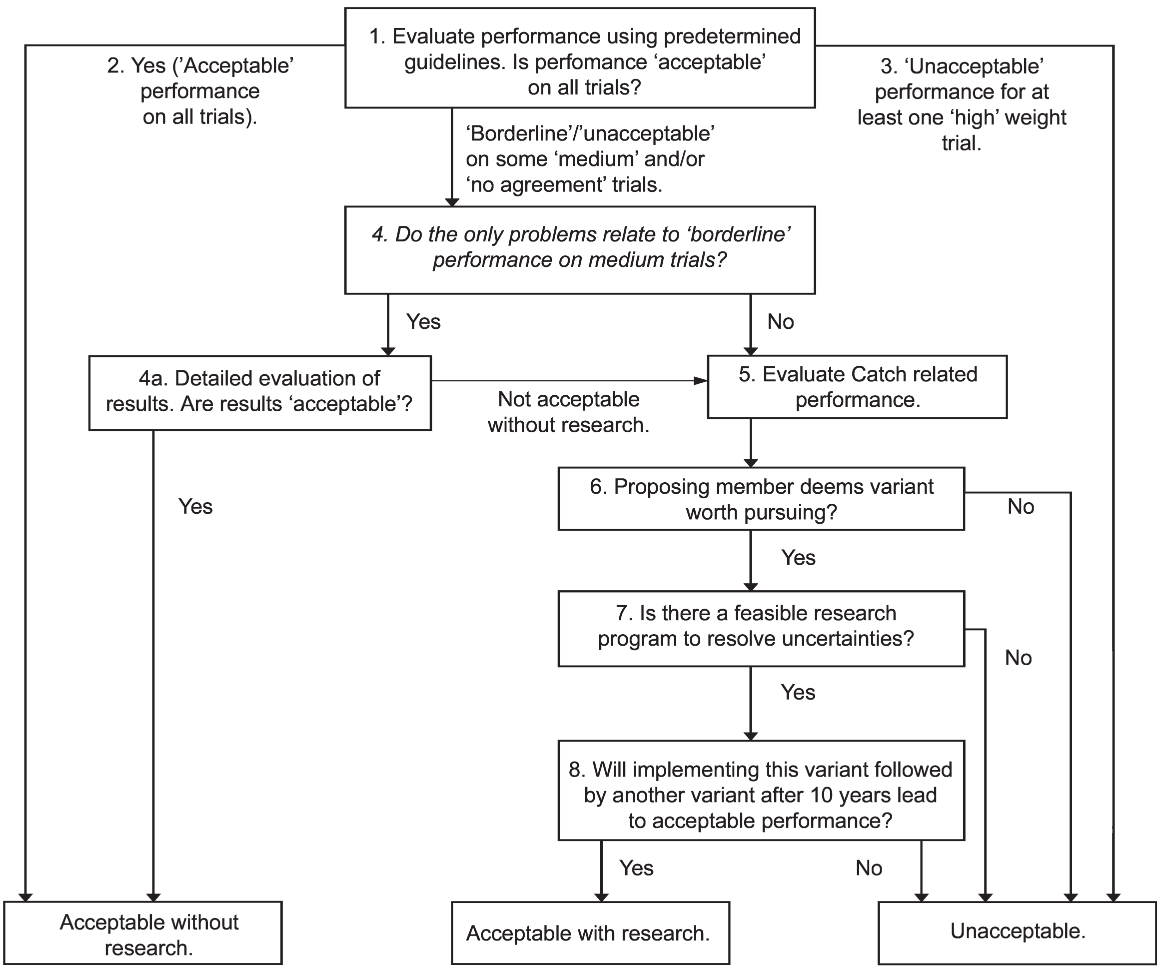

Fig. 2. Schematic of the review process (and see text).

   (e) the 5%-ile of the population size trajectories by stock (1980 to the end of the projection period) for all of the RMP variants;
   (f) the median catch trajectories for the RMP variants (since 1935 and since 1980); and
   (g) ten individual population size trajectories for each stock under the specific RMP variant.

(3) A table for each of the trials for which $MSYR_{(mat)}$=1% showing for each RMP variant: the median catch over the entire projection period; the 5%, median and 95%-iles of the annual catch over the first 10 years; and a summary of the application of the procedure for defining 'acceptable - A', 'borderline - B' and 'unacceptable - U' performance. The table shows results for each performance statistic and stock separately, results by stock (i.e. after aggregating the outcomes for two performance statistics), and results in total (i.e. after aggregating outcomes from each performance statistic and stock).

(4) A table showing the detailed results for each trial and RMP variant (and the two no commercial 'catch' scenarios). The following information is included in this table:
   (a) median catch over the entire projection period and over the first 10 years;
   (b) lower 5%-ile and median of the final depletion distribution (by stock);
   (c) lower 5%-ile and median of the minimum depletion distribution (by stock);
   (d) lower 5%-ile and median of the minimum depletion ratio distribution (which is scaled by the no commercial catch trajectory) (by stock); and
   (e) lower 5%-ile and median of the initial depletion distribution (by stock).

This table will also include the values for the thresholds for each performance statistic and stock for the trials for which $MSYR_{(mat)}$=1% and the outcomes of the application of the procedure for defining 'acceptable', 'borderline' and 'unacceptable' performance using the symbols described for (3).

(5) A table showing all of the performance statistics for each trial and RMP variant (and the scenario with only the incidental catch).

5. REVIEW TRIAL RESULTS

The Workshop had available to it the preliminary results for a number of trials; however, given the additional work required to develop final specifications that occurred at the Workshop itself, it was clearly not possible to obtain final trials results for any of the trials. Allison and de Moor focused on ensuring that the new factors were carefully programmed and checked by the end of the Workshop. As shown under Item 7, a process to ensure that the final trial results are available well before the 2013 Annual Meeting was developed.

However, even recognising the limitations of the preliminary trial results, certain features of those allowed the Workshop to refine (and reduce) the total number of management variants to be considered. The final list of variants is summarised below (and included in Annex H).

(1) *Small Areas* equal sub-areas. For this option, the *Small Areas* for which catch limits would be set are 5, 6W, 7CS, 7CN, 7WR, 7E, 8, 9*, and 11.
(2) 5, 6W, 7+8, 9*, and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CN, 9, and 11.
(3) 5, 6W, 7+8, 9*, and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 9, and 11.
(4) 5, 6W, 7CS, 7CN, 7WR+7E+8, 9* and 11 are *Small Areas* and catches are taken from sub-areas 5, 6W, 7CS, 7CN, 7WR, 9 and 11.
(5) 5 and 6W are *Small Areas* and catches are taken from sub-areas 5 and 6W. 7+8+9*+11+12 is a combination area and catches are cascaded to the sub-areas within the combination area. The catch limits for sub-areas 12SW and 12NE are not taken.
(6) 5, 6W, 7+8, 9*, and 11 are *Small Areas* except that the catches from the 7+8 *Small Area* are taken from sub-areas 7CS and 7CN using the same method as for catch cascading to allocate the catch across the two sub-areas.
(7) 5+6W+6E+10W+10E, 7+8+9*+11 are *Small Areas*; catches from the 5+6W+6E+10W+10E *Small Area* are taken from subareas 5 and 6W using the same method as for catch cascading to allocate the catch across those five sub-areas, and catches from the Small Area 7+8+9+11 are taken in the sub-area 7CN.
(8) 5, 6W, 7+8+9*+11+12 are *Small Areas* and catches from sub-areas 5, 6W and 7+8+9*+11+12 *Small Area* are taken from sub-areas 8 and 9 using the same method as for catch cascading to allocate the catch across the two sub-areas.
(9) 5, 6W, 7+8+9*+11+12 are *Small Areas* and catches from sub-areas 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8 and 9 using the same method as for catch cascading to allocate the catch across these sub-areas.
(10) 5, 6W, 7+8+9*+11+12 are *Small Areas* and catches from sub-areas 7+8+9*+11+12 *Small Area* are taken from sub-areas 7CS, 7CN, 7WR, 7E, 8, 9 and 11 using the same method as for catch cascading to allocate the catch across these sub-areas. Catches from sub-area 11 occur in May and June only.

6. RECOMMENDATIONS FOR THE SCIENTIFIC COMMITTEE

The Chair noted that until the final trial results were available it would not be possible for recommendations to be developed for consideration by the Scientific Committee. The recommendations would normally cover the following:

(1) *Management Areas*;
(2) RMP variant(s) and operational constraints;
(3) inputs for *CLA* (estimates of abundance and future removals);
(4) future research to narrow the range of plausible hypotheses; and
(5) dentification of less conservative RMP variants which may be acceptable with research, together with the nature and duration of that research.

The Workshop **agreed** a mechanism to ensure that most of these recommendations could be developed prior to the 2013 Annual Meeting. The exceptions are for (3) and (4) above which it refers to the Committee itself.

7. WORK PLAN UNTIL SCIENTIFIC COMMITTEE MEETING

The Workshop **agreed** to the work plan given in Table 3.

8. ADOPTION OF REPORT

The report was adopted at 14.15 on 23 March 2013 subject to final email confirmation. The Chair thanked all of the participants for the co-operative approach to the meeting.

Table 3

Work plan. NB: these dates have had to be modified due to unforeseen problems in sorting out the 'zero estimates' issue (see Annex F).

Task	Date	Responsible persons
Finalise the present report and circulate to participants for final comments or additional pieces.	**5 April 2013**	Donovan, Butterworth
Send final comments/additional pieces to Donovan.	**12 April 2013**	All members
Complete final report and place on IWC website.	**30 April 2013**	Donovan
(1) Run all of the baseline trials for the agreed variants, a no incidental catch scenario and a no catch of any kind scenario. (2) Collate the results and present them in the agreed graphical and tabular formats. (3) Place these in the appropriate Dropbox folder.	Place online as become available with all results to be available by: **3 May 2013**	Allison and de Moor
Complete all of the conditioning runs, with an initial focus on those for which results have not yet been seen and place the results in the agreed format in the appropriate Dropbox folder.	Place online as become available with all results to be available by: **10 May 2013**	Allison and de Moor
Produce a summary of the key results, highlighting the key trials and suggesting possible conclusions for: (1) management areas; (2) acceptable variants; and (3) any candidates for possible 'acceptance with research' in the format of an additional report to the Scientific Committee.	Place online within the Dropbox folder by: **10 May 2013**	Allison, Punt, Donovan
Provide comments on the draft conclusions via email to the full group.	**17 May 2013**	All members
Incorporate comments and place final report for the Scientific Committee on the IWC website.	**23 May 2013**	Donovan

He thanked the rapporteurs for their prompt production of the report. He also thanked Allison and de Moor for their extensive work up to and during the Workshop. The complexity of the computing work for this *Implementation Review* cannot be over-emphasised. Although the Workshop was unable to fully meet its objectives, he was confident that the mechanism developed would allow recommendations to be developed in a timely fashion for the 2013 Annual Meeting as scheduled. The Workshop thanked the Chair for his usual efficient and good humoured handling of the meeting.

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Adams, D. 1995. *Hitchhikers Guide to the Galaxy: a Trilogy in Five Parts*. William Heinemann, London. 784pp.

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International Whaling Commission. 2009. Report of the First Intersessional RMP Workshop on North Atlantic Fin Whales, 31 March to 4 April 2008, Greenland Representation, Copenhagen. *J. Cetacean Res. Manage. (Suppl.)* 11:425-52.

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Annex A

List of Participants

Japan
T. Miyashita
T. Sakamoto
H. Shimada

Republic of Korea
Y.-R. An
J.-Y. Park

USA
P. Wade

Invited Participants
D.S. Butterworth
C.L. de Moor
A.E. Punt

Secretariat
C.A. Allison
G.P. Donovan

Annex B

Agenda

1. Introductory items
    - 1.1 Welcoming remarks
    - 1.2 Election of Chair
    - 1.3 Appointment of rapporteurs
    - 1.4 Adoption of Agenda
    - 1.5 Review of documents
2. Progress since Annual Meeting in relation to the work plan
    - 2.1 Updated trials specification document
    - 2.2 Choice of surveys to be used in trials and the months to which they are to be taken to refer
        - 2.2.1 Choice of surveys
        - 2.2.2 Future surveys
        - 2.2.3 Acceptability of past surveys in relation to the months in which they took place
    - 2.3 Plans for trials not yet conditioned
3. Review new conditioning results (to come)
4. Guidelines on the review of *IST*s
5. Review trial results
6. Recommendations for the Scientific Committee
7. Work plan until Scientific Committee meeting
8. Adoption of Report

Annex C

List of Documents

SC/M13/NPM

1. Allison, C. Proposal for combining surveys. 3pp.
2. Allison, C., de Moor, C. L., Punt, A.E. Trial Specifications, 13 March 1013 (sic). 67pp.

3rev. Hakamada, T., Matsuoka, K. and Miyashita, T. Abundance estimate of western North Pacific minke whales using JARPNII dedicated sighting survey data obtained in 2012. 7pp. [Upgraded from working paper during the Workshop].

Annex D

Approach for accounting bycatch in sub-areas 7CS and 7CN

André E. Punt

The future bycatches by sex, month, sub-area and year are generated assuming that the exploitation rate due to bycatch in the future equals that estimated for the most recent five-years for which data are known, i.e.

$$C_{B,t}^{g,k,q} = \overline{\overline{F}}^{k} \tilde{P}_t^{k,q} Q_B^{g,k,q} \tag{D.7}$$

where:

$\tilde{P}_t^{k,q}$ is the availability-weighted population size in sub-area k during month q:

$$\tilde{P}_t^{k,q} = (P_t^{k,q,J/E} + \lambda^{k,q} P_t^{k,q,O/OW}) \frac{\overline{P}^{k,q,J/JE} + \overline{P}^{k,q,O/OW}}{\overline{P}^{k,q,J/JE} + \lambda^{k,q} \overline{P}^{k,q,O/OW}} \tag{D.8}$$

where:

$\overline{P}^{k,q,O/OW}$ is the average population size (including calves) of stock O/OW in sub-area k during month q over the last five years;

$\overline{P}^{k,q,J/JE}$ is the average population size (including calves) of stock J/JE in sub-area k during month q over the last five years;

$P_t^{k,q,O/OW}$ is population size (including calves) of stock O/OW in sub-area k during month q of year t;

$P_t^{k,q,J/JE}$ is population size (including calves) of stock J/JE in sub-area k during month q of year t;

$\lambda^{k,q}$ is a relative availability factor for O/OW whales relative to J/JE whales:

$$\lambda^{k,q} = \frac{(1-\ddot{P}^{k,q})}{\ddot{P}^{k,q}} \frac{\overline{P}^{k,q,J/JE}}{\overline{P}^{k,q,O/OW}} \tag{D.9}$$

$\ddot{P}^{k,q}$ is the weighted mean proportion of stock J/JE in sub-area k during month q (Table 2b of Annex H).

This catch is allocated the J/O (JE/OW) stocks as follows:

$$C_{B,t}^{g,k,q,J/JE} = \frac{P_t^{g,k,q,J/JE}}{\lambda^{k,q} P_t^{g,k,q,O/OW} + P_t^{g,k,q,J/JE}} C_{B,t}^{g,k,q} \tag{D.10a}$$

$$C_{B,t}^{g,k,q,O/OW} = \frac{\lambda^{k,q} P_t^{g,k,q,O/OW}}{\lambda^{k,q} P_t^{g,k,q,O/OW} + P_t^{g,k,q,J/JE}} C_{B,t}^{g,k,q} \tag{D.10b}$$

where:

$P_t^{g,k,q,O/OW}$ is population size (including calves) of animals of gender g from stock O/OW in sub-area k during month q of year t; and

$P_t^{g,k,q,J/JE}$ is average population size (including calves) of animals of gender g from stock J/JE in sub-area k during month q of year t.

Annex E

Comparison of τ Values for Different Sets of Surveys

C.L. de Moor

An alternative set of surveys to be used in the calculation of τ was tested. The surveys to be removed from the current set were those occurring in months other than those chosen for future surveys, with the exception that if the only historical surveys available in a sub-area were from 'wrong' months, then they were still included. This resulted in only 3 surveys in sub-area 8 being removed from the original set of surveys used for conditioning. Comparisons are thus only shown for sub-area 8 as the τ estimates are the same in all other sub-areas.

The estimates of τ are the same for all variants as they are based on historical data. The estimates of τ are the same for alternative combinations of surveys (see Item 2.2.1) as they are based on the historical surveys used in conditioning.

The 5%ile, median and 95%ile of the τ values are given below for the original and alternative sets of data for sub-area 8, for trials B01-1 and C01-1.

	B01-1			C01-1	
	Original	Alternative		Original	Alternative
5%ile	3.95	3.30	5%ile	4.03	3.36
Median	3.99	3.32	Median	4.05	3.38
95%ile	4.02	3.35	95%ile	4.07	3.40

Annex F

Derivation of revised estimate for subarea 7 in 1991 and zero abundance estimates

Doug Butterworth and Tomio Miyashita

An estimate of abundance sub-area 7W[3] in 1991 used in the 2003 trials was actually an estimate developed from the combination of results of surveys in 1990, 1991 and 1992. It is not acceptable to derive estimates for the component subareas (7CN, 7CS and 7WR) by splitting the estimate proportional to sub-area size because the sighting rates in the three sub-areas had been very different. These data were re-analysed in a manner that took account of this difference and the resultant alternative for splitting the overall abundance estimate between the three sub-areas was **agreed** for use in projections for the *ISTs*.

Table 1 shows the abundance prorated by nA/L from total estimate. The two estimates for each subarea were averaged to give the following estimates for use in trials: 7CS 0; 7CN 853 CV=0.23; 7WR 311 CV=0.23.

Inclusion of zero abundance estimates in the trials

Table 1 includes one abundance estimate which is zero. Annotation (29) of the RMP specification document (IWC, 2012) specifies how a Poisson likelihood component is developed in cases when a zero abundance estimate occurs. The annotation says:

> (29) An example where the lognormal assumption cannot be used is when the estimate of absolute abundance is zero. Zero estimates of absolute abundance arise when no sightings of the target species are made on primary effort during a survey of an area. This should not be a frequent occurrence, but such estimates should not be ignored when they do occur.
>
> Although several factors contribute to the variance of an estimate of absolute abundance, the variance is dominated by the variance in the number seen when the number of sightings is very low. The variance of the number of sightings will be at least as high as the variance of a random variable with a Poisson distribution with expectation equal to the expectation of the number of sightings. The number of sightings refers to the number of schools or groups, rather than to individual animals.
>
> The expected number of sightings, $E(n)$, is proportional to the true absolute abundance, P: $E(n) = P/\alpha$
>
> The parameter α represents the estimate of absolute abundance that would have been obtained had there been exactly one sighting. This will be a function of the survey effort, the size of the area, and survey parameters that may need to be estimated by adopting values from similar surveys. Ignoring the variance of α, the likelihood of the zero estimate of absolute abundance is the following function of the true absolute abundance:
>
> $L(P) = \exp(-P/\alpha)$
>
> Since the only covariance between the absolute abundance estimate and other absolute abundance estimates is that due to the α parameter, whose variance is being ignored, the joint likelihood function of the zero estimate of absolute abundance and the remaining estimates is taken to be the product of the respective likelihood functions.
>
> The information about the zero estimate of absolute abundance that needs to be supplied to the *Catch Limit Algorithm* is: (i) the year of the zero estimate; (ii) the fact that it is a zero estimate; and (iii) the value of the α parameter. The computer program implementing the *Catch Limit Algorithm* that has been validated by the IWC Secretariat has the facility to handle zero estimates of absolute abundance in this manner. P is identified with the simulated population size generated by the *Catch Limit Algorithm*'s internal calculations.
>
> Since the treatment above ignores some contributions to the variance of a zero estimate of absolute abundance, it assigns more weight to a zero estimate than is strictly warranted.

[3]Subarea 7W was used in the 2003 trials and is a combination of the current sub-areas 7CS, 7CN and 7WR.

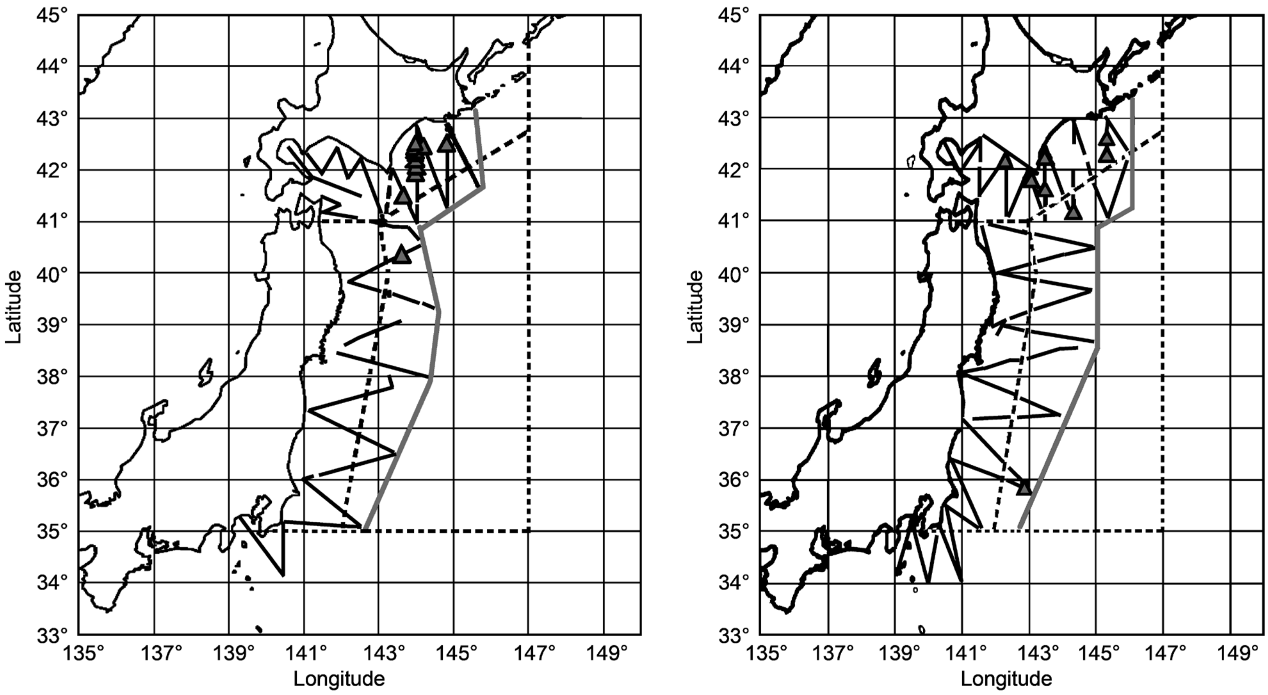

Fig. 1. Track line on effort (black thick line), primary sighting (triangle), sub-area definition (dotted thick line) and area definition for estimate (grey thick line) for *Shunyo Maru* in 1991 (left) and 1992 (right).

Table 1

Abundance prorated by *nA*/*L* from total estimate (1,164 animals, CV=0.183).

	91 *Shunyo Maru*			92 *Shunyo Maru*		
	7CN	7CS	7WR	7CN	7CS	7WR
L: Research distance (n.miles)	775	516	597	703	774	816
n: no. of primary sightings	11	0	1	6	0	2
A: Area (n.miles^2)	15,948	26,828	26,088	16,545	26,826	34,232
*n/L*A*	226.3483	0	43.67138	141.2217	0	83.89933
P	976	0	188	730	0	434
Coverage (%)	87.2	100	4.03	90.5	100	29.2

Table 2

Population estimates to replace zero estimates in the trials.

Sub-area	6E			10E			10W	7CN		7WR		7E	8		11	
Season	2002	2003	2004	2002	2003	2005	2006	1991	1992	1991	1992	2006	2006	2007	2003	2007
L	1,676	1,226	1,037	486	651	466	1,157					461	1,039	914	192	564
n	21	19	7	10	7	9	36	11	6	1	2	2	3	2	10	19
A	71,914	71,914	71,914	27,823	27,823	17,912	63,912					48,208	162,789	162,789	15,243	9,064
P	891	935	727	816	405	599	2,477	976	730	188	434	247	309	391	882	377
Scaled	18.1	21.0	44.2	34.8	24.6	28.4	29.3	37.8	51.8	80.1	92.4	52.6	43.9	83.3	37.6	8.5
Average		**27.8**			**29.3**		**29.3**	**44.8**		**86.3**		**52.6**	**63.6**		**23.0**	

For the zero abundance estimate obtained above for subarea 7CS in 1991, there is a final output of a negative log – likelihood component of *P*/98.6 where *P* is the true abundance present. This could not, however, be used directly in the *IST*s as the program implementing the RMP (which is also used for the *IST*s) does not make allowance for such terms. Accordingly the Workshop agreed to replace this form with a negative log-likelihood based on the assumption of a log-normally distributed pseudo estimate, which as with the Poisson form would yield a value of 1when *P*=98.6. Since this is not sufficient to define this likelihood term unambiguously, the Workshop decided to fix the mean at 42 (Adams, 1995) which resulted in a standard deviation of 0.603. This approach is also to be applied to other cases of zero abundance estimates which may occur in the projections as well.

These other sub-areas with zero abundances, either in the past or in future projections are to be accorded negative log-likelihoods with the same standard deviation, but a different mean depending on the what the population estimates would have been for recent surveys in those areas had there been only one minke whale sighting made. Specifically, with averages taken over such population estimates calculated separately for each of the surveys listed and then scaled by 42/98.6, the results are given in Table 2.

REFERENCES

Adams, D. 1995. *Hitchhikers Guide to the Galaxy: a Trilogy in Five Parts*. William Heinemann, London. 784pp.

International Whaling Commission. 2012. Requirements and Guidelines for *Implementations* under the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 13:495-506.

Annex G

Updated table of abundance estimates

Cherry Allison, Doug Butterworth and Tomio Miyahsita

The Workshop's recommendation on acceptance of the abundance estimates for use in the current *Implementation Simulation Trials* are reflected in the final two columns of the table below in the form of yes/no agreement/no, followed by a brief rationale for any disagreement. NA=No agreement. It was agreed that the two 'no agreement' estimates would not be used in the current trials - see main text (Item 2.2). The notation '*' indicates that further analysis needs to be considered for an estimate to become acceptable for use in a real application.

Sub-area	Year	Season	Aerial coverage (%)	STD estimate[1]	CV[2]	Current conditioning	Used in 2003 trials?	Use in current trials?	Rationale and notes
5	2001	Apr.-May	13.0	1,534	0.523	Minimum	-	Yes*	Low area coverage. Only area completed. Needs further analysis.
	2004	Apr.-May	13.0	799	0.321	Minimum	-	Yes*	Low area coverage. Only area completed. Needs further analysis.
	2008	Apr.-May	13.0	680	0.372	Minimum	-	Yes*	Low area coverage. Only area completed. Needs further analysis.
	2011	Apr.-May					-	Yes*	Only area completed. Needs further analysis.
6W	2000	Apr.-May	14.3	549	0.419	Minimum	-	Yes*	Low area coverage. Use inshore segment only with adjustment for differential extent of inshore coverage (no extrapolation).
	2002	Apr.-May	14.3	391	0.614	Minimum	-	Yes*	As above
	2003	Apr.-May	14.3	485	0.343	Minimum	-	Yes*	As above
	2005	Apr.-May	14.3	336	0.317	Minimum	-	Yes*	As above
	2006	Apr.-May	14.3	459	0.516	Minimum	-	Yes*	As above
	2007	Apr.-May	14.3	574	0.437	Minimum	-	Yes*	As above
	2009	Apr.-May	14.3	884	0.286	Minimum	-	Yes*	As above
	2010	Apr.-May	14.3	1,014	0.397	No	-	Yes*	As above
6E	2002	May-Jun.	79.1	891	0.608	Yes	-	Yes*	Poor coverage and analysis difficulties. Poor availability. Only use northern part. Original estimate was based only on northern part.
	2003	May-Jun.	79.1	935	0.357	Yes	-	Yes	
	2004	May-Jun.	79.1	727	0.372	Yes	-	Yes	(Incomplete coverage). Only N offshore block used.
10W	2006	May-Jun.	59.9	2,476	0.312	Yes	-	Yes	
10E	2002	May-Jun.	100.0	816	0.658	Yes	-	Yes	61% of pre-determined track line was covered on effort and is sufficient to retain the estimate.
	2003	May-Jun.	100.0	405	0.566	Yes	-	Yes	
	2004	May-Jun.	100.0	474	0.537	Yes	-	NA*	Design question: (most sightings in concentration near coast).
	2005	May-Jun.	64.6	599	0.441	Yes	-	Yes	In 2005, survey blocks were surveyed twice. In order to avoid double counting the abundance was estimated using 2nd part and only in offshore block. (Number of primary sightings: 1st part : one over 387n.miles, 2nd part: nine over 842n.miles). The estimate was re-calculated using 2nd part and only in offshore block. Area, *n* and *L* were re-calculated; ESW and *S* were the same as for the whole area.
7CS	1991	Aug.-Sep.	-	0	-	2003 only	Yes	Yes*	See Annex F for details of how the original estimate for subarea 7W was split to subarea (prorated by *nA/L* from the total estimate)
	2004	May	36.7	504	0.291	Yes	-	Yes*	Use northern part only. Res.: *n*, *L* and *A*rea were recalculated for the northern part only; the estimates of ESW and *s* used were from the whole area.
	2006	Jun.-Jul.	100.0	3,690	1.199	Yes	-	Yes*	Analysis for non-random start. Note different survey timings.
	2012	May-Jun.	100.0	890	0.393	No	-	Yes*	See Item 2.2 above, and SC/M13/NPM3.

Cont.

Sub-area	Year	Season	Aerial coverage (%)	STD estimate[1]	CV[2]	Current conditioning	Used in 2003 trials?	Use in current trials?	Rationale and notes
7CN	1991	Aug.-Sep.	-	853	0.23	2003 only	Yes	Yes*	See Annex F for details of how the original estimate for subarea 7W was split to subarea (prorated by *nA/L* from the total estimate).
	2003	May	75.4	184	0.805	Yes	-	NA*	Inadequate and heterogeneous coverage.
	2012	May-Jun.	66.7	302	0.454	No	-	(Yes*)[3]	See Item 2.2 above and SC/M13/NPM3.
		Sep.	66.7	398	0.507	No	-	Yes*	
7WR	1991	Aug.-Sep.	-	311	0.23	2003 only	Yes	Yes*	See Annex F for details of how the original estimate for subarea 7W was split to subarea (prorated by nA/L from the total estimate).
	2003	May-Jun.	26.7	267	0.700	Min	-	Yes*	Low area coverage. Estimate recalculated for northern portion only. With analysis for non-random starts.
	2004	May-Jun.	88.8	863	0.648	Yes	-	Yes	-
	2007	Jun.-Jul.	88.8	546	0.953	Yes	-	Yes*	With analysis for non-random start.
7E	1990	Aug.-Sep.		791	1.848	2003 only	Yes	No	CV too high to be meaningful.
	2004	May-Jun.	57.1	440	0.779	Yes	-	Yes	-
	2006	May-Jun.	57.1	247	0.892	Yes	-	Yes	-
	2007	Jun.-Jul.	57.1	0		Yes[4]	-	Yes*	With analysis: non-random start; no planned coverage in upper left (Russian EEZ).
8	1990	Aug.-Sep.	62.2	1,057	0.706	Yes	Yes	Yes	Agreed in 2003. In other years, no whales observed in area not covered.
	2002	Jun.-Jul.	65.0	0		Yes	-	Yes	Note different survey timings.
	2004	Jun.	40.5	1,093	0.576	Yes	-	Yes	In other years, no whales observed in area not covered.
	2005	May-Jul.	65.0	132	1.047	Yes	-	Yes*	With analysis: non-random start; no planned coverage in upper left (Russian EEZ), two sets of lines in lower blocks.
	2006	May-Jul.	65.0	309	0.677	Yes	-	Yes	-
	2007	Jun.-Jul.	65.0	391	1.013	Yes[4]	-	Yes*	With analysis: non-random start; no planned coverage in upper left (Russian EEZ).
9	1990	Aug.-Sep.	35.1	8,264	0.396	Yes	Yes	Yes	Agreed in 2003.
	2003	Jul.-Sep.	33.2	2,546	0.276	Minimum	-	Yes	Survey not co-incident with density peak in Aug.-Sep.
9N	2005	Aug.-Sep.	67.8	420	0.969	Yes	-	(Yes)	Agreed estimate. Not used as catch limits are not set for 9N.
11	1990	Aug.-Sep.	100.0	2,120	0.449	Yes	Yes	Yes	Agreed in 2003.
	1999	Aug.-Sep.	100.0	1,456	0.565	Yes	Yes	Yes	Agreed in 2003. *Check map to make sure.
	2003	Aug.-Sep.	33.9	882	0.820	Yes	-	Yes*	Potentially biased due to weather induced coverage omission to north. Agreed: not acceptable to include coastal transect in analysis. Confirmed: estimate refers only to surveyed part of subarea and excludes transit legs.
	2007	Aug.-Sep.	20.2	377	0.389	Minimum	-	Yes*	Low area coverage. Estimate was confirmed to have come from transect lines only.
12SW	1990	Aug.-Sep.	100.0	5,244	0.806	Yes	Yes	Yes*	Agreed in 2003.
	2003	Aug.-Sep.	100.0	3,401	0.409	Yes	-	Yes*	Low area coverage. Confirmed: estimate refers only to part of sub-area with had adequate coverage.
12NE	1990	Aug.-Sep.	100.0	10,397	0.364	Yes	Yes	Yes*	Agreed in 2003.
	1992	Aug.-Sep.	89.4	11,544	0.380	2003 only	Yes	Yes*	Agreed in 2003. Year wrong in IWC (2012).
	1999	Aug.-Sep.	63.8	5,088	0.377	Yes	-	Yes*	Omit E block – inadequate coverage. Limit N block to area surveyed. Estimate recalculated using only those parts of the various strata which had been covered effectively.
	2003	Aug.-Sep.	46.0	13,067	0.287	Yes	-	Yes*	Agreed: 2 blocks should be omitted due to inadequate coverage. Question concerning coverage in the other 3 blocks (2 NW and one E). Confirmed: the estimate is based on the 3 blocks with adequate survey coverage and for the Northernmost block includes only the area covered by completed transects.

[1]The Standard (STD) estimate based on 'Top and Upper bridge' will be used as given in the catch limit calculations (when conditioning the estimates are adjusted for *g*(0)). [2]CV does not consider any process errors. [3]This estimate was agreed to be suitable for use in trials but will not be used in the current trials as the September estimate (which has the correct formal time stamp for RMP input) will be used instead. [4]For conditioning, the estimate of 0 from sub-area 7E was combined with the estimate of 391 from sub-area 8. [5]International Whaling Commission. 2012. Report of the first RMP intersessional workshop for western North Pacific common minke whales. *J. Cetacean Res. Manage. (Suppl.)* 13:411-60.

Annex H

North Pacific Minke Whale *Implementation Simulation Trial* Specifications

See Annex D1, Appendix 2, this volume pp. 133-158

Report of the Fourth Intersessional Workshop on the Review of Maximum Sustainable Yield (MSYR) in Baleen Whales

Report of the Fourth Intersessional Workshop on the Review of Maximum Sustainable Yield Rates (MSYR) in Baleen Whales[1]

The Workshop took place at the Southwest Fisheries Science Center, La Jolla, USA, from 26-28 March 2013. The list of participants is given as Annex A.

1. INTRODUCTORY ITEMS

1.1 Welcoming remarks
Butterworth (Convenor) welcomed participants to the Workshop. Since 2007, the Committee has been discussing maximum sustainable yield rate (MSYR) in the context of a general reconsideration of the plausible range to be used in population models used for testing the *Catch Limit Algorithm* (*CLA*) of the RMP (IWC, 2008; 2009a; 2009b; 2010a; 2010b; 2010c; 2011a; 2011b; 2012). The current range is 1% to 7%, in terms of the mature component of the population. At the 2012 Annual Meeting, the Committee had expressed concern that once again the process had not been completed and it carefully examined whether it was worth continuing the process. Given progress made at that meeting and the work plan developed, the Committee had agreed that one more year be allocated for the MSYR Review, but that if it could not be completed at the 2013 meeting, the current range of MSYR rates would be retained (IWC, 2013b; 2013c).

Butterworth thanked the hosts, the National Marine Fisheries Service for making their facilities available, and especially Weller for assisting in the meeting organisation. Weller explained the logistical arrangements for the Workshop.

1.2 Election of Chair
Donovan was elected Chair.

1.3 Appointment of rapporteurs
Butterworth and Punt served as rapporteurs with the assistance of the Chair.

1.4 Adoption of Agenda
The adopted Agenda is given as Annex B.

1.5 Review of documents
A list of the documents prepared for the Workshop is given as Annex C.

2. PROGRESS SINCE ANNUAL MEETING IN RELATION TO THE WORK PLAN

Not as much progress had been made prior to the Workshop as had been anticipated in the work plan agreed at the 2012 Annual Meeting (IWC, 2013b). However, sufficient progress had been made to hold the Workshop.

2.1 Overview of present methods
The approach agreed at the 2012 Annual Meeting (IWC, 2013b) involves developing a posterior distribution for the quantity r_0/r_{max}, i.e. the ratio of the increase rate in the limit of zero population size to the maximum rate of increase of a whale stock which is demographically possible. The value for r_{max} for each stock is computed from values for adult survival rate, calf survival rate, fecundity rate (female calves per mature female) and the age-at-first-parturition. The subsequent analysis is based on the application of a Bayesian hierarchical model in which r_0/r_{max} is assumed to be interchangeable among stocks and beta-distributed. The parameters of the beta distribution are assumed to be U[0,10]. The data agreed at that time for inclusion in the likelihood function were the estimates of rates of increase for 15 stocks, while the variances of the model estimates of the rates of increase combined sampling error and 'process error'. 'Process error' is the variation in the true value for r_0/r_{max} caused by environmental variation. The estimates of the extent of process error depend on the number of years for which data are available to estimate r_0, the true value for r_0/r_{max} (lower for values of r_0/r_{max} close to 1 in terms of the model used for the effects of environmental variability (Cooke, 2007a)), and the extent of environmentally-induced variation (and its autocorrelation) in the rate of increase.

Punt (2012) describes the model used to determine the extent of process error in r_0/r_{max}. The key inputs to this model are r_0/r_{max} and the variation and temporal autocorrelation in the annual rate of increase. The values for these parameters for each stock are derived from a population dynamics model which is parameterised in terms of adult survival rate, calf survival rate, fecundity rate, and the age-at-first-parturition, as well as the variation and temporal autocorrelation in the fecundity.

In discussion, it was noted that assuming U[0,10] hyperpriors on the two hyperparameters (α, β) of the beta distribution for the rate of increase is not non-informative regarding r_0/r_{max}, i.e. the posterior for r_0/r_{max} when there are no data is not flat across the range 0-1. Kitakado determined that a prior on the logarithms of α and β from 0 to 3.3 implied an approximately uniform prior on r_0/r_{max}, and the Workshop consequently **agreed** to replace the U[0,10] hyperpriors on α and β by U[0,3.3] hyperpriors on lnα and lnβ.

2.2 Refinement of population model used to estimate variability parameters
Punt reported that the population dynamics model used to calculate the extent of variation and temporal autocorrelation in the annual rate of increase had been modified to impose the constraint that females which had calves which survived their first year cannot give birth in successive years (common and Antarctic minke whales usually give birth every year but are not included in the meta-analysis). In discussion, it was noted that females of some species (e.g. humpback and fin whales) do occasionally give birth in successive years while the inter-calving intervals for other species (e.g. right whales) can be a mixture of two, three and more years.

2.3 Coding of methods that generate variability in survival rate
Punt reported that an option had been added to the software developed to implement the meta-analysis that allows for

[1]Presented to the meeting as SC/65a/Rep05.

Table 1

Estimates of rates of increase used as r_0 and the associated time periods over which they were estimated based upon the review provided in IWC (2010a) apart from for southern right whales which was based upon IWC (2013a). The main reference is given for each population but a fuller discussion of depletion and reliability can be found in the two reports. L=low; M=medium; H=high.

	Population level	Reliability of data	r_0 (%) (95% CI)	SE	Time period	Year-span	References
Blue whale							
Central N Atlantic	L	H	9.0 (2.0, 17.0)	3.83	1987-2001	15	Pike *et al.* (2007)
S Hemisphere	L	H	8.2 (1.6, 14.8)	3.37	1978/79-2003/04	26	Branch (2007)
EN Pacific	L	H	3.2	1.4	1991-2005	16	Calambokidis *et al.* (2007)
Fin whale							
N Norway	L	H	5 (-13, 26)	9.95	1988-98	11	Vikingsson *et al.* (2007)
EN Pacific	L	H	4.8 (-1.6, 11.1)	3.24	1987-2003	15	Zerbini *et al.* (2006)
Humpback whale							
W Australia	L	H	10.1 (0.9, 19.3)	4.69	1982-94	13	Bannister and Hedley (2001)
E Australia	L	H	10.9 (10.5, 11.4)	0.23	1984-2007	24	Noad *et al.* (2008)
EN Pacific	L	H	6.4	0.9	1992-2003	12	Calambokidis and Barlow (2004)
Hawaii	L	H	10 (3-16)	3.32	1993-2000	18	Mizroch *et al.* (2004)
Bowhead whale							
B-C-B	M	H	3.9 (2.2, 5.5)	0.84	1978-2001	24	Zeh and Punt (2005)
Southern right whale							
SE Atlantic (S Africa)	L	H	6.8 (6.4, 7.2)	0.2	1979-2010	32	Brandão *et al.*(2011)
SW Atlantic (Argentina)	L	H	6.0 (5.5, 6.6)	0.28	1971-2010	40	Cooke *et al.* (2001)
SE Indian (Australia)	L	H	6.6 (3.8, 9.3)	1.40	1993-2010	18	Bannister (2011)

variation in natural mortality rather than fecundity. This involves selecting the central value for natural mortality and the variance parameter for log-normal variation in natural mortality so that the expected rate of increase and its variation match pre-specified values. The Workshop noted that ideally account should be taken of correlation between natural mortality and fecundity; this is discussed further under Item 4.

3. ESTIMATES OF *r* AND ASSOCIATED VARIABILITY (REPRODUCTIVE COMPONENT)

3.1 Update of estimates

The Workshop briefly reviewed the previous work and agreements on appropriate data sources to use, in particular estimates of rates of increase to use as r_0 equivalents in the meta-analysis, and values for calving rates used in the calculation of $\tilde{\sigma}$ and $\tilde{\rho}_f$ (the standard deviation and temporal aurocorrelation in fecundity) using the agreed method (Brandon and Kitakado, 2011; Cooke, 2011b)[2].

With respect to the former, the Workshop **agreed** that in order to satisfy the condition that the observed rates of increase could be used to approximate r_0, it would limit the stocks included in the meta-analysis to those that had been depleted to 'low' levels (less than about 30% of initial, based on discussions in IWC (2010a)), apart from the Bering-Chukchi-Beaufort Seas stock of bowhead whales which was classified as 'medium' although it may have been 'low' at the start of the series. Given concerns about the relationship between feeding aggregations and the remainder of the stock, the Workshop also agreed to exclude western North Pacific gray whales and Gulf of Maine humpback whales from the meta-analysis. The final list of stocks included in the meta-analysis is given in Table 1.

As part of its discussions and decisions, the Workshop took into account SC/M13/MSYR1, which investigated the potential for biases in the estimates of the annual variation in the average birth rates of baleen whale populations based on the report of the 2010 Workshop (IWC, 2010a). In particular, it examined the appropriateness of the geographical and temporal scales of the data collections, as well as indications for other sources of additional variation and categorised the data quality.

Originally, the values for the demographic parameters were based on estimates for individual stocks (IWC, 2011a). However, given the paucity of direct data, especially for some of the stocks for which r_0 values were available, and the fact that the values are not that well-determined such that differences in point estimates amongst different stocks within the same species are probably not meaningful, the Committee agreed its 2012 meeting (IWC, 2013c) to combine some estimates within certain species groups to set all equal to a rounded figure. At the Workshop, this process was taken to its natural conclusion by agreeing single estimates for each species (Table 2). These rounded values were based on the estimates listed in IWC (2012), except that values for different stocks for southern right whales were taken from updated values provided in IWC (2013a).

Table 3 lists the percentiles of the posterior distributions of $\tilde{\sigma}$ and $\tilde{\rho}_f$ based on the meta-analysis of annual calving rates (IWC, 2012) while Table 4 summarised the input values for the reference case.

Table 2

Values of demographic parameters used to calculate r_{max} on a per-species basis. S is the annual adult survival rate, assumed to apply from age 1 and above; S_J is the survival rate for the first year of life which is assumed to equal S^2, a_{fp} is the age at first parturition, f is the highest fecundity considered possible, and r_{max} is the corresponding exponential growth rate in steady unexploited conditions.

	S	S_J	a_{fp}	f	r_{max}
Blue whale	0.98	0.96	5	0.5	0.114
Fin whale	0.98	0.96	5	0.5	0.114
Humpback whale	0.97	0.941	5	0.5	0.103
Bowhead whale	0.99	0.98	22	0.33	0.043
Southern right whale	0.99	0.98	8	0.33	0.076

[2]The ~ notation here is used to signify that these estimates are derived from the actual data. Without the ~, these symbols signify equivalent values used in the environmental variation population dynamics model of Cooke (2007a) – see Adjunct A of Appendix 2 of IWC (2013c).

Table 3

Percentiles of the posterior distributions of $\tilde{\sigma}$ and $\tilde{\rho}_f$ based on the meta-analysis of annual calving rates (IWC, 2012). The values in **bold** typeface are used in the reference case meta-analysis of rate of increase.

		Percentiles										
Species	Stock	1	2.5	5	10	25	50	75	80	95	97.5	99
Sigma												
Blue whale	EN Pacific	0.020	0.037	0.056	0.093	0.188	**0.380**	0.607	0.857	1.028	1.183	1.386
Bowhead whale	B-C-B	0.578	0.618	0.663	0.721	0.835	**0.995**	1.189	1.413	1.555	1.668	1.778
Fin whale	Gulf of St Lawrence	0.034	0.069	0.125	0.235	0.455	**0.765**	1.088	1.363	1.532	1.662	1.800
Gray whale	Eastern	0.013	0.027	0.044	0.079	0.174	0.378	0.727	1.199	1.440	1.626	1.786
Humpback whale	Gulf of Maine	0.044	0.072	0.094	0.117	0.161	0.209	0.264	0.330	0.379	0.423	0.515
Humpback whale	Gulf of St Lawrence	0.020	0.037	0.060	0.092	0.175	0.294	0.427	0.566	0.668	0.748	0.869
Humpback whale	SE Alaska	0.006	0.012	0.019	0.034	0.075	**0.135**	0.214	0.309	0.398	0.489	0.636
Right whale	SE Atlantic	0.002	0.004	0.006	0.011	0.023	**0.042**	0.068	0.100	0.136	0.205	0.395
Right whale	SW Atlantic	0.213	0.226	0.237	0.251	0.277	**0.308**	0.344	0.383	0.408	0.435	0.469
Right whale	N Atlantic	0.143	0.179	0.208	0.241	0.298	0.366	0.444	0.532	0.599	0.667	0.761
Generic		*0.010*	*0.027*	*0.045*	*0.077*	*0.179*	*0.371*	*0.710*	*1.100*	*1.340*	*1.561*	*1.737*
Rho												
Blue whale	EN Pacific	-0.941	-0.902	-0.860	-0.790	-0.575	**-0.181**	0.291	0.646	0.818	0.906	0.961
Bowhead whale	B-C-B	-0.672	-0.566	-0.472	-0.373	-0.167	**0.065**	0.309	0.509	0.602	0.672	0.748
Fin whale	Gulf of St Lawrence	-0.737	-0.569	-0.351	-0.117	0.281	**0.636**	0.800	0.882	0.914	0.936	0.956
Gray whale	Eastern	-0.934	-0.862	-0.772	-0.627	-0.312	0.093	0.458	0.714	0.838	0.925	0.971
Humpback whale	Gulf of Maine	-0.952	-0.924	-0.888	-0.825	-0.677	-0.412	-0.054	0.225	0.389	0.516	0.634
Humpback whale	Gulf of St Lawrence	-0.940	-0.887	-0.799	-0.674	-0.414	-0.002	0.440	0.727	0.838	0.910	0.959
Humpback whale	SE Alaska	-0.943	-0.861	-0.702	-0.473	-0.119	**0.320**	0.729	0.904	0.948	0.972	0.986
Right whale	SE Atlantic	-0.895	-0.783	-0.642	-0.481	-0.169	**0.169**	0.575	0.898	0.966	0.990	0.998
Right whale	SW Atlantic	-0.546	-0.478	-0.417	-0.339	-0.220	**-0.074**	0.074	0.222	0.315	0.396	0.514
Right whale	N Atlantic	-0.746	-0.526	-0.380	-0.237	-0.027	0.195	0.409	0.593	0.683	0.758	0.839
Generic		*-0.953*	*-0.895*	*-0.807*	*-0.656*	*-0.307*	*0.076*	*0.421*	*0.696*	*0.816*	*0.881*	*0.945*

Table 4

Summary of the values for the reference case to be used in the meta-analysis. The values in **bold** typeface are taken from estimates that pertain to the stock in question; other values are assigned from stocks of the same species listed in Table 3.

	r_0 (%) (SE)	Year-span	r_{max}	$\tilde{\sigma}_f$	$\tilde{\rho}_f$
Blue whale					
Central N Atlantic	9.0 (3.83)	15	0.114	0.380	-0.181
S Hemisphere	8.2 (3.37)	26	0.114	0.380	-0.181
EN Pacific	3.2 (1.4)	16	0.114	**0.380**	**-0.181**
Fin whale					
N Norway	5 (9.95)	11	0.114	0.765	0.636
EN Pacific	4.8 (3.24)	15	0.114	0.765	0.636
Humpback whale					
W Australia	10.1 (4.69)	13	0.103	0.135	0.320
E Australia	10.9 (0.23)	24	0.103	0.135	0.320
EN Pacific	6.4 (0.9)	12	0.103	**0.135**	**0.320**
Hawaii	10 (3.32)	18	0.103	0.135	0.320
Bowhead whale					
B-C-B	3.9 (0.84)	24	0.043	**0.995**	**0.065**
Southern right whale					
SE Atlantic (S Africa)	6.8 (0.2)	32	0.076	**0.042**	**0.169**
SW Atlantic (Argentina)	6.0 (0.28)	40	0.076	**0.308**	**-0.074**
SE Indian (Australia)	6.6 (1.40)	18	0.076	0.042	0.169

4. METHODS SPECIFYING VARIABILITY IN SURVIVAL

Cooke (2011a) addressed correlation between variability in reproductive rates and in survival rates. If the correlation is positive, these two sources of variability will compound each other with regard to the variability in net recruitment rate. The model developed by Cooke (2011a) assumes that each individual 'chooses' how much of the available energy to allocate to reproduction, so as to maximise the sum of survival and reproduction. The available energy varies with environmental conditions. When the available energy is low, the optimal choice is not to reproduce at all.

Explorations of the model by the author over a range of parameters that are plausible for whales showed that the correlation between survival and reproduction is positive at higher energy levels, but can, in the absence of individual variability, become negative at lower levels, because the survival rate of parents is higher when the energy is not quite enough for reproduction than when it is just enough for reproduction. However, when individual variability is introduced, the population average correlation between reproduction and survival becomes positive for all the parameter combinations considered. This is because, in the presence of individual variation, the population proportion of individuals that reproduce varies smoothly with the average available energy, even though the relationship is non-smooth for each individual. The author considered that a substantial level of individual variation in whales is likely, because, in the few cases which have been studied, there are considerable individual differences in the choice of prey or feeding ground.

The Workshop **agreed** that positive correlation between survival rate and reproduction was the most likely case, but **agreed** to include the cases of negative, zero and positive correlation in the meta-analysis as sensitivity checks, consistent with the view of the Scientific Committee (IWC, 2013c).

The Workshop noted that the analysis requires not only the correlation between survival and reproduction to be specified but also the absolute level of variability in survival (or mortality). Cooke **agreed** to further explore the plausible parameter space for the model in Cooke (2011a), with a view to determining the plausible range of variability in survival, and to present the findings to the 2013 Scientific Committee meeting. If this is not successful, the conclusions will continue to be based on sensitivity tests which assume that mortality and reproduction contribute in equal measure to the variation in the net recruitment rate.

SC/M13/MSYR2 described an individual based model for a whale population based on standard energetic relationships.

The model uses a detailed energy budget to simulate whale reproductive success and mortality in an environment where food has a patchy spatial distribution. The major processes of an animal's seasonal activities are modelled, including migration, breeding and feeding. Animals have to search for food, and look for new food patches when local food abundance falls due to the effects of local intra-specific competition and stochastic variability.

SC/M13/MSYR2 gave examples from the model of relationships between the values of the annual births, which were subject to variation due to stochastic prey availability (as characterised here by $\tilde{\sigma}_f$), and additonal deaths.

Additional deaths are those due to shortages of prey, and hence that are not taken into account in the minimum mortality arising from the lower bound on natural mortality. The model led to similar predictions to those in Cooke (2013) that there is a positive correlation between survival rate and birth-rate in stochastic variability in prey abundance. The paper also demonstrated how the model could be used to develop an emulator of the model outputs that would produce additional deaths as a function of stochastic births at a much lower computational overhead, such that they could be used in existing programs. Setting up the emulator would require tuning the energetics model so that it reproduced the values for r_{max}, r_0 and $\tilde{\sigma}_f$ given in Tables 1 and 2.

In discussion, another approach was suggested in which the model is used directly to generate the values of σ_r at fixed values of r_0/r_{max} after conditioning on the estimated variability in birth rate. The Workshop **encouraged** de la Mare to provide further analysis on both these approaches to the 2013 Annual Meeting, so that they could be used in examining the effects on the meta-analysis arising from combined variability in births and deaths.

Given the absence of data to allow direct estimation of the extent of variability in survival, unlike the situation for variability in reproductive success, the Workshop **agreed** that analyses including variability in the former as well as the latter should be seen as providing robustness tests for the results of analyses taking account of the latter alone.

Following wide ranging discussion regarding the quantification of the extent of variability in survival and its correlation to variability in reproductive success, a set of sensitivity runs which explore the implications variation in natural mortality was **agreed**, the results of which are reported and discussed in the following section.

5. THE r_0/r_{max} DISTRIBUTION

5.1 Estimates of the r_0/r_{max} distribution

The reference case analysis is based on the rate of increase data for the stocks in Table 4. It involves defining the extent of variation in the rate of increase using the environmental model parameterised in terms of the posterior medians for the extent and autocorrelation of variation in fecudity ($\tilde{\sigma}_f$, $\tilde{\rho}_f$) (see Item 3). Note that this reference case only considers variation in fecundity; variation in survival rate is considered only in sensitivity tests. Fig, 1. shows the posterior distribution for the ratio r_0/r_{max} for an unknown stock, expressed as a probability density function and as a cumulative probability distribution, as well as the posterior distributions for $r_0 / \hat{r}_0$, the ratio of the rate of increase relative to the observed rate of increase, for each stock.

Figure 2 contrasts the sampling distributions for the rate of increase for the 13 stocks, with the posterior distributions for r_0, illustrating the effect of imposing a prior on r_0/r_{max} which has support from 0 to 1. The posterior distributions for stocks for which the sampling distribution for the rate of increase includes values below 0 or above r_{max} must differ from the sampling distributions. The posteriors for r_0 for stocks for which environmental variation is estimated to be high are flat because there is little information on r_0/r_{max} given high observation and process noise.

Table 5 lists the lower 5th and 10th percentiles for r_0/r_{max}, along with estimates of $MSYR_{1+}$ for stocks with the lowest and highest r_{max} values in Table 4 (right and blue/fin whales respectively), under the assumptions that: (a) $MSYR_{1+}=r_0/2$; and (b) $MSYR_{1+}=r_0/1.619$. The reasons for these choices are explained in the following section.

The sensitivity of the outputs from the meta-analysis to varying the value for r_{max} was explored by increasing and decreasing the maximum fecundity rates by 20%. The posterior distribution for r_0/r_{max} is shifted to the left when the r_{max} values are increased, and to the right when the r_{max} values are decreased. The posterior distributions for $r_0 / \hat{r}_0$ are centred closer to 1 when the values for r_{max} are increased because increasing r_{max} reduces the impact of the prior assumption that $r_0 \leq r_{max}$ (Fig. 3; Table 5b).

Table 5a lists the sensitivity of outputs from the meta-analysis to varying the specifications of the analysis.

- Application of the environment model. The options considered were:
  - (a) ignore the effects of the environment ('No environmental effects' in Table 5a);
  - (b) assume that $\tilde{\sigma}_f$ and $\tilde{\rho}_f$ for all stocks are equal to the medians of the posterior distributions for these parameters for an unknown stock from the meta-analysis conducted by Brandon *et al.* (2012) ('common median $\tilde{\sigma}_f$ and $\tilde{\rho}_f$', in Table 5a);
  - (c) assume that $\tilde{\sigma}_f$ and $\tilde{\rho}_f$ for each stock are equal to the upper 75%iles of the posterior distributions for these parameters for an unknown stock from meta-analysis conducted by Brandon *et al.* (2012) ('75% $\tilde{\sigma}_f$ and $\tilde{\rho}_f$' in Table 5a); and
  - (d) assume that $\tilde{\sigma}_f$ and $\tilde{\rho}_f$ for each stock are equal to the upper 95%iles of the posterior distribution for these parameters for an unknwn stock from the meta-analysis conducted by Brandon *et al.* (2012) ('95% $\tilde{\sigma}_f$ and $\tilde{\rho}_f$' in Table 5a).

- Data sets included in the meta-analysis. The options considered were:
  - (a) ignore the data for bowhead whales ('No bowhead whale data' in Table 5a);
  - (b) ignore the data for fin whales ('No fin whale data' in Table 5a); and
  - (c) use only the data for right whales ('Right whale data only').

- Allowing for variation in natural mortality as well as fecundity. The extent of variation in natural mortality, σ_M, for each stock is selected so that the variance in the rate of increase when there is stochastic natural mortality only matches that when there is stochastic fecundity only (see Item 2.3). Three sensitivity tests explore cases in which there is variation in both natural mortality and

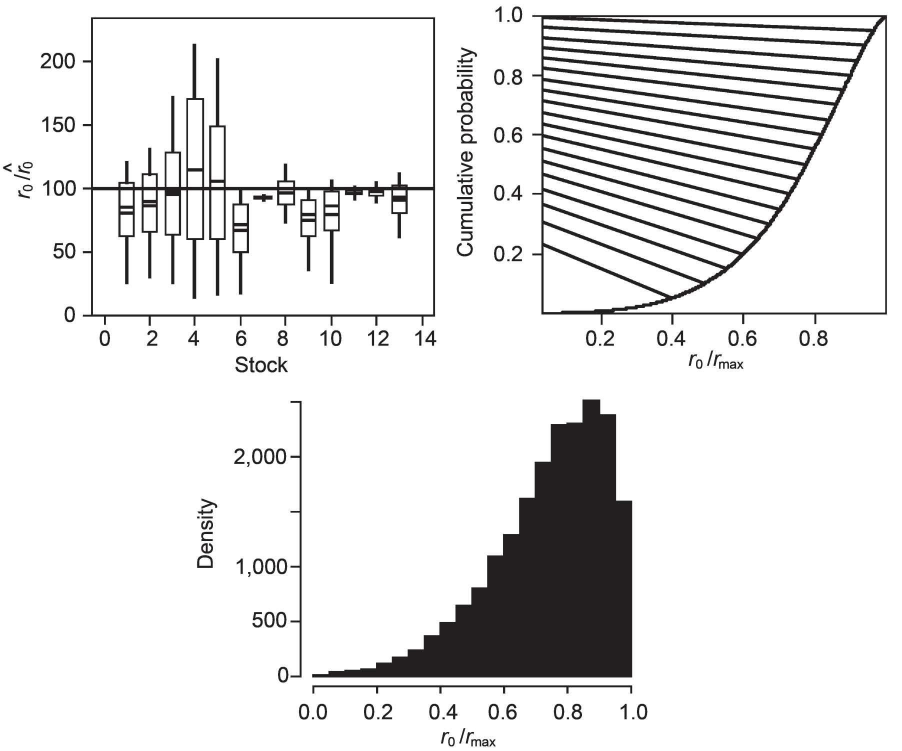

Fig. 1. Posterior distributions for the ratio of r_0 to the observed rate of increase (upper left panel), the cumulative posterior distribution for r_0/r_{max} (upper right panel), and the posterior distribution for r_0/r_{max}.

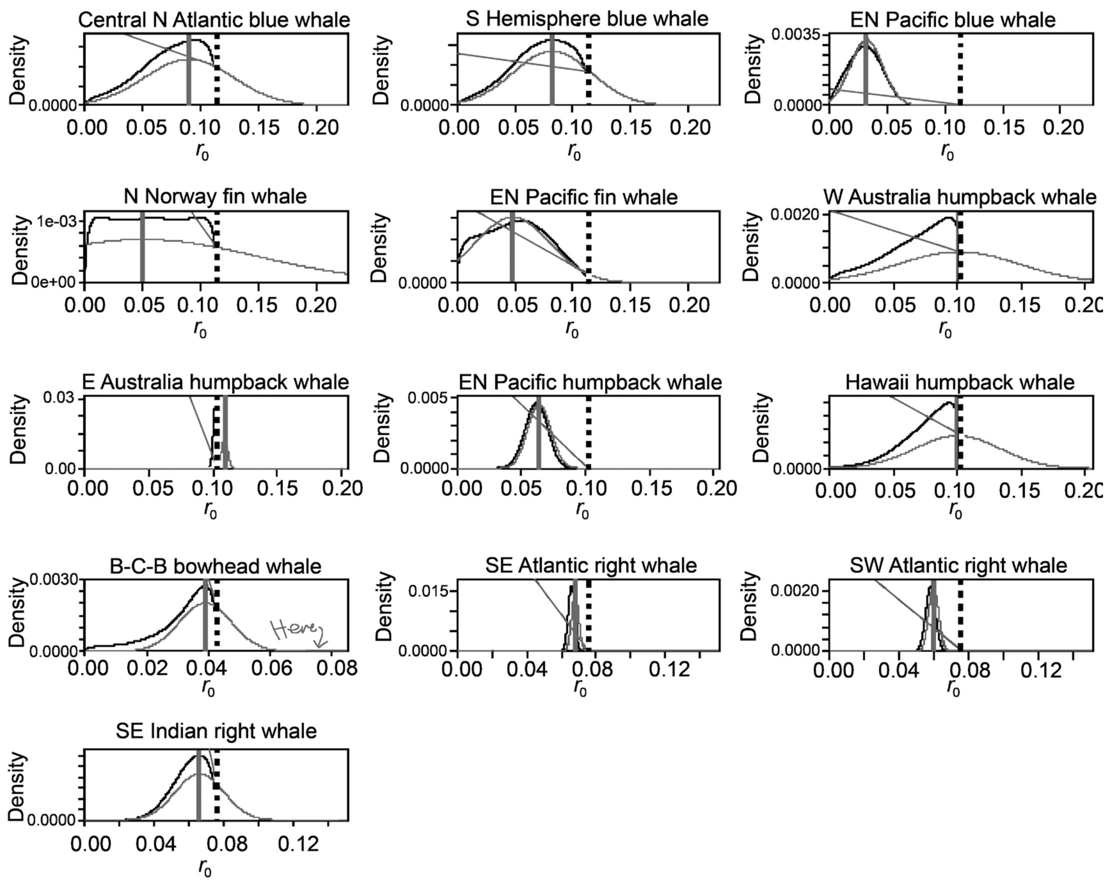

Fig. 2. Sampling distributions for r_0 (grey distributions and the vertical grey lines) and the posterior predictive distributions r_0 (black distributions) by stock. The vertical dotted lines denote r_{max}.

fecundity: (a) variation in natural mortality and fecundity are independent ('Independent M and F' in Table 5a); (b) variation in natural mortality and fecundity are perfectly positively correlated ('Positive correlation M and F' in Table 5a); and (c) variation in natural mortality and fecundity are perfectly negatively correlated ('Negative correlation M and F' in Table 5a).

Table 5(b) shows the sensitivity of outputs to higher and lower specifications for the value of r_{max}, effected by modifying the values assumed for the highest fecundity which are given in Table 2.

The results of the meta-analysis were generally insensitive to changing the assumptions upon which it is based, with a few exceptions (Fig. 3). In particular, increasing the extent of variation and autocorrelation of fecundity leads to a posterior distribution for r_0/r_{max} which emphasises higher values for r_0/r_{max}. This is because higher environmental variation leads to higher overall variation (process and observation) for stocks with lower r_0/r_{max}. Consequently, the relative weight given to stocks for which the rate of increase is close to r_0 (especially the right whale stocks) becomes greater. The rates of increase for the right whale stocks are generally close to r_{max} (see the results for 'Right whale data only' in Fig. 3).

5.2 Approaches to relate the r_0/r_{max} distribution to an appropriate MSYR range

The last discussion of this matter took place during the 2009 intersessional Workshop on MSYR for baleen whales (IWC, 2010a), at which two views emerged. One view, based on Butterworth and Best (1990), argued that estimates for $MSYR_{1+}$ could be inferred from estimates of r_0 given the bound $MSYR_{1+} \geq r_0/2$. This view arises from the assumptions that the relationship between the *per capita* growth rate and population size is smooth and convex. The alternative view is that $MSYR_{1+}$ can be lower than this bound, and is based on arguments of 'supercompensation' (Holt, 1985) whereby high growth rates at low population size drop rapidly thereafter, queries concerning the analyses that led to the conclusion of convex per capita growth rate relationships, and the effects of stochasticity. That Workshop had concluded that while both views remained, the fact that regularly monitored right and humpback whale populations had shown no evidence for a reduction in high growth rates over the past two decades implied that the 'supercompensation' argument was not as plausible as it had been earlier.

In the light of those discussions, a proposal made in the past Workshop to assume $MSYR_{1+}=r_0/2$ was again put forward. An alternative proposal advanced during the Workshop was to assume $MSYR_{1+}=r_0/1.619$ as follows from the age-aggregated Pella-Tomlinson population model with MSYL=0.6*K*, which is used frequently in the Scientific Committee.

However, the basis for these inferences was questioned on the grounds that they failed to take account of more recent work (Cooke, 2007a; de la Mare, 2011) on the impacts on the shape of yield curves resulting from environmental stochasticity and predator-prey effects.

The Working Group **agreed**, as an interim approach, to list results based on both assumptions above for the relationship between $MSYR_{1+}$ and r_0. This matter will be revisited at the 2013 Scientific Committee meeting in the light of work to be undertaken by Cooke in the interim using the environmental stochasticity model of Cooke (2007b) to inform on the likely relationship between these two variables.

Table 5

Outputs from the Bayesian meta-analysis. Results are shown for the lower 5th and 10th percentiles of the posterior for r_0/r_{max}.
For each percentile, results shown are: (a) r_0/r_{max}, $r_0/r_{max}/2$, $r_0/r_{max}/1.619$; and (b) the product of r_{max} and $r_0/r_{max}/2$, $r_0/r_{max}/1.619$ for two choices for r_{max}.
See main text for the definitions of the sensitivity tests.

	Lower 5th percentile							Lower 10th percentage						
				r_0/r_{max}* r_{max}/divisor							r_0/r_{max}* r_{max}/divisor			
	r_0/r_{max}	r_0/r_{max}/divisor		r_{max}=0.0426		r_{max}=0.114		r_0/r_{max}	r_0/r_{max}/divisor		r_{max}=0.0426		r_{max}=0.114	
Divisor	1	2	1.619	2	1.619	2	1.619	1	2	1.619	2	1.619	2	1.619
Reference	0.396	0.198	0.245	0.008	0.01	0.022	0.028	0.490	0.245	0.303	0.01	0.013	0.028	0.034
Case (a) Sensitivity tests to assumptions														
No environmental effects	0.386	0.193	0.239	0.008	0.010	0.022	0.027	0.481	0.241	0.297	0.010	0.013	0.027	0.034
Common median $\tilde{\sigma}_f$ and $\tilde{\rho}_f$	0.395	0.198	0.244	0.008	0.010	0.022	0.028	0.488	0.244	0.302	0.010	0.013	0.028	0.034
75% $\tilde{\sigma}_f$ and $\tilde{\rho}_f$	0.431	0.216	0.266	0.009	0.011	0.024	0.03	0.524	0.262	0.323	0.011	0.014	0.03	0.037
95% $\tilde{\sigma}_f$ and $\tilde{\rho}_f$	0.621	0.311	0.384	0.013	0.016	0.035	0.044	0.688	0.344	0.425	0.015	0.018	0.039	0.048
No bowhead whale data	0.370	0.185	0.228	0.008	0.010	0.021	0.026	0.464	0.232	0.287	0.010	0.012	0.026	0.033
No fin whale data	0.412	0.206	0.255	0.009	0.011	0.023	0.029	0.506	0.253	0.313	0.011	0.013	0.029	0.036
Right whale data only	0.579	0.29	0.358	0.012	0.015	0.033	0.041	0.651	0.325	0.402	0.014	0.017	0.037	0.046
Independent *M* and *F*	0.414	0.207	0.256	0.009	0.011	0.024	0.029	0.508	0.254	0.314	0.011	0.013	0.029	0.036
Positive correlation *M* and *F*	0.391	0.195	0.241	0.008	0.010	0.022	0.027	0.485	0.242	0.299	0.010	0.013	0.028	0.034
Negative correlation *M* and *F**	0.406	0.203	0.251	0.009	0.011	0.023	0.028	0.500	0.250	0.309	0.011	0.013	0.028	0.035
Case (b) Sensitivity to specifications for r_{max}														
20% higher fecundity	0.595	0.297	0.367	0.013	0.016	0.034	0.042	0.679	0.339	0.419	0.014	0.018	0.039	0.048
20% lower fecundity	0.335	0.167	0.207	0.007	0.009	0.019	0.023	0.42	0.21	0.259	0.009	0.011	0.024	0.029

*Ignoring the data for fin and bowhead whales because the populations do not persist given the assumed levels of variation of natural mortality and fecundity.

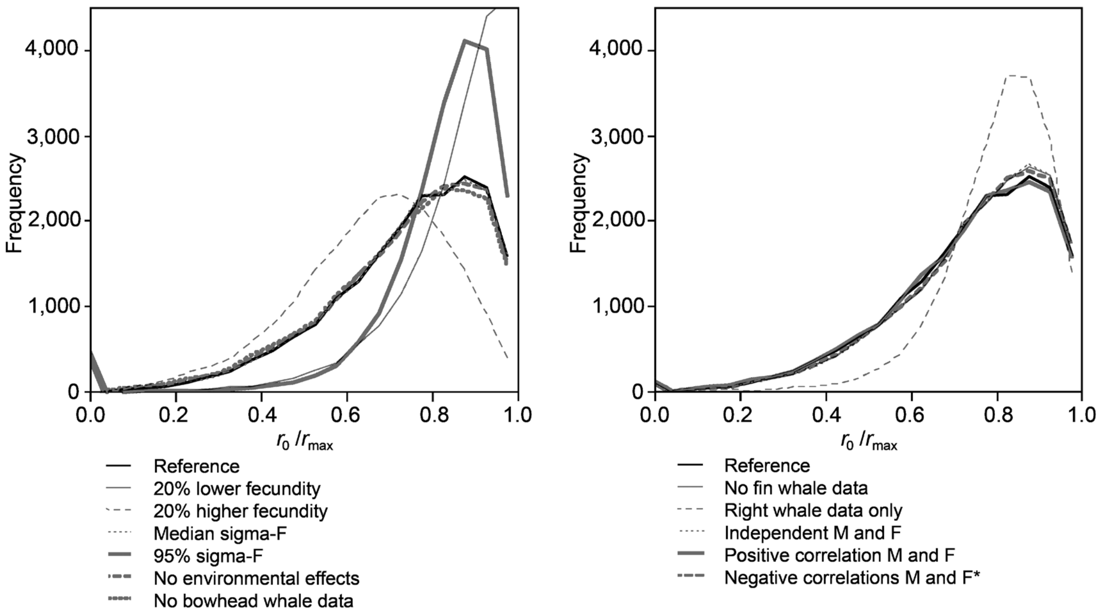

Fig. 3. Posterior distributions for r_0/r_{max} for the reference case analysis and the sensitivity tests.

To provide an indication of the implications of these assumptions for the range of plausible $MSYR_{1+}$ values for the unknown stock, Table 5 gives results for $MSYR_{1+}$ for both assumptions coupled to the highest and lowest values for r_{max} in Table 4. The interpretation of the resultant sets of values in Table 5 is taken forward in the section following.

6. RECOMMENDATIONS FOR THE SCIENTIFIC COMMITTEE

The Workshop **agreed** that while it had made considerable progress, it was not in a position to develop recommendations for the Scientific Committee on the appropriate range of MSYR rates. In the time available, the Workshop summarised the issues that must be explored more fully during the 2013 Scientific Committee meeting. In summary, these related to three major areas:

(1) the limitations of the modelling approach itself;
(2) the limitations within the approach (e.g. paucity of data); and
(3) the interpretation of the results in the context of the RMP.

Inclusion of the summary issues below does not imply that all members of the Workshop necessarily agreed with each.

(a) *The validity of the assumption that the distribution of r_0/r_{max} is independent of r_{max}.* In species such as right whales, where there is high maternal investment and the maximum breeding rate is quite low, the realised *r* may often approach r_{max}, as has been observed in the two Southern Hemisphere populations included in the analysis. Common minke whales, by contrast, might be an example of a species with an annual breeding cycle, but lower maternal investment (early weaning) such that the potential r_{max} is quite high, but the realised *r* may come close to r_{max} only rarely, if at all, if the consequence of early weaning was higher calf mortality or a consequence of annual breeding was lower female survival. The Workshop noted that there are no data available to be able to evaluate this suggestion directly.

(b) *The validity of extrapolating to species with a higher r_{max} than those included in the meta-analysis and how this should be done*. It was suggested that a meta-analysis similar to that performed for r_0/r_{max} be performed for r_0, i.e. corresponding to the assumption that it is r_0 rather than r_0/r_{max} which has a universal distribution. While such an assumption is clearly problematic in certain respects, the purpose would be to use the lower tail of this distribution to bound the extent to which the extrapolation concern might impact the interpretation of the results in Table 5. This analysis would ignore environmental variability, given that this had had little impact on the results for the base case for the r_0/r_{max} distribution (Table 5a). The Workshop agreed that a beta distribution ranging from 0 to 20% be used for this analysis, with the priors on the beta distribution parameters being chosen to yield a roughly uniform prior for r_0. Punt agreed undertake this analysis.

(c) *The effect of the r_{max} constraint, uncertainty in r_0 and the variability in fecundity*. There was some discussion of the fact that the assumed r_{max} constraint of the model, in combination with the uncertainty in the r_0 estimates and the amount of variability in fecundity caused the median of the posterior for r_0 to be smaller than actual observed value for r_0 for 11 of the 13 stocks in the reference case (Fig. 1). The sampling distribution for r_0 may exceed r_{max} owing to either observation error, an incomplete model (including r_{max} values which are too low), or a combination of these factors. In this situation, and as indicated for the majority of the stocks analysed, the posterior for r_0 will have the bulk of its mass below the observed value for r_0, generating r_0 estimates that are smaller than the estimates from the data.

(d) *Sample size limitations*. The Workshop also noted the limitations of any meta-analysis which relies on a small number of populations from a limited number of species (and the absence of some key species such as common and Antarctic minke whales). In particular, the analysis here can be said to over-represent populations recovering in regions where most other large whales populations are also depleted and where there are limited, if any, effects from forage fisheries. These conditions are not representative for a substantial number of other populations. Even for the populations included in the analysis, multi-species and changes in fisheries effects mean that current observed ratios of r_0/r_{max} may not relate to future MSY rates when the populations have recovered in the same or similar ways as assumed in Item 5.2.

(e) *Use within the RMP*. In terms of possible uses within the RMP, one suggestion was given for using the appropriate result for $MSYR_{1+}/r_{max}$ from Table 5 (given the selection of an $r_0 – MSYR_{1+}$ relationship and the percentile of the distribution of r_0/r_{max} on which to base a lower bound on the range of MSYR to be considered for the RMP). When *IST*s for the species and stocks under consideration for an RMP *Implementation* (*Review*) were developed, a plausible range of r_{max} should be developed for the species and region concerned from the demographic parameter and other pertinent information available. This range would then multiply the appropriate value for $MSYR_{1+}/r_{max}$ from Table 5 to provide a basis to choose the lowest plausible value for $MSYR_{1+}$ for use in those *IST*s.

(f) *Reference component of the population*. The Workshop noted that the tuning of the RMP is expressed in terms of the MSYR for the mature component of the population. It recalled the Scientific Committee's previous finding that the relationship between $MSYR_{1+}$ and $MSYR_{mat}$ could for practical purposes be expressed as a simple scaling factor of approximately 1:0.67 (IWC, 2004, p.6). However, that finding was based on a deterministic model, and the relationship would not necessarily be as simple in the presence of high levels of variability in the net recruitment rate. The Workshop **recommended** that the relationship between $MSYR_{1+}$ and $MSYR_{mat}$ be re-examined in the context of variability for the sets of parameter values given in Table 3. Cooke **agreed** to undertake this analysis.

7. WORK PLAN UNTIL SCIENTIFIC COMMITTEE MEETING

The Workshop noted four areas of work that, if able to be completed, would assist discussions at the 2013 Annual Meeting.

(a) Cooke **agreed** to explore further the plausible parameter space for the model in Cooke (2011a), with a view to determining the plausible range of variability in survival.
(b) de la Mare **agreed** to investigate use of his individual based model (SC/M13/MSYR2) to examine the relationship between variability in reproduction and survivorship further.
(c) Cooke **agreed** to examine the relationship between $MSYR_{1+}$ and $MSYR_{mat}$ in the context of variability in net recruitment.
(d) Punt **agreed** to conduct a meta-analysis of r_0 values.

The Workshop **agreed** that for the results of these analyses to be properly considered at the 2013 Annual Meeting, they should be circulated by **15 May 2013**. Cooke, de la Mare and Punt each agreed to do so or notify the Workshop participants if they were unable to complete the work.

The Workshop also **agreed** that it would be valuable if short papers were developed addressing the issues raised under Item 6.

8. ADOPTION OF REPORT

The Chair thanked the participants for their co-operative attitude and contributions to the Workshop. In particular, he thanked Punt and Butterworth for their work on the report and Punt for undertaking the computing work. The report was adopted by email on 26 April 2013. The participants thanked the Chair for his usual good humoured and efficient handling of the meeting.

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Annex A

List of Participants

AUSTRALIA

W.K. de la Mare

DENMARK

L. Witting

JAPAN

T. Kitakado

NORWAY

L. Walløe

INVITED PARTICIPANTS

D.S Butterworth
J.G. Cooke
A.E. Punt

SECRETARIAT

G.P. Donovan

Annex B

Agenda

1. Introductory items
   1.1 Welcoming remarks
   1.2 Election of Chair
   1.3 Appointment of rapporteurs
   1.4 Adoption of Agenda
   1.5 Review of documents
2. Progress since Annual Meeting in relation to the work plan
   2.1 Overview of present methods
   2.2 Refinement of population model used to estimate variability parameters
   2.3 Coding of methods that generate variability in survival rate
3. Estimates of *r* and associated variability (reproductive component)
   3.1 Update of estimates
4. Methods specifying variability in survival
5. The r_0/r_{max} distribution
   5.1 Estimates of the r_0/r_{max} distribution
   5.2 Approaches to relate the r_0/r_{max} distribution to an appropriate MSYR range
6. Recommendations for the Scientific Committee
7. Work plan until Scientific Committee meeting
8. Adoption of Report

Annex C

List of Documents

SC/M13/MSYR

1. Witting, L. and Brandon, J. Potentials for positive biases in estimates of the annual variation in average birth rate of baleen whale populations. 3pp.
2. de la Mare, W.K. Implications of energy budgets in determining the characteristics of whale yield curves (Draft). 129pp.

Report of the IWC Scientific Committee Workshop on Marine Debris

Report of the IWC Scientific Committee Workshop on Marine Debris[1]

1. INTRODUCTORY ITEMS

1.1 Welcome and opening remarks

The Workshop was held from 13-17 May 2013 at the Quissett Campus of the Woods Hole Oceanographic Institution (WHOI). The first day was a public seminar consisting of a number of keynote presentations and question and answer sessions.

Michael Moore, the Director of the Marine Mammal Center at WHOI welcomed everyone. He gave a brief description of the Woods Hole scientific community and noted that Woods Hole village had been a small whaling port, with the old spermaceti factory extant, and still known as the Candle House.

Mark Simmonds, as Workshop Convener, thanked Michael and WHOI for hosting the Workshop and everyone for coming. He commented that the old adage that things at sea tend to go on out of sight and out of mind certainly applied to a significant extent to marine debris. However, whale entanglement was a well-known phenomenon in this part of the USA and one that many here were working hard to respond to. He added that this is an historic meeting. Both the IWC and the Woods Hole Oceanographic Institution were born long ago (the IWC in 1949 and WHOI in 1930). Both are concerned with marine conservation but this the first time that they have joined together in an initiative, and the first time that the IWC had held a public seminar. He then thanked all the sponsors of the IWC's work on marine debris, including Oceancare, the World Society for the Protection of Animals (WSPA), the US National Oceanic and Atmospheric Administration (NOAA), the UK, the Environmental Investigation Agency (EIA), Humane Society International and the WHOI Marine Mammal Center.

A list of attendees is provided at Annex A.

1.2 Procedural matters

Simmonds was elected as Chair and Baulch, Brockington, Hudak, Rosa, Saez and Thiele were appointed as rapporteurs.

The adopted Agenda is given in Annex B.

1.3 Review of documents

Simmonds drew attention to the documents which had been submitted to the Workshop and were available through the IWC's document management website.

2. KEYNOTE PRESENTATIONS

2.1 Introduction to the work of the International Whaling Commission on environmental issues

Simon Brockington, Executive Secretary of the IWC, introduced the range of environmental work being undertaken by the Commission. In particular, he highlighted progress to coordinate national programmes established to respond to whales entangled in marine debris. The IWC strives to facilitate a co-ordinated, global capacity for responding to entangled whales, where apprentices from more than 15 countries have already been trained in safe disentanglement procedures. Other environmental work includes development of measures to reduce incidents of ship strikes, development of guidelines for sustainable whale watch operations and a range of dedicated conservation projects for small cetaceans.

The IWC recently introduced Conservation Management Plans (CMPs) as a practical tool to co-ordinate the diverse work being undertaken. To date, three CMPs have been prepared: one for gray whales *Eschrichtius robustus* in the western North Pacific, and two for southern right whales *Eubalaena australis* on the east and west coasts of South America. Additional plans are currently being developed. The successful implementation of the CMPs will depend on continued and increased partnership working between range states and the full range of stakeholder organisations.

2.2 Marine debris in our oceans – an overview

Nancy Wallace, Marine Debris Programme (MDP) Director and Division Chief, US National Oceanic and Atmospheric Administration (NOAA) provided an introduction to the issues arising from marine debris in the world's oceans. The MDP was formed in 2006 after passage of the Marine Debris Research, Prevention and Reduction Act.

Wallace noted that, in 2006, Senator Daniel Inouye of Hawaii stood on the floor of the Senate chamber and introduced a bill he felt very passionate about; one that focused on a problem that he felt went unnoticed. That problem was marine debris. He said: 'From the shore, our oceans seem vast and limitless, but I fear that we often overlook the impacts our actions have on the sea and its resources. In a high-tech era of radiation, carcinogenic chemicals, and human-induced climate change, the problem of the trash produced by ocean-going vessels and dumped at sea must seem old-fashioned by comparison. Sea garbage would seem to be a simple issue that surely cannot rise to the priority level of the stresses our 21st century civilization places on the natural environment. Regrettably, that perception is wrong. While marine debris includes conventional 'trash', it also includes a vast array of additional materials. It is discarded fishing nets and gear. It is cargo washed overboard. It is abandoned equipment from our commercial fleets. Nor does the 'low-tech' nature of solid refuse diminish its deadly impact on the creatures of the sea. Dead is dead - whether an animal dies from an immune system weakened by toxic chemicals, or drowns entangled in a discarded fishing net.' Senator Inouye proposed giving the USA the tools it needed to develop effective marine debris prevention and removal programmes, and with that, the NOAA Marine Debris Program was formed.

Marine debris is a global problem, and it is an everyday problem. There is no part of the world that is untouched by debris and its impacts. It is pervasive, it is an eyesore, and it harms our natural resources. Marine debris is a threat to our environment, navigation safety, the economy, and human health.

Derelict fishing gear is a major marine debris issue that has a profound impact on natural resources. Discarded nets, rope, and monofilament fishing line continue to fish even as they drift through the ocean. They can entangle animals, maim them, or prevent them from hunting food. Lost or

[1]Presented to the meeting as SC/65a/Rep06.

discarded traps and pots can continue to entrap animals for years after they are lost adding to resource and economic losses. Both primary sources and secondary sources of plastic are another major issue related to marine debris. Plastics can be ingested by marine life and can lead to starvation and death. There are also many questions related to the chemical impacts of plastics and research is underway to address these.

A majority of marine debris can be prevented but some cannot. Natural disasters such as Hurricane Katrina, the 2009 tsunami in American Samoa and the 2011 tsunami in Japan are examples of events that led to substantial amounts of debris entering the ocean. Working with federal, state, and local partners to implement response plans help to mitigate impacts from this type of debris.

While there are many challenges related to marine debris, there are also many efforts to reduce the impacts. The NOAA Marine Debris Program has established a presence throughout the USA and has formed partnerships with local organisations to carry out removal and prevention projects. As well, research projects are underway to address the impacts of microplastics and derelict fishing gear on marine life, and to understand the economic impacts of marine debris. Examples of these projects can be found at *http://www.marinedebris.noaa.gov*. Interagency collaboration is mandated by the Marine Debris Act and NOAA works very closely with US agencies such as the Environmental Protection Agency, the Department of Interior, and the Department of Defense, the US Coast Guard, the Department of State, as well as other federal agencies.

Marine debris is a global problem and solutions must be at the global level. Two years ago, NOAA, the United Nations Environment Programme (UNEP), and stakeholders from all over the globe came together to draft the Honolulu Strategy[2], a global strategy for reducing marine debris.

2.3 Cetacean entanglement: detection and impacts

Moore noted that entanglement of cetaceans can involve peracute underwater entrapment, or chronic debilitation, lameness, impaired gait, chronic infection, host immune responses and ultimately death. This usually begins by entanglement in actively fished gear, whereas debris is discarded material floating, in the water column or on the bottom. Where active gear is torn away by the power of the animal, or the entangled animal is cut out from the gear by the fisher, it could be defined at that point as debris. Fishing gear consists of rope, traps and floats from fixed trap fisheries, especially lobster gear, gillnet and its associated ropes and floats, monofilament and braided hook and line fishing gear, and mobile trawl gear. On the eastern seaboard of the United States and Canada, large whales (Van der Hoop *et al.*, 2012), dolphins, porpoises and seals all get entangled in fishing gear. An annual average of 2,773 whales, dolphins and seals died in fishing gear in the NW Atlantic waters of the United States for the period 2005 to 2009[3]. Relocation of floating whale carcasses at sea has been successful using drift forecasts by the US Coast Guard SAR plot model assuming the carcass is a 70% submerged 40' container drift paradigm.

Entangled cetaceans can become asphyxiated when entrapped below the surface of the water; if the animal can surface, it can remain anchored in place, or if it is cut free or can break away, the result may be chronic entanglement, with resultant laceration, incision, constriction, feeding impairment, increased drag (Van der Hoop *et al.*, 2014), loss of body condition, bony proliferation, infection and ultimate death (Cassoff *et al.*, 2011). The timing of death can be minutes to years after the initial event (Moore *et al.*, 2006). The symptoms can include acute distress in whales that cannot surface and therefore drown at some point soon after the normal dive duration, which ranges from minutes to more than an hour in the case of some whales. Chronic cases presumably suffer from severe and chronic pain (Moore and Van der Hoop, 2012). Diagnosis of acute drowning entanglement often involves subtle surface markings from the gear, airway froth and systemic congestion, suggestive of a terminal struggle (Moore *et al.*, 2013). Chronic entanglement cases often exhibit resultant wounds and emaciation. Mitigation can include reactive disentanglement on a case-by-case basis, which may be valuable for critically endangered species. This may include large whale disentanglement programmes, with substantial tool innovation, which could perhaps be enhanced by available at-sea sedation techniques (Moore *et al.*, 2010). Low impact tagging systems to enhance relocation of entangled animals would also enhance disentanglement response. Major challenges to addressing the issue of cetacean entanglement in fishing gear include:

(1) cost to the fishing industry of poorly tested but mandated gear modifications, or seasonal and area closures;
(2) poor detection and reporting of entangled animals; and
(3) competing agendas in terms of other regulatory priorities for fishing industry goals and stock management.

Most efforts to reduce marine mammal entanglement have been driven by concerns over species and stock survival. There seems to be minimal legal or popular motivation to reduce these very serious welfare concerns for the sake of the individual animal. The welfare status of all cetaceans should be independent of their conservation status. For most whales, actively fished gear is the primary entanglement problem. Ingestion of macrodebris is a problem at least for sperm whales, *Physeter macrocephalus*. Mitigating debris interactions is politically easier than mitigating interactions between cetaceans and actively fished gear – hence the focus may be on the former when the latter may be the bigger problem.

2.4 Cetacean entanglement: scope and response

David Mattila, the technical adviser to the International Whaling Commission, noted that the IWC has a long history of investigating the scope and impacts of large whale entanglement, through the Human Induced Mortality (formerly Bycatch) Working Group of the Scientific Committee. Additionally, recent findings concerning both the welfare and conservation impacts of entanglement have brought the topic to the attention of both the Commission's Whale Killing and Associated Welfare Issues Working Group and its Conservation Committee. While the extent to which marine debris may contribute to cetacean entanglements is not fully understood, the impacts and potential responses once entangled are largely the same. In response to the growing awareness of the impacts of entanglement, Australia, Norway and the USA convened an IWC-endorsed Workshop of experts on the topic (IWC, 2012). The Workshop reviewed the scope, impacts and potential responses to large whale entanglement, and found that all large whales can become entangled anywhere in the world's oceans where they encounter rope and net in the

[2] *http://marinedebris.noaa.gov/projects/pdfs/HonoluluStrategy.pdf.*
[3] *http://www.nefsc.noaa.gov/nefsc/publications/tm/tm213/.*

water column (IWC, 2012). With respect to understanding whether entangling ropes and nets were in active use or not when entanglement occurred, it was noted that a large percentage of the materials removed are reported as being of 'unknown' origin and only in a few instances (e.g. less than 5%), are the materials determined to have been lost, abandoned or otherwise discarded, prior to entanglement. However, given a current review of gear loss and continued ghost fishing, in some regions it may account for up to 30% of entanglements (Mattila and Lyman, 2006). In addition, given the cryptic nature of the entanglement events and the general lack of reporting infrastructure, it is generally agreed that the numbers of entanglements are widely and severely under-reported. The 2010 Workshop therefore recommended capacity building on the topic, better data collection, and ultimately prevention. In response to the Commission's endorsement of this report and its recommendations, the USA seconded a technical expert (Mattila) to the IWC Secretariat to focus on advancing work on this topic.

Given the strong recommendation for capacity building, a second IWC Workshop was convened (IWC, 2013) to develop principles and guidelines for response to entangled whales, as well as a strategy and curriculum for capacity building. In the 18 months since that Workshop, the IWC entanglement response capacity building initiative has reached approximately 500 responders, managers and scientists, in 20 different countries. The capacity building curriculum includes exposure to techniques and methodologies for investigating the causes, scope and impact of large whale entanglements, including in marine debris, as well as current information on attempts to prevent it. During both conceptual and practical training, the consensus principles and guidelines are stressed, including human safety, animal welfare, and the collection of information about the whale and the entangling materials, which will ultimately be used to inform mitigation.

2.5 Microplastics

Cristina Fossi of the University of Siena reported that microplastics, plastic fragments smaller than 5mm, is an emerging issue for cetaceans. The impacts of microplastics on baleen whales that are potentially ingested by filter-feeding activity, are largely unknown.

Fossi presented a case study on the fin whale, *Balaenoptera physalus*, in the Mediterranean Sea, one of the largest filter feeders in the world. These whales feed primarily on planktonic euphausiid species. With each mouthful, fin whales can trap approximately 70,000 litres of water, and their feeding activities include surface feeding. They could therefore face risks caused by the ingestion and degradation of microplastics. Microdebris[4] can be a significant source of lipophilic chemicals (primarily persistent organic pollutants – POPs) and a source of pollutants such as polyethylene, polypropylene and, particularly, phthalates. These chemical pollutants can potentially affect marine organisms and are potential endocrine disruptors.

This study, supported by the Italian Ministry for the Environment, is the first evidence of the potential toxicological impact of microplastics in a baleen whale and suggests the use of phthalates as a tracer of the intake of microplastics through the ingestion of microdebris and plankton. The toxicological effects of microplastics on fin whales were studied comparing two populations living in areas characterised by different human pressure: the Pelagos Sanctuary (Mediterranean Sea, Italy and France) and the Sea of Cortez (Mexico). The work was implemented through four steps:

(1) collection/count of microplastics in the Pelagos Sanctuary (Mediterranean Sea);
(2) detection of phthalates in superficial neustonic/planktonic samples;
(3) the detection of phthalates in Mediterranean stranded fin whales; and finally
(4) the detection of phthalates and biomarker responses (CYP1A1, CYP2B, lipid peroxidation) in skin biopsies of fin whales collected in the Pelagos Sanctuary and Sea of Cortez.

A high presence of plastic particles with high concentration of phthalates (Di(2-ethylhexyl)phthalate or DEHP and Mono(2-ethylhexyl) phthalate or MEHP) has been detected in superficial neustonic/planktonic samples collected in the Pelagos Sanctuary areas that were investigated (mean value 0.62 items/m^3). As well, MEHP concentrations were detected (57.9ng/g) for the first time in blubber samples of five stranded fin whales collected along the Italian coasts. Finally, relevant concentrations of MEHP and elevated biomarker responses (CYP1A1, CYP2B, lipid peroxidation) were detected in the skin biopsies of fin whales collected in the Mediterranean areas in comparison to the specimens from whales in the Sea of Cortez. The results of this study support a strategy of using phthalates as a tracer of microplastics consumption in fin whales, and represent a warning signal for this emerging threat in baleen whales.

These preliminary investigations underscore the importance of future research on the detection of the toxicological impact of microplastics in filter-feeding species such as mysticete cetaceans, the basking shark and the devil ray. These results also underscore the potential use of these species in the implementation of Descriptor 10 (marine litter) in the European Union (EU) Marine Strategy Framework Directive as indicators of the presence and impact of micro-litter in the pelagic environment.

2.6 Closing the loop: repackaging plastic debris as a hazardous substance

Mark Browne, of the National Center for Ecological Assessment and Synthesis (NCEAS), University of California, Santa Barbara, suggested that the policies for managing plastic waste were out dated and threatened the health of people and wildlife. Plastic debris can physically harm wildlife and many plastics can be chemically harmful in certain contexts. In 2012, 280 million tonnes of plastic were produced globally, less than half of which was consigned to landfill or recycled. Yet in the USA, Europe, Australia and Japan, plastics are classified as solid waste, and are therefore treated in the same way as food scraps or grass clippings. If countries classified the most harmful plastics as hazardous, their environmental agencies would have the power to restore affected habitats and prevent more dangerous debris from accumulating. If current rates of consumption continue, the planet will hold another 33 billion tonnes of plastic by 2050, filling about 2.75 billion standard rubbish-collection trucks. This could be reduced to just 4 billion tonnes if the most problematic plastics (e.g. polyvinyl chloride or PVC, polystyrene, polyurethane, polycarbonate) are classified as hazardous immediately and replaced with safer, reusable materials in the next decade.

[4]Throughout this document the following definitions are used: microdebris refers to plastic particles smaller than 5mm and macrodebris to plastic particles greater than 5mm.

2.7 Overview of cetacean interactions with marine debris

Sarah Baulch, of the Environmental Investigation Agency (EIA), presented results from a literature review of published and unpublished data on debris interactions involving cetaceans. This review found that entanglement and ingestion interactions have been recorded in 46 cetacean species, equivalent to 53% of all cetacean species. The majority of records are from one-off stranding events, which represent a small but unknown proportion of interactions occurring unobserved at sea. Furthermore, there is much data that remains unpublished.

Baulch's review found that in the cases collated, items ingested were most commonly plastic (54%), with fishing gear comprising 20.7% and miscellaneous or unidentified items constituting the remainder (25.3%). Almost all of the entanglements in debris documented were caused by lost fishing gear (97%). The review indicated that ingestion of marine debris occurs in a large number of cetacean species (seven mysticete and 35 odontocete species) that employ a variety of foraging strategies at different levels of the water column. There appears to have been an increase in the number of cases reported per decade, with more than a seven-fold increase in the number of reported ingestion events in the last 50 years. Also, there has been an increase in the number of cetacean species that have been recorded ingesting debris. It is not clear to what extent the increase in records may be evidence of an increasing problem or whether it reflects increased detection and reporting rates. Notwithstanding the welfare concern of debris interactions at an individual level, there is a need to identify methods to determine whether there are population-level effects of marine debris ingestion and entanglement for cetaceans.

It was noted that another recent review came to similar conclusions, and also highlighted the possibility that deep-diving cetaceans (sperm whales and beaked whales) may be especially vulnerable to ingestion (Simmonds, 2012).

Discussion

The seminar concluded with a panel discussion that touched on the following topics:

- the legal requirements for monitoring and responding to marine debris vary around the world, and are also often complicated by a lack of capacity to enforce laws even if they exist;
- cooperation with other international organisations and existing frameworks was **encouraged**, including but not limited to: the Convention on Migratory Species (CMS) Resolution on Marine Debris, the UNEP/GPA Global Partnership on Marine Litter, UNEP Regional Seas Programme, MARPOL[5], the UN Food and Agriculture Organisation (FAO) and the Convention for Biological Diversity (CBD);
- the potential importance of fishing gear-marking strategies to the problem of derelict fishing gear;
- how local actions may relate to a global problem; and
- how countries might best develop partnerships to execute recommendations and strategies related to this issue.

In closing, Simmonds noted that these and other matters would be considered during the Workshop that would follow. It would focus on determining how to better understand the risks that marine debris poses to cetacean species and would also inform a second IWC Workshop on marine debris directed by the IWC's Conservation Committee, which will be concerned with addressing the threats posed by marine debris to cetaceans.

[5]MARPOL is the International Convention for the Prevention of Pollution From Ships (1973) as modified by the Protocol of 1978.

3. ENTANGLEMENT

3.1 Overview of papers relating to entanglement

3.1.1 Entanglement records in Italy

Podestá presented an overview of information from the Italian cetacean stranding network and a summary of entanglement records. The Italian Stranding Data Bank, managed by the University of Pavia and the Natural History Museum of Milan on behalf of the Italian Ministry of the Environment, collects and validates stranding data[6]. Data collection started in 1986 and continues today; each record in the database is geo-referenced and provides information about the event (location, species, sex, length, etc.) The records also capture information on samples collected and the institutes where samples are stored. The database is linked to the Cetacean Tissue Bank of the University of Padova, where samples collected from the stranded specimens are stored and available for research[7].

Podestá searched the Italian national database and summarised records of cetacean strandings that were related to entanglements in fishing gear over the last 11 years (2002-12). A total of 99 'bycatch' events were recorded, representing nearly 8% of the total strandings and affecting seven different species. Verified entanglements in fishing gear were reported for 36 cetaceans within the total number of bycatch recorded. The majority of the entangled animals were found dead (23), while 13 were found alive and were successfully released (Pace *et al.*, 2008). Nine of the live specimens were large cetaceans: eight sperm whales and one humpback whale, *Megaptera novaeangliae*. No information about whether entangling debris was active or lost fishing gear was available. Also, the source of entangling gear was often difficult to determine and in many cases was classified as 'unidentified fishing gear'.

Analyses of the data indicate that the number of entanglements were decreasing in the years considered, and represent a small percentage compared to the total number of strandings. Considering the bias in the data collection (different effort in different areas), Podestá stated that the number of entanglements has likely been underestimated in the considered period of time. Stranding data can be of help to report cetacean interactions with fishing gear, but dedicated studies are needed to analyse the problem in the whole Mediterranean area. Cooperation with researchers working on fisheries has to be improved in order to share data and information.

Podestá clarified that four entanglement cases involving sperm whales were determined to be in an active fishing nets, as opposed to lost gear, because the fishermen themselves contacted the Coast Guard for help. Podestá noted that fishing nets are not known to commonly wash up on the beaches as debris in Italy and that entangling gear is not retrieved in Italy for later analysis or archiving, primarily because people are not available to collect and do the categorisation.

DISCUSSION

In recognition of the importance of better understanding this issue, including the relative occurrence of derelict versus actively-used gear involved in cetacean entanglements, the Workshop **recommended** that all gear removed from cetaceans be retained, documented and detailed, archived, and analysed wherever feasible. Collection of entangling gear should not compromise human or cetacean safety.

[6]Data available online at *http://mammiferimarini.unipv.it*.
[7]See *http://www.mammiferimarini.sperivet.unipd.it*.

It was noted in relation to assumptions about the survival of released animals, that not all disentangled whales will survive, and that they are less likely to survive if released by untrained individuals, as untrained individuals often leave small, but lethal wraps of gear on the animal as it swims away. The recommendation for disentanglement teams to work with experts to determine the origin of the gear removed was noted as a component of the IWC principles and guidelines for proper entanglement response (IWC, 2013).

The EU has conducted research using Synthetic Aperture Radar (SAR) to successfully detect the presence of anchored gillnets after fishery management effort restrictions (Rosenthal and Lehner, 2011). SAR allows for remote detection of fishing effort without the need for traditional methods of recording effort, such as logbooks and vessel monitoring systems.

3.1.2 Overview of large whale entanglement records

Saez presented an overview of US west coast (California, Oregon, and Washington) large whale entanglement records and the trends in associated entangling gear types. Whale entanglements on the US west coast are reported from opportunistic on-water sightings, stranding records, and commercial fishery observers. Gray and humpback whales are the most commonly reported entangled large whale species. A switch in most common entangling gear types, from gillnet to trap/pot, is likely a reflection of management actions in California. Except for commercial fishery observer records, it is difficult to determine if the entangling gear was active gear or marine debris (lost gear) at the time of entanglement.

The co-occurrence of fixed gear commercial fisheries and large whales (blue, fin, gray, humpback, and sperm whales) off the US west coast was modelled to look for areas where, and months when, large whales are more likely to encounter gear and becoming entangled. Fishery effort for 11 fixed gear fisheries was modelled by combining fishery landings data with areas defined by common fishing depths. The co-occurrence model showed that the highest risk for blue, fin, humpback, and sperm whales was during the fall, and for gray whales the highest risk was in January and May. The Dungeness crab trap fishery had the highest co-occurrence scores/entanglement risk for all whale species. There are multiple confirmed entanglements of gray and humpback whales in the Dungeness crab trap fishery; however, there have been no recorded entanglements of blue whales in any type of fishing gear on the US west coast. Whale behaviour and morphology could possibly explain the discrepancy between the model results and what is in the entanglement records.

Saez noted that a Fixed Gear Guide was developed as part of a larger effort addressing the issue of marine mammal entanglements and to assist in classification of gear (active or lost)[8]. Photos, diagrams, and maps are used throughout the document in combination with written descriptions of gear, gear configurations, and management/regulations to characterise each fishery (Saez *et al.*, 2013).

DISCUSSION

The Workshop noted that microchips that can be scanned to identify origins of the material could be inserted into plastic; chemical markers can also be used. Gear guides should be considered locally applicable and subject to regular revision.

[8]The guide is a living document and available online at *http://www.swr.nmfs.noaa.gov/psd/fixed_gear.htm*.

It was asked if fishing gear was regularly dumped and, in the case of trawl gear because of its cost, this seemed unlikely. In other fisheries there are a variety of reasons for gear being lost and/or dumped (McElwee *et al.*, 2012; McElwee and Morishige, 2010).

In some fisheries, the value of catch is high enough to incentivise the fishermen to put out more gear than is needed. In such situations, discard occurs due to lack of capacity on the boat to haul the gear to port when some of it is full. The Workshop recognised that reduced fishing effort can result in greater profit-for-unit investment, while substantially reducing entanglement risk.

The Workshop **recommended** that fishery effort models should be coupled to lost gear recovery effort data to evaluate whether higher fishing effort is correlated with areas of higher densities of lost gear.

3.2 Review of the available marine debris entanglement data – consideration of species and data-types

3.2.1 Gear recovery in California and modelling impacts in Puget Sound, Washington, USA

Gilardi presented information on lost gear recovery efforts in California and also on a cost-benefit analysis for gear removal relating to loss of commercially valuable species in derelict nets in Puget Sound. The California Lost Fishing Gear Recovery Project, a programme of the UC Davis Wildlife Health Center, has been removing lost commercial and recreational fishing gear from California coastal waters since 2006. Lost gear is located and recovered by contract divers (commercial urchin harvesters), and either repatriated to original owners or disposed. Data on location, gear type, and number of entanglements or entrapments are recorded. To date, the programme has recovered more than 60 tons of gear and debris, and has documented more than 800 entanglements, including five small cetaceans and one pinniped.

The programme has also conducted research to better understand the population-level impacts of derelict fishing gear on marine species. A retrospective epidemiologic investigation of more than 12,000 intake medical records of gulls, pelicans and pinnipeds admitted to wildlife rehabilitation centres in California revealed that, depending on location and season, more than 10% of gulls and up to 4% of pinnipeds were impacted by fishing gear entanglement or ingestion injuries (Dau *et al.*, 2009).

In collaboration with the Northwest Straits Initiative, derelict nets in Puget Sound were monitored by divers over two-month periods to measure entanglement rates, in order to develop a predictive model for estimating total mortality caused by a net during its lifetime as derelict (Gilardi *et al.*, 2010). This model was then used to estimate the cost-to-benefit ratio for commercial fisheries of derelict gear removal, based on true costs and market values. This evaluation suggested that, regarding entanglement of Dungeness crab in derelict gill nets specifically, the cost-to-benefit ratio was 1 to 14.5. When the model was applied to grossly estimate total mortality of marine mammals in derelict gillnets in Puget Sound, and costs of gear recovery compared to costs to rehabilitate marine mammals impacted by oil spills, derelict gear removal was determined to be a highly cost-effective measure to mitigate anthropogenic impacts on marine mammals.

DISCUSSION

The Workshop **agreed** that lost gear recovery has saved thousands of animals, even ones that do not have a commonly associated monetary value. Combining government mandates to conserve endangered species and marine mammals with conservation of commercially valuable species makes a strong case for supporting lost gear recovery.

Although some people have considered lost gear as 'artificial habitat', recovery efforts result in the restoration of natural habitat and the removal of debris that will cause damage. The Workshop noted that the entanglement risk of man-made materials on the sea bed and other environmental consequences likely exceed the perceived benefits that items such as tires, toilets and traps may have by creating artificial habitat.

The Workshop **recommended** that when derelict fishing gear is removed from the marine environment, that a dedicated observer (biologist) is on board to collect data on the species, composition, and numbers encountered in the gear, as well as on the type and condition of the gear.

3.2.3 The work of the Consortium for Wildlife Bycatch Reduction

Werner reported the on-going research programme of the Consortium for Wildlife Bycatch Reduction, a group he directs that comprises members from US east coast fishing groups and academic institutions. The Consortium supports the investigation of innovative fishing techniques that can potentially reduce endangered species bycatch. The focus of the presentation was on several research projects the Consortium is undertaking to examine potential fishing gear modifications for mitigating large whale entanglements, in particular for the North Atlantic right whale (NARW), *Eubalaena glacialis*, an endangered species with an estimated global population of only 500 individuals. These projects are evaluating:

(1) ropes of different colour (and luminosity) to determine if NARWs show different avoidance behaviour;
(2) ropes with reduced breaking strength that are still durable enough for fishing;
(3) 'stiff ropes' that may have reduced entanglement properties because they are materially stiffened (e.g. hard lay ropes) or are under higher tension (such as in the northeastern portion of Maine where buoy lines tend to be stiffer, pulled taught by the opposing forces of flotation at the sea surface and weight of bottom gear, both exposed to high current and tidal forces); and
(4) rope-less fishing techniques, such as those that incorporate acoustic release technology to maintain buoy lines close to the sea floor until the time they are released to the surface for hauling.

In addition, given that testing of experimental gear with large whales is impractical, especially noting the need for statistically adequate sample sizes, the Consortium is supporting the development of a computer model to evaluate and test bycatch mitigation techniques with large whales.

Although these projects are still on-going, as a justification for the research into reduced breaking strength ropes, Werner presented the results of analysis of ropes retrieved from disentangled right whales showing evidence that breaking strength of rope is a factor affecting the likelihood that a large whale can break free upon entanglement in fixed fishing gear. In addition, he shared knowledge about a fisherman in Australia who has incorporated acoustic releases into his lobster fishing gear. These kinds of examples help inform what is possible in terms of practical fishing methods that can also reduce entanglements, but need to be evaluated within the local fishing context. Considering the potential of reduced breaking strength rope, its application is probably only suitable in areas that can use 'light duty' gear. Also, the appeal to an Australian lobster fisherman to use acoustic releases involves several unique local circumstances that include a high market price/kilo of product, a previous management action that reduced the number of fishermen in the fishery, and other factors. In the northeast US, lobster fishermen have raised their objections to using this technology by pointing out the high cost of the devices currently available on the market, and the increased probability of gear conflicts both within the fishery and with draggers.

The Consortium's research is directed at avoiding the incidence of whale entanglements in the first place, which Workshop participants acknowledged as the preferred solution to the problem of marine mammal entanglements in fishing gear. One concern was that gear modifications mandated by federal regulators in the US in response to whale entanglements (such as 'weak links' inserted between the top of a buoy line and the buoy, and groundlines attached to adjacent lobster traps that are negatively buoyant), whilst intuitively believed to reduce whale entanglements, have yet to produce scientific proof of their efficacy as deterrents. As such, they represent examples of often costly and perhaps even impractical modifications for fishermen that should be monitored to measure their effectiveness as entanglement deterrents and the consequences to fishermen.

These kinds of projects, involving collaboration among engineers, wildlife biologists, and fishers, highlight the advantages of engaging fishers as part of the solution to marine mammal entanglements. The idea for carrying out research into ropes with reduced breaking strength emerged from teams of fishermen and scientists who jointly studied gear retrieved from disentangled whales. Furthermore, it highlights that incentives exist for fishermen to modify fishing gear that reduce marine mammal bycatch, and that the problem can sometimes be solved without relying on new regulations enacted by government agencies.

The Workshop **recommended** that ideas for reducing cetacean entanglements and the occurrence of derelict gear should be generated in collaboration with fishermen, recognising that practical and sustainable bycatch solutions and reduction of loss of gear tend to emerge from partnerships between science and industry.

As well, the Workshop **recommended** that fisheries managers consider the influence that fisheries management schemes (e.g. ITQs, TACs, etc[9].) have on facilitating the incorporation of fishing methods that can be better for whales and that lead to a reduction of marine debris.

The Workshop also **recommended** that in fisheries where regulatory actions and agencies are unlikely to exert a strong influence over local fishing practices (such as in small-scale artisanal or non-industrial fisheries) the onus should be on collaborative research with fishermen. This should aim to identify practical solutions that provide local incentives to adopt alternative fishing methods that reduce the generation of marine debris and entanglement risk for cetaceans.

The Workshop also highlighted that prevention of entanglements is the preferred method, but stressed that concerted and well-funded research is required to evaluate fishing innovations for reducing marine mammal bycatch and generation of debris.

There are examples of programmes that are currently removing derelict fishing gear in different parts of the world.

[9]An ITQ is an Independent Transferable Quota and is part of a Total Allowable Quota (TAC). Both are typically set each season for each fished stock.

These projects provide immediate benefits to marine animals, including cetaceans, by removing gear that is a threat to entanglement and ingestion (McElwee and Morishige, 2010). The knowledge and experience from these on-going programmes could be beneficial to other countries that have not yet tackled the problem of derelict fishing gear.

The Workshop **recommended** that a programme is initiated through the IWC to provide an effective transfer of information and methods from on-going programmes to countries interested in beginning new derelict gear removal programmes and to stimulate the adoption of official programmes for removing fishing gear as debris. This could be modelled after the IWC's disentanglement training programme with guidance from the IWC's Scientific Committee and supported through the IWC.

The Workshop **recommended** that the IWC should identify effective programmes of derelict gear removal. Furthermore, the IWC should share knowledge gained on gear removal and its benefits.

It was noted that marine spatial planning and technological innovations might help to reduce conflicts between different maritime activities that may result in the creation of marine debris.

The Workshop discussed the effectiveness of management measures such as sinking ground line requirement and weak links. The NOAA Fisheries Atlantic Large Whale Take Reduction Team (TRT) has compiled a matrix to summarise the gear research that has been proposed and conducted to reduce entanglements of large whales in the Atlantic[10].

There was also a suggestion to revisit the feasibility of lipid-soluble rope for use in fisheries and other marine industries that rely heavily on the use of rope. The concept of lipid-soluble rope was not practical when originally researched in the past, but technological advances may make it possible today.

In some countries efforts are made to reduce bycatch, but rarely is it noted that sometimes these actions increase the amount of gear (marine debris) in the environment. This message should be shared with the next entanglement Workshop.

The Workshop **strongly encouraged** continued research and development into alternative fishing techniques, strategies to reduce the entanglement of cetaceans in active fishing gear, and validation of the effectiveness of existing fishing practices that lower the risk of entanglement incidence and severity. The Workshop **further encouraged** that the assessment of such alternatives in active fishing gear include evaluation of their potential to alter the contribution of marine debris in the environment and the risk of entanglement or ingestion by cetaceans.

Furthermore, the Workshop **recommended** that future efforts to both understand and mitigate cetacean entanglement should include participation from multiple stakeholders (e.g. manufacturers, fishers and other relevant ocean users).

3.3 Distinguishing active fishing gear entanglements from entanglement in marine debris

With regard to the issue of cetacean entanglement in man-made materials, a growing body of evidence indicates that the vast majority of entanglements occur in synthetic ropes and nets associated with fishing (e.g. Johnson *et al.*, 2005). Entanglements have been reported for most cetacean species in a wide variety of fishing gear, but predominantly in gear that is either drifting or anchored. While the relative entanglement risk posed by actively fished gear versus that posed by lost, abandoned or otherwise discarded fishing gear, is unclear, it is very clear that the solution to both can only be reached through full engagement with the manufacturers of fishing gear and the raw materials used to produce it, fishers and other involved parties.

A number of potential methods of distinguishing active gear from derelict gear were discussed. These included: gear marking; modelling fisheries activity, identifying geographic positions exhibiting high gear loss (through reporting and gear retrieval programmes), and using information on rates of gear loss to predict likelihood of gear being derelict; consideration of fouling organisms; engagement with fisheries to collate further information on potential methods of distinguishing active from derelict gear, as well as to identify key causes for loss or dumping of gear; and consideration of the number of different gear types (where multiple gear types are found on an animal they are likely to have been derelict at the time of entanglement).

With respect to gear marking, the Workshop **recommended** that every effort should be made to distinguish whether the entangling gear was active or derelict at the time of entanglement. Recognising the difficulty involved in this, the Workshop **recommended** further research to assist this process.

When considering the entanglement risk of debris: if gear is lost, there is an unknown period of time during which it may pose the same entanglement risk as active gear (McElwee and Morishige, 2010). Fishing gear, whether active or derelict, often lacks traceability to owner or fishery, and is comprised of materials and components designed to optimise fishing, but with the potential to injure or kill cetaceans.

The Workshop **recommended** combining existing fisheries knowledge and appropriate fishing techniques with applied research and innovation to engineer and utilise fishing gear that ideally is: (1) traceable; (2) generates less debris; and (3) causes fewer injuries and mortality to cetaceans.

It was suggested that the Workshop remain mindful of the idea of overall reductions of volume of man-made material in the ocean.

3.4 Pathology protocols: recommendation for diagnosis of entanglement and ingestion impacts of fishing gear and aquatic debris in cetaceans

In situ examination of entangling and ingested debris and associated traumatic injuries in live and dead animals is essential for revealing pathologic impacts of fishing gear and debris on cetaceans. Changes can include laceration, amputation, and constriction-related injuries externally, and/or, ileus, strangulation, ulceration, impaction, emaciation, and/or rupture internally. Evidence of chronic effects (e.g. emaciation) or prior trauma from entanglement and debris interaction, where material is no longer present, can also be obtained through careful clinical or post-mortem examinations by scientists and through subsistence harvest monitoring. In addition to the information provided for impacts assessment, this information will be beneficial for assessment of actual synthetic material/debris interactions (exposures) for cetaceans. Potential chemical exposure should be evaluated, and may or may not be accompanied by gross or histologic changes due to transfer of monomers, additives and sorbed priority pollutants from the plastic into the tissues (Rochman and Browne, 2013).

[10]Available at: *http://www.nero.noaa.gov/whaletrp/plan/gear/Gear%20 Research%20Matrix_Oct%202010_final.pdf.*

The Workshop **recommended** the following diagnostic approach.

Evaluating possible impacts due to entanglement and ingestion impacts of fishing gear and debris should be done using a classical differential diagnostic approach when possible, to enable: (a) detection of trauma, chemical exposure and other sequelae related to exposure; and (b) analysis of their roles in contributing to morbidity and mortality in the context of other potential causes, such as infectious or non-infectious disease, nutrition, and other possible etiologies. In situations when a full differential diagnostic approach is not possible, efforts to document the presence of marine debris, both ingested and entangled, are still very important. Most efforts focus on macrodebris but efforts should also focus on microdebris. Efforts should be made to include the following components in the examination of all live and dead wild cetaceans as appropriate.

(1) Gross necropsy examination and report: description, sketches, images, measurements, collection and preservation of entanglement/debris, and affected body part(s). The entire gastrointestinal tract should be opened and examined. Standard cetacean necropsy protocols should be followed (Barco and Moore, In press; McLellan *et al.*, 2004; Pugliares *et al.*, 2007).
(2) Debris characterisation: material should be categorised as rope, net, floats, monofilament, braided line, hooks, packaging, cigarette butts, plastics and other anthropogenic material. Size, shape (image analysis of digital photographs), mass, volume, and polymer type if plastic (e.g. vibrational spectrometry) should all be recorded, and all evidence should be identified as to source using established techniques (Browne *et al.*, 2010) as practical and in collaboration with the relevant industries, to maximise the integration of data into these industries, such as plastics and fishing.
(3) Confirmatory diagnostics: further analyses as practical and indicated should be undertaken, such as histopathology, imaging, analytical chemistry, blood test and organ function tests, to document presence of and type of debris as well as possible impacts to the animals. It would be useful to provide resources to develop techniques to identify particles of plastic in the tissues of animals. Criteria for the assignation of degree of confidence of findings (e.g. quality of data) of entanglement or ingestion contributing to or causing morbidity and mortality have been recently published and should be applied (Moore *et al.*, 2013). Chain of Custody documentation should be maintained as required or possible.
(4) Training designed for specific countries and regions, and database maintenance would both enhance understanding of these problems.

3.5 Classification of debris types

The group noted that classifying marine debris is essential for understanding its sources, distribution, and impact on cetaceans. The Workshop **recommended** a two-part classification system to address this requirement. The first aspects should include characteristics adequate to understand the use, configuration, and other aspects of the debris while it is still in active use. Largely, these characteristics will map to the industrial function of the item – holding liquids, catching fish, providing buoyancy. The second aspect of the classification system should focus on characteristics of the item after it has left human possession and contribute to the harm the item might cause to cetaceans. For instance, this might include colour (i.e. visibility), flexibility, sharp edges, size, strength, density, site in water, flexibility, shape/aspect ratio, and a host of other aspects that affect its ability to harm cetaceans.

Currently there are projects to classify debris to a source in the Northwest Hawaiian Islands and Australia. Clean-up efforts are very labour intensive and expensive; therefore recent efforts in the Hawaiian Islands have focused more on removing gear. Local fishermen involved in lost gear recovery in California and on the US east coast have assisted in identifying a fishery and sometimes a specific fisherman. Fishermen may also be useful in determining active versus derelict gear in entanglement cases. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia has developed a cluster analysis of the physical origination sources of debris. Debris from commercial and recreational fisheries can be difficult to identify, especially if trying to trace to a certain area.

4. INGESTION

4.1 Papers relating to ingestion

Baulch presented an analysis of data collated on published and unpublished cases of debris ingestion from across the globe (1960-present). Ingestion of debris has been reported in the literature from 43 cetacean species, comprising seven mysticete and 35 odontocete species. The chances of detecting the ingestion of debris may be lower in mysticete species due to lower stranding and necropsy rates. Hence, the low number of mysticete species documented ingesting debris to date should not be taken as evidence that it does not occur. A number of studies (where sample size was >10) have assessed occurrence rates of cetaceans observed to have ingested debris. The occurrence rates of debris ingestion ranged from 2.2% in harbour porpoises, *Phocoena phocoena*, that stranded on the UK coast (Deaville and Jepson, 2010) to 31% in Franciscana dolphins, *Pontoporia blainvillei*, bycaught in Argentina (Bastida *et al.*, 2010). It was noted that publications have consistently showed high rates of debris ingestion in franciscana dolphins and given that these studies were based on animals captured as bycatch, ingestion of debris is unlikely to be over-represented as compared to strandings data.

Baulch presented maps showing where interactions have been reported. A relatively high number of cases have been reported in the US, Japan, Australia, South America, and parts of Europe, but records are lacking from Africa and Asia. Such differences in reporting rates between different regions are likely to influence perceptions of the severity, distribution and frequency of debris interactions at a global scale. Google fusion tables (Google forms and open data kit) were presented as a potentially valuable tool for collating global data in the future (see Fig. 1). Data collection forms can be designed and sent to stranding networks and responses can then automatically populate an online table. This would greatly facilitate data collection and collation and thereby aid understanding of the threat of marine debris. It was further emphasised that it would be important to collect information on rates of debris occurrence in animals necropsied (presence/absence) as well as rate and type of pathology (impact on animal) to gain a better understanding of the extent of the threat it poses to different species and populations.

Discussion

The Workshop noted that there will be low reporting levels for ingestion of debris in some areas, and that even where

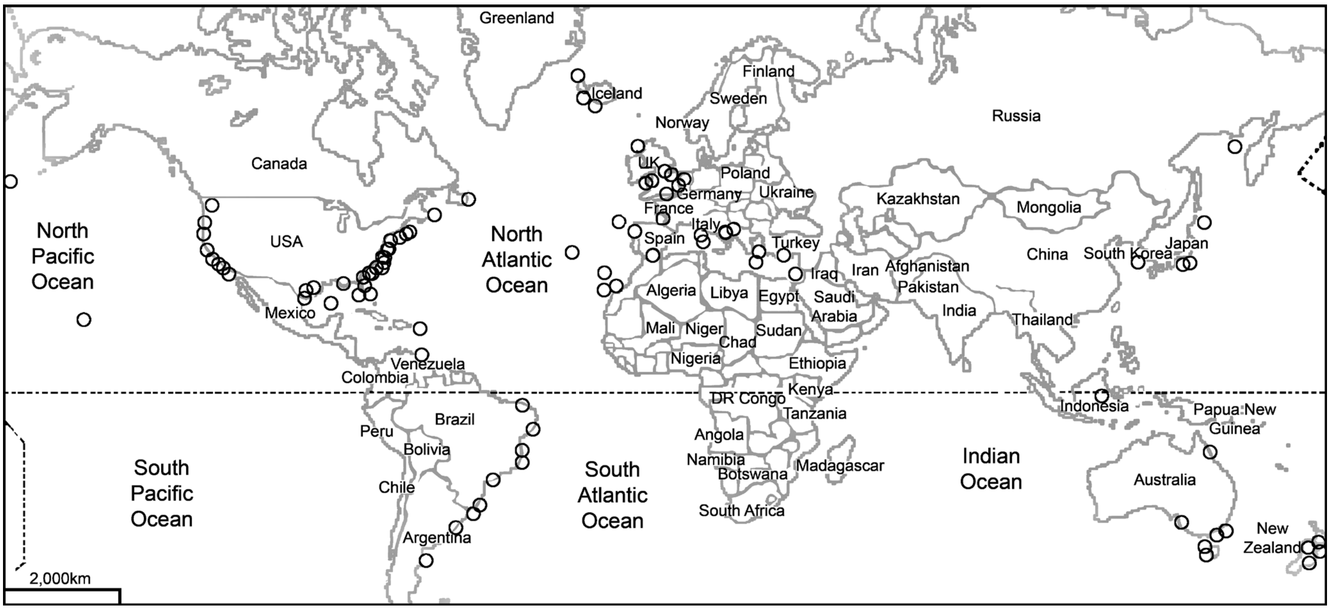

Fig. 1. Distribution of debris ingestion events reported in the literature (1960-2012).

data are collected, there may be poor accessibility to and collation of the data at a national and international scale. Possible formats for a global database were discussed, including the use of freely accessible databases such as that presented by Baulch, the IWC's Cetacean Emerging and Resurging Diseases (CERD) website, and the inclusion of this data within countries progress reports to the IWC.

Therefore, noting the poor coverage of global data on rates of debris ingestion, the Workshop **recommended** that where possible, full investigation of the gastrointestinal tract should be part of necropsy procedures. It also **recommended** that information on rates of debris occurrence in animals necropsied (presence/absence) as well as the rate and type of related pathology (impact on animal) should be collected in order to better understand potential population-level threats. Also, it **recommended** that data collected on debris interactions should be submitted to a global database, for which a standardised data form should first be designed.

As a first step, the Workshop **recommended** that rates of marine debris interactions with cetaceans be reported by IWC member countries, in the appropriate data fields within their National Progress Reports (e.g. stranding and bycatch), and that the data be recorded in such a way that it is available for future analysis. The Workshop also **recommended** that the Scientific Committee revisit the possibility of including a link to a marine debris reporting/data aggregation site on the CERD homepage at the upcoming IWC meeting or, if this was not viable for the Scientific Committee to recommend, an appropriate format for future data management.

4.2 Review of the available marine debris ingestion data

4.2.1 Case studies: Italy

Podestá reported the results of gastric analyses performed on stranded cetacean species in Italy, focusing on those where ingestion of marine debris had been documented. The most interesting case was of seven sperm whales that stranded together in 2009 (Mazzariol *et al.*, 2011). Gastric contents were examined in six of the seven sperm whales. Stomach contents consisted of cephalopod beaks and synthetic materials, including fishing gear and hooks, ropes and various plastic objects. No evident obstruction or perforation of the alimentary tract was noted, suggesting that marine debris was not the cause of death in these cases. Weight of synthetic materials varied from 9.5g in one individual to nearly 5kg in one of the stranded animals. Plastic was found in the stomachs of all six specimens and fishing nets, lines and one hook were found in two animals. Marine debris was documented in the stomachs of seven out of twelve additional sperm whale strandings recorded in the Mediterranean Sea (De Stephanis *et al.*, 2013; Roberts, 2003).

Among the other species studied, only two of 10 Cuvier's beaked whales, *Ziphius cavirostris*, stranded in Italy have been recorded to have plastic debris in their stomachs. Marine debris was not found in any of the 50 striped dolphins, *Stenella coeruleoalba* studied and only two of 24 bottlenose dolphins, *Tursiops truncatus*, had fishing net in their stomachs, most likely as a result of depredation on fishing gear.

The preliminary results support the idea, as reported in other papers (Evans and Hindell, 2004; Jacobsen *et al.*, 2010; Laist, 1997), that sperm whales seem particularly affected by marine debris ingestion. Small dolphins were never found with ingested plastic, and while some had fishing nets, these were probably linked to depredation. Podestá urged that more detailed studies on debris ingestion should be a priority for the whole Mediterranean area, which is highly polluted by plastic debris. Fossi noted that the problem of marine debris in this area is supported by the high occurrence of marine debris in the stomach contents of Mediterranean turtles (see also Garibaldi and Podestá, 2013).

DISCUSSION

It was noted during discussion that ingestion of marine debris is not always an accidental process for cetaceans and that depredation on fishing gear may result in ingestion of fishing gear. A Workshop on marine mammal bycatch in longline fishing gear sponsored by the Consortium for the Wildlife Bycatch Reduction and NOAA's Office of International Affairs is being held in October 2013[11]. It should be noted that ingestion of fishing gear due to depredation presents a different management problem to the passive ingestion of marine debris.

[11] *http://www.bycatch.org/node/796.*

The Workshop **recommended** that identifying the sources and fates of plastic debris would help improve and support Extended Producer Responsibility (EPR) initiatives by the manufacturer or distributor of the plastic. EPR is an effective tool for informing product design and could be used to raises awareness of the issue.

4.2.2 The structure of ziphiid stomachs

Yamada presented his research with collaborators, which finds that cetaceans, and especially ziphiids, may be particularly susceptible to ingesting plastic debris because of their stomach structure (Yatabe *et al.*, 2010). These studies were based on stranding data from Japan. Yamada introduced the anatomy of cetacean digestive tracts: the existence of connecting chambers was highlighted as a potential hindrance factor for the passage of non-digestible material, including debris, through the digestive tract (see Fig. 2.).

The number of connecting chambers varies between eight and 11 and the minimum diameter of the passage aperture between chambers is less than 15mm (Tamada, pers. obs.). The flow of digestive material into connecting chambers may be prevented when the main stomach is full. In ziphiids, the connecting chambers are divided into many smaller chambers, with more than 10 small chambers in some species (Mead, 2007), which may limit the passage of large items.

In necropsies of 80 stranded ziphiid carcasses, 73.8% of *Mesoplodon stejnegeri*, 50% of *M. ginkgodens*, 33.3% of *M. carlhubbsi*, 66.7% of *M. densirostris*, 100% of *Indopacetus pacificus* and 33.3% of *Ziphius cavirostris* had foreign substances in their stomachs. In most animals, quantities of foreign material in these stomachs were not seriously large; however some individuals had a huge volume of man-made debris that filled the main stomach. These animals would have suffered from the blockage of their digestive tract and may have been malnourished and lost body condition as a result, similar to the case of Inky, a pygmy sperm whale, *Kogia breviceps,*, treated at the National Aquarium of Baltimore (Stamper *et al.*, 2006). Yamada noted that debris had also been observed in finless porpoise, *Neophocaena phocaenoides*, rough-toothed dolphins, *Steno bredanensis* and spotted dolphins, *Stenella attenuata* stranded in Japan. Yamada also presented the results of acoustic research conducted by the National Research Institute of Fisheries Engineering.

DISCUSSION

During discussion it was noted that in addition to recording attributes of ingested debris, such as the weight, volume and type of debris, its size in relation to that of the digestive tract should be noted in different species, and that an index that quantifies or qualifies how full the stomach is would be useful. The issue of whether ziphiids were able to regurgitate synthetic materials ingested was raised. It is unclear whether this is possible. It was also noted that sub-lethal pathology can occur when the quantities of debris are lower and that this should also be investigated and noted in necropsies. Effects may include dietary dilution and reduced appetite with resulting reductions in body condition and other fitness-related pathology. While these may be less readily observed, it is important that such impacts are considered in cases of sub-lethal debris ingestion.

Moore noted that D-tags on beaked whales have been used to image the acoustic signature of their prey items at foraging depths up to 1,800m (Madsen *et al.*, 2005). With further information on the acoustic signature of plastic items versus prey items, it might be possible to establish whether and which debris items were being selectively ingested by cetaceans.

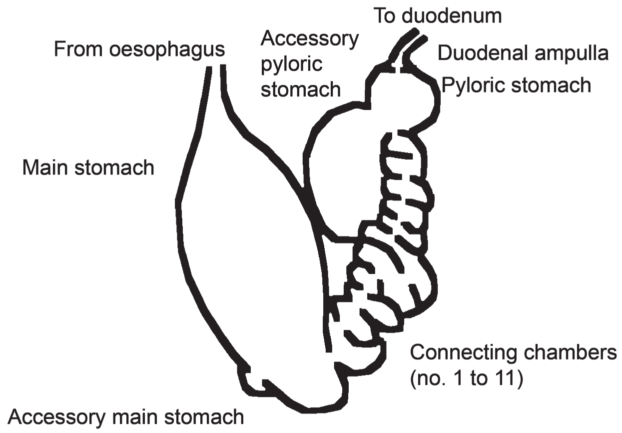

Fig. 2. Schematic illustration of the stomach of *Mesoplodon ginkgodens*.

The Workshop **commended** the valuable work conducted by Yamada and colleagues and **recommended** further research in the following areas: obtaining acoustic information on how marine debris is perceived by cetaceans, which would help understanding of the causes of ingestion; determining the distribution of debris within the habitat of deep diving whales; and given the overall paucity of information on rates of debris ingestion in wild cetacean populations, non-lethal research and evaluation of strandings to measure rates of occurrence of debris ingestion and the pathological impacts would be valuable in a range of species and areas.

The Workshop noted and **expressed concern** regarding the high rates of debris ingestion in certain species (e.g. ziphiids, sperm whales and certain populations of franciscana dolphins). The Workshop **agreed** that, depending on severity, ingestion of debris is a welfare concern at an individual level. While it remains unclear whether there are any species or areas where it is a population- level concern, the conservation threat should be assessed in the context of the local population size, where even low mortality levels may be of concern.

The Workshop noted that the impact on cetaceans of entanglement and debris in the Arctic may increase as industries move into higher latitudes with climate change-driven ice recession opening up new areas for industrialisation. In this regard Reeves *et al.* (2012) noted that in 2009, the North Pacific Fisheries Management Council closed the Arctic Management Area (federal waters in the US Arctic) to commercial fishing. This area will be closed until more data are collected (largely absent at present), so that fishing can be conducted sustainably and with due concern for other ecosystem components. The Workshop **recommended** the benign collection of benchmark data on the impacts of marine debris on cetaceans in this area at the earliest opportunity.

4.3 Recommended pathology protocols

The Workshop's recommended pathology protocols are given at Item 3.4.

4.4 Categorisation of ingested debris types

See Item 3.5.

4.5 Toxicological effects of plastic additives

Panti presented information on the toxicological effects of plastic additives on cetaceans. The assessment of toxicological risk in marine mammals requires the development of sensitive biomarkers to evaluate the exposure to plastic additives, such as bisphenol A (BPA) and phthalates. BPA and phthalates are widely distributed in the marine environment, acting as agonists or antagonists for endocrine receptors. To propose new gene expression biomarkers in cetaceans Panti and collaborators have developed an *ex vivo* approach (organotypic cultures), exposing cetacean skin biopsies to increasing doses of mixture of contaminants. Organotypic cultures collected from fin whales, killer whales, sperm whales and bottlenose dolphins were exposed to increasing concentrations of BPA and phthalates. Two potential biomarker genes were selected, the peroxisome proliferator-activated receptors α and γ (PPAR α and γ), which belong to a superfamily of ligand-dependent nuclear receptors that regulate physiological processes of lipids homeostasis, inflammation, adipogenesis, reproduction, etc. The mRNA levels of the two PPARs were quantified in response to the two different treatments in the four species. The results revealed that the BPA and phthalates treatments induce the expression of the genes PPARα and PPARγ, showing a dose-response trend. Based on these results, the gene expression biomarkers were also measured in skin biopsies from free-ranging Mediterranean fin whales and bottlenose dolphins from Mediterranean Sea and Sea of Cortez. The study was carried out in order to validate the *ex-vivo* approach, but more importantly, to assess the potential exposure of the two species to plastic additives. Due to the up-regulation of the PPARγ gene (an early warning signal), both fin whales and Mediterranean bottlenose dolphin appear to be exposed to plastic additives. These data represent the first evidence of emerging contaminant exposure in free-ranging fin whales and bottlenose dolphins, suggesting the potential use of these diagnostic markers as an early warning signal of exposure to plastic released compounds in marine mammal monitoring.

Panti noted that their research currently focuses on mysticetes and that there is a need to develop a suite of specific biomarkers. There are unresolved questions regarding the relative rates of leaching of contaminants from microplastics versus macro-debris. Initial research suggests that in cases of macro-debris ingestion, there is no evidence of phthalate exposure and this is borne out by research in sea turtles, and stranded sperm whales along the Italian coast, that presented with macro-plastic debris in their stomachs.

The Workshop recommended that further work on surface filter feeders, particularly the North Atlantic right whales, should be undertaken. As surface feeders, right whales may be exposed to high quantities of microplastics in the surface microlayer. The Workshop also commended the work of researchers at the University of Sienna and **encouraged** further work of this kind.

By 2050, an extra 33 billion tonnes of plastic is expected to be added to the planet (Rochman and Browne, 2013). This material enters and persists in environments from the poles to the equator and down to the depths of the sea. Slow degradation into smaller particles means that microplastics have been accumulating in the environment (Browne *et al.*, 2007; 2010; 2011; Thompson *et al.*, 2004). Once ingested by animals, such microplastics can accumulate within the guts of organisms where it can be engulfed and stored by cells (Browne *et al.*, 2007; 2008). This provides a feasible pathway for microplastic to transfer sorbed contaminants, constituent monomers and additives into the tissues of animals and affect physiological processes that sustain health (Teuten *et al.*, 2007; 2009). At least 78% of priority pollutants listed by the EPA and 61% listed by the European Union are associated with plastic debris (Rochman and Browne, 2013). While there are established techniques for quantifying other contaminants in tissues of cetaceans, strikingly, there is still little information on the uptake and toxicological consequences of microplastics (e.g. endocrine disruption). Preliminary research suggests fin whales (Fossi *et al.*, 2012) may contain large quantities of phthalates (potentially derived from microplastic) with possible alterations to the expression of genes associated with endocrine disruption.

DISCUSSION

The Workshop expressed concern regarding the potential impact of microplastics and made the following **recommendations** with regards to further research:

- develop and validate the use of direct (vibrational spectroscopy) and indirect (e.g. contaminants associated with plastic: phthalates, PCBs, PBDEs) measures of ingested microplastic in baleen whales;
- examine whether ingested micro- and nano-plastic can transfer into the food chains of cetaceans;
- evaluate the use of established biomarkers of exposure to assess the toxicity of microplastics, including endocrine disruption; and
- conduct laboratory and field experiments to investigate the bioavailability and toxicity of priority pollutants and additives from microplastic.

It is also important that future research on the uptake and toxicological impacts of microplastics in filter-feeding species of mysticetes includes both species with intense surface feeding activities (e.g. right whales) and species with feeding related to the sediment (e.g. grey whales).

The Workshop also noted that baleen whales and other large filter feeders should be considered in national and international marine debris strategies (e.g. Descriptor 10 [marine litter] in the EU Marine Strategy Framework Directive) as critical indicators of the presence and impact of microplastics in the marine environment.

In conclusion, the Workshop agreed that ingestion and inhalation of marine debris may sometimes be lethal, that sub-lethal pathology may also occur, and that intake of debris is a problem, both as an individual welfare concern and potentially for some populations and species. Therefore, the Workshop encouraged further non-lethal research on the individual and potential population-level impacts of ingestion of debris and, noting the promising research on biomarker development, the group **recommended** further work in this field.

5. THE DISTRIBUTION OF DEBRIS

5.1 Request for papers relating to investigating the distribution of marine debris

Known marine debris databases were described with the caution that not all will have geo-referenced locations and may not pertain exclusively to cetaceans. The Marine Debris Monitoring and Assessment Project (MDMAP) is expanding the use of standardised shoreline survey protocols and building our understanding of debris types and abundances across geographies. The efforts of the MDMAP partner organisations, including volunteer coordination, field surveys, and data submission, are critical for this type of large-scale data collection. The many shoreline monitoring teams have uploaded their survey data to the *md-map.net* database. A pending NOAA Marine Debris Monitoring Tech Memo will be outlining protocols for monitoring marine debris. An additional source of a long-term database comes from the Norwegian survey and derelict gear removal programme, which has been systematically removing derelict fishing gear from their waters from 1983 to the present time.

5.2 Modelling approaches to identify spatial overlap between cetaceans and harmful debris

Wilcox presented three projects on risk analysis for marine debris impacts on wildlife. The first focused on derelict fishing gear impacts on marine turtles. This project involved modelling the spatial overlap between drifting gear and marine turtles as a proxy for entanglement risk. The model was validated against both known tracks of drifting gear and data on locations where turtles were entangled and stranded. The model was able to make accurate predictions of catch. Based on the analysis it was possible to identify cost effective areas in which to conduct surveillance and recovery of abandoned gear. The second two projects involved analysing the spatial overlap of marine debris more generally, with either marine turtles or seabirds, respectively. In this case, the researchers used a global model of marine debris distribution, based on oceanographic drift patterns and population density. This was overlain with species distributions to predict relative encounter rates for species as a measure of risk. These predictions were then compared to literature data on stomach contents as a measure of plastic ingestion. The comparison revealed that consideration of species ecology was an important component of making accurate predictions, but in general encounter rates were a reasonable predictor of ingestion rates. It was suggested that this approach could be used to make predictions of relative entanglement or ingestion rates for cetaceans, although it is important to be aware of the limitations of the large-scale analyses in making local predictions.

DISCUSSION

Risk analysis provides a framework for complex problems. Simple encounters appear to be a good measure of risk and models help with making informed decisions (e.g. where to do surveillance or interceptions). It was noted that the ecology of the species concerned is also important in the analysis and that traits are useful for making predictions. The solutions are complex and incentives and alternative income sources are going to be a powerful tool (especially for developing nations). For example, derelict fishing gear has been turned into art, or used fishing rope has been turned into doormats. In addition, risk analysis models potentially could reduce management costs. Debris density plots with vertical aspects (layers of debris) were also discussed with potential benefits from the analysis. Further applications of risk analysis can be extended to other fisheries (besides 'ghostnets'), which would be beneficial to numerous regions (e.g. Brazil's marine debris problems with active and derelict longlines).

Potential projects will be looking at a global dataset of fisheries spatial data overlaid with range maps of marine mammals. However, caution should be used regarding known entanglement events due to the limited number of known events as well as the caveat that the comparison may apply to small cetaceans, but not necessarily to large whales due to the ability to drag gear for longer ranges.

The Workshop **recommended** an increase in the usage of theoretical global models that help identify locations where there is greater potential for interactions of cetaceans with debris.

The Workshop also **recommended** engagement with international aid agencies and international financial institutions (such as the World Bank) involved in the development of fisheries management in developing countries to ensure they take into account the impacts to cetaceans from unintended consequences of the various types of gear being brought into communities as an economic development strategy.

DeForce presented the work of the Sea Education Association (SEA), which has been collecting data on floating plastic debris for more than 25 years. These data are typically collected on six-week long educational research cruises as part of the undergraduate SEA Semester programme. From the data collected on the research cruises, the longest and most extensive data set on floating plastic debris in the open ocean was published in 2010 (Law *et al.*, 2010).

In 2010, the Plastics at SEA: North Atlantic Expedition set out to document for the first time the easternmost extent of plastic accumulation in the North Atlantic and measured the highest concentration of plastic debris ever recorded (26 million pieces/km^2) and found that high plastic concentrations extend at least as far as the middle of the Atlantic Ocean. To expand our knowledge of how plastic marine debris is affecting the ecosystem, the Plastics at SEA: North Pacific Expedition set sail from San Diego to Hawaii in Oct 2012. This cruise sampled not only the concentration of plastic but also micro/macro organisms growing on plastic, plastic submerged in the water column due to wind (Kukulka *et al.*, 2012), environmental persistent organic pollutants, and surveys for potential tsunami debris. This research programme continues, and plastic concentrations from 11 years of data collected by SEA in the North Pacific subtropical gyre are currently being analysed for publication.

In reference to microorganisms on marine debris, several sources of health biomarkers were discussed by the Workshop, including research on microorganisms on whales, and research of barnacles on sea turtle carapaces. One future line of investigation could be investigating the correlation of mean sea state and plastic distribution. Another project could be applying gear degradation assessment technology to gear removed during disentanglement. A potential collaboration on the filtration of baleen whales and plastics density/buoyancy/shape was also mentioned.

Mindful of emerging technologies such as deep DNA sequencing, the Workshop **recommended** that the scientific community continue to use novel approaches to support further research on the interaction between cetaceans and marine debris.

Drinkwin presented an overview of Washington State's Derelict Fishing Gear Database. This database is used to collect and store data on derelict fishing gear: debris locations, and the species and habitats documented to be impacted by the debris. In particular, most of this data relates to the Northwest Straits Initiative's Derelict Fishing Gear Program in Puget Sound, an inland sea in Northwest Washington, but also includes data from Oregon and British Columbia. The Initiative's programme has removed over 4,400 derelict fishing nets and more than 2,900 derelict crab pots from Puget Sound since 2002. The removal protocols include an on-board biologist on every removal vessel documenting and cataloguing data about the gear removed, the species found entangled, and the habitat it is affecting. The state-wide derelict gear database operates on a Structured Query Language (SQL) web platform. It is accessible through the internet to approved users. The database includes all data related to removal efforts of derelict fishing gear as well as the locations and disposition of reported gear. Data retrieval is partitioned between confidential data (not available to the public) and non-confidential data. Access to non-confidential data is routinely approved for researchers, resource managers, and interested citizens. Through an Access™ interface, the uploaded data are quality checked before officially being entered into the database for retrieval. The data can be queried in multiple ways and may be exported for spatial display and analysis.

The requirement that fishermen report lost nets was addressed, referencing the requirement of reporting based on recent implemented laws in the state of Washington, USA. A point was raised regarding using existing marine debris databases frameworks and the possibility of cloning pre-existing frameworks to maintain consistency. A short discussion pertained to the active versus passive participation in providing marine debris data to a central database. The utilisation of technology, in particular sonar, was discussed and it was determined that the expertise of the sonar operator is very important in correctly identifying gear. In the continuation of discussion of database programs, several participants have provided several references of field database programs (see below), which will reduce the error of data transfer from paper format as well as provide a unique identifier for each entry and forces the entering of a complete data form. The participants also recognise the difficulty in identifying and retrieving derelict gear in deep water.

The Workshop **recommended** the promotion and utilisation of existing database frameworks and protocols with the aim of establishing a centralised database for a comprehensive picture of global marine debris impacts on cetaceans.

5.3 The application of quantitative field sampling techniques to investigate prevalence of marine debris in cetacean habitats, including seas

The Workshop **recommended** a general broadening of cetacean boat-based surveys to include marine debris data collection.

6. POPULATION LEVEL IMPACTS OF MARINE DEBRIS

The Workshop noted that a significant amount of information on entanglement exists and can be cross-referenced from past IWC efforts. Welfare concerns related to cetacean entanglement in active fishing gear and marine debris have been well recognised by the IWC following publication of the extended time-to-death of chronic entanglement in right whales (Moore *et al.*, 2006). Recent publications have reinforced this concern (Moore and Van der Hoop, 2012; Moore *et al.*, 2013).

Recent research indicates that North Atlantic right and humpback whales have lower apparent survival after entanglement than other cetacean species (Knowleton *et al.*, In prep; Robbins and Knowleton, 2012; Robbins and Landry, 2012). The number of observed entanglement deaths has the potential to impact population viability (Glass *et al.*, 2012; Van der Hoop *et al.*, 2012). In the case of North Atlantic right whales, research suggests that reproductive rates are also impacted by entanglement (Knowleton *et al.*, In prep). The degree to which marine debris *per se* is responsible for individual and population-level entanglement impacts is an important issue that requires further study.

Several welfare concerns related to the ingestion of marine debris in cetaceans were recognised. Evidence of significant gastrointestinal impaction and other damage following the ingestion of debris as described by Yamada and reviewed by Baulch in this Workshop suggest that there is a welfare concern for ingestion comparable to entanglement, especially for sperm and beaked whales. While it was noted that several of the Workshop presentations and background information papers contributed to the current state of research in this area, the group **recommended** additional research to further detail both the physical and toxicological/physiological impacts of debris ingestion.

The Workshop group recognised the significant impact that marine debris can have on cetacean welfare and **recommended** that additional research be undertaken to further evaluate the impacts of ingested debris on cetacean welfare and population health.

Modelling of debris ‘tracks’ was noted to be of potential use in cetacean marine debris interaction estimations. There was discussion of the potential application of fishing net track models which are currently being applied in sea turtle debris interaction studies, to cetaceans. This modelling considers the path of debris that the animal encounters as well as general distribution of debris, and uses this information to make projections that may be applicable to stock assessment. These models would allow estimation of the number of animals dead but not recovered/seen. Knowledge of the ‘floating characteristics’ of cetaceans is considered critical to these models and it was noted that the UK has performed research on drifting body information that could inform these models.

The Workshop **recommended** additional investigation into the applicability of debris track modelling with particular emphasis on the scaling up of models from the regional level to a level that would benefit stock assessment and allow the determination of population level impacts.

7. CETACEANS IN FRESHWATER HABITATS

Most of the information considered at the Workshop related to cetaceans in the marine environment, but it was noted that the threats posed by man-made debris applied equally to freshwater cetaceans. Evidence from studies of river dolphins (e.g. *Inia geoffrensis* and *Sotalia fluviallis*) indicates that debris, including derelict fishing gear and actively fished gear, occurring in freshwater habitats can entangle or become ingested by cetaceans, with both lethal and sub-lethal effects (Iriarte and Marmontel, 2011) . In comparison with marine cetaceans, freshwater species tend to occur within more contained bodies of water often downstream of, or adjacent to, large urban areas that are a major source of debris within these aquatic habitats.

The Workshop **encouraged** further research into the impacts of man-made debris on freshwater cetaceans, as well as effort to mitigate the threats to these animals, some of which are amongst the most endangered of all cetaceans.

8. OVERARCHING EVALUATION OF DATA AND RECOMMENDATIONS

The application of science-based information can often be sensitive, especially considering that this information will be utilised by, and potentially impact the lives of, a diverse group of stakeholders. Thus, science-based information must be objective, transparent, and of high integrity. This requires appropriate structures (e.g. databases, networks) and personnel (e.g. scientists) to maintain the integrity of data in terms of its acquisition, analysis, storage, and maintenance. The Workshop **recommended** that these structures and personnel should be well-established in order to create and develop the best science-based approaches and/or solutions.

The Workshop group strongly supported augmented datasharing and encouraged improved coordination with respect to marine debris data and research. The group **recommended** that marine debris interactions with cetaceans be reported by IWC member countries, in the appropriate data fields within their National Progress Reports (e.g. stranding and bycatch), and that the data be recorded in such a way that it is available for future analysis.

8.1 Recommendations for future research and priorities

- The Workshop **agreed** that the overall goal of any marine debris-related research endeavour should be designed to help build risk assessment model(s) and address the issues raised in the risk models, which can be applied to other cetacean species with different geographical ranges.
- The Workshop **encouraged** debris sampling when conducting cetacean research at sea and the reporting of these results to relevant groups such as the IWC.
- The Workshop **recommended** that the IWC promote research on debris-related impacts from fisheries and **encouraged** that data reported via fisheries be collected in a format more amenable to stock assessment and risk assessment analyses (i.e. via FAO guidance).
- The Workshop **recommended** that industry partners be involved in marine debris prevention, research and response to ensure success in reducing marine debris impacts on cetaceans; and
- In the context of addressing global marine debris impacts on cetaceans, the Workshop **recommended** that the IWC utilise existing national and intergovernmental platforms for responding to the issue.
- The Workshop **encouraged** governments and industry to support all the research identified by this Workshop (and the Workshop noted that none of its recommendations would require cetaceans to be taken).
- The Workshop found that:
  - (a) entanglement of whales can involve peracute under-water entrapment, chronic debilitation, impairment of mobility, chronic infection, and ultimately death;
  - (b) recent findings concerning both the welfare and conservation impacts of entanglement have brought the topic to the attention of both the IWC's Whale Killing Methods and Associated Welfare Issues Sub-Committee and its Conservation Committee;
  - (c) the extent to which marine debris may contribute to whale entanglements is not fully understood; and
  - (d) lost gear recovery has saved thousands of animals, even ones that do not have a commonly associated monetary value.
- The Workshop therefore **recommended** that ideas for reducing large whale entanglements and the occurrence of derelict gear be generated in collaboration with fishermen, recognising that practical and sustainable solutions to minimise bycatch tend to emerge from partnerships between science and industry.
- The Workshop **recognised** the influence fisheries management schemes, e.g. Individual Transferable Quotas (ITQs), Total Allowable Catches (TACs), etc. have on facilitating the incorporation of fishing methods that can be better for cetaceans and that lead to a reduction of marine debris.
- The Workshop **recognised** that it may be difficult to exert influence over small-scale artisanal or non-industrial fisheries and, as such, the onus should be on collaborative research with fishermen to identify practical solutions that provide local incentives to adopt alternative fishing methods.
- The Workshop highlighted that fact that, while prevention of entanglements is the preferred approach, concerted and well-funded research is required to evaluate fishing innovations for reducing marine mammal bycatch.
- The Workshop **recommended** the collection of small-scale commercial and artisanal data on total global distribution of fisheries effort extrapolated from global catch, as it was noted that there are limitations to the data that FAO collects. In addition, it was noted that estimates of gear loss from relevant fisheries would be very helpful toward understanding the relative risk of active versus derelict gear.
- The Workshop **recommended** that fishery effort models should be coupled to lost gear recovery effort data to see if increased effort is correlated with higher densities of lost gear.
- The Workshop **encouraged** the IWC-supported entanglement prevention Workshop to review and incorporate appropriate recommendations from the marine debris Workshops into their report, and underlined the importance of understanding how both Workshops' recommendations will impact each other.
- The Workshop found that:
  - (a) the distribution of marine debris is dependent on the distribution of sources (e.g. urban areas, tourist beaches, shipping routes, fishing grounds) and oceanographic processes, with, for example, coastal marine areas receiving sewage, having 250% more microplastic than those not receiving sewage (Browne *et al.*, 2011);
  - (b) greater than 60% of priority pollutants are found sorbed to plastic debris at concentrations that may be hundreds of times that found in sediments and millions of times that occurring in seawater (Rochman and Browne, 2013), likely causing greater impacts to cetacean species living in areas adjacent to large human populations;
  - (c) there is minimal understanding of the extent of exposure of plastics ingested by cetaceans and the impact that such exposure has on fitness;
  - (d) all cetaceans must use the upper water-column and penetrate the surface to breathe; and
  - (e) low density microplastics (e.g. polypropylene) and concentrated lipophillic pollutants may become airborne (Wallace and Duce, 1978) and be available for inhalation above the air-water interface for risk of inhalation.
- Therefore, using existing expertise within and external to the IWC, the Workshop **recommended** that the IWC Scientific Committee evaluate the risks of ingestion and inhalation based upon: (1) the spatial distribution of microplastics and macro debris; and (2) the feeding strategies and location of feeding areas of cetaceans, and that the Scientific Committee prioritise studies of those cetacean that are likely at greatest risk of ingesting or inhaling macro- and micro- debris and associated pollutants (Fossi *et al.*, 2012). The Workshop thus

recommended that the initial focus of research be on three species of filter-feeding whales: the North Atlantic right whale, the fin whale in the Mediterranean Sea, and the gray whale in the eastern North Pacific.
- Assessment of the impact of ingested debris on the welfare and fitness (e.g. contaminants and biomarker responses) of cetacean populations should also be explored, including translocation and storage of microplastic in the tissues of whales (Browne *et al.*, 2008). The Workshop noted that additional research is needed on sub-lethal effects of ingested debris.
- The Workshop identified the following **priority mitigation measures.**

Entanglement
Since both active and derelict gear are largely responsible for cetacean entanglements, focus should be to mitigate the impacts of both of these sources on cetaceans. The Workshop **recommended** a consideration of how different managerial regimes affect (i.e. facilitate or hinder) the feasibility of implementing actions, regulatory or otherwise, intended to reduce the risk of entanglement to cetaceans, maximise the return of lost viable gear to fishers, and avoid the introduction of derelict fishing gear into aquatic environments. These actions include:

(1) targeting reduction of fishing effort;
(2) modifying of fishing gear;
(3) developing a response system to respond to and retrieve lost gear; and
(4) implementing time-area closures and marine spatial planning.

Ingested debris
As impacts are largely dependent on species group, we strongly recommend research that allows prioritisation of relevant cetacean populations as data does not exist at this time to allow this. The group **encouraged** modelling approaches that examined the relationship between marine debris 'hot spots' and information on distributions, feeding strategies and mortality rate data already collected by the IWC and other organisations. The group also **recommended** the determination of hazard function of specific debris with subsequent connection with the modelling data.

9. THE IWC RESPONSE

9.1 Work being undertaken by other IGOs

9.1.1 Europe's response to marine debris
De Ruiter presented a summary of efforts addressing the debris problem in Europe.

Information on debris in European seas is very scarce. The CleanSea project started in 2013 and its aim is to assess distribution, fate and impact of marine litter, with 17 international parties involved. OSPAR[12] Beach Litter Monitoring has been conducted in nine European countries since 2002. On average, volunteers collect 700 litter items per 100m of beach. Ropes, nets, balloons and bottle caps are found most commonly along the beaches that are monitored. Research has shown that >90% of all northern fulmars, *Fulmaris glacialis*, have an average of 30 pieces of plastic in their stomach (J.A. Van Franeker, IMARES, pers. comm.). The northern fulmar is an indicator species for the Marine Strategy Framework Directive.

The OSPAR Convention is the current legal instrument guiding international cooperation on protection of the northeast Atlantic marine environment. The Helsinki Commission (HELCOM) works to protect the Baltic Sea's marine environment from all sources of pollution through intergovernmental co-operation. ASCOBANS is the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas. A working group on marine debris formed in 2012. The aim of the Marine Strategy Framework Directive (MSFD) is to achieve good environmental status of the EU's marine waters by 2020. The MSFD Task Group Marine litter aims for a measurable and significant decrease (10%/year on coastlines) in the total amount of litter in the environment by 2020. NGOs (European Environmental Bureau, Marine Conservation Society, Surfrider Foundation, Birdlife Sweden, LPN, Bund, North Sea Foundation, Seas At Risk (SAR)) advised the MSFD on a stronger aim: a 50% reduction in 2020, compared to 2012 and problem solved within one generation: by 2038 (MSFD GES Technical Subgroup on Marine Litter, 2011).

In Norway, the Directorate of Fisheries organises retrieval surveys of gill nets annually since 1980. Within the Kommunenes Internasjonale Miljøorganisasjon (KIMO) project Fishing for Litter in the UK, Baltic and Netherlands, fisherman are provided large bags to remove litter from the sea. Within the Netherlands a group of divers remove ghost nets from shipwrecks. The Surfrider Foundation organises beach clean-ups worldwide. The Marine Conservation Society organises beach clean-ups with thousands of volunteers: they do litter surveys, published a Good Beach Guide and have campaigns on specific items, such as balloons and plastic bags. The North Sea Foundation focuses on tackling the problem at the source, with lobbying, beach surveys (OSPAR) and several campaigns, such as Beat The Micro Bead, Coastwatch (education) and MyBeach (awareness).

9.1.2 CMS/UNEP presentation
Thiele provided an overview of the Convention on Migratory Species (CMS) including its organisational structure, legal framework, and cetacean specific agreements and activities, including ASCOBANS, ACCOBAMS[13], the Pacific Islands Cetacean Memorandum of Understanding (MOU), the Western African Aquatic Mammals MOU, the Global Programme of Work on Cetaceans, and the Resolution on Marine Debris. The presentation included ideas for strengthened collaboration and opportunities for future engagement. In summary, there are 119 parties to CMS, across the globe, and species are listed in either Appendix I (endangered) or II (unfavourable status). A total of 15 cetaceans are listed in Appendix I and 43 cetaceans listed in Appendix II. The Pacific Cetacean MOU was negotiated in collaboration with the Pacific Regional Environment Programme (SPREP) and includes an action plan that mirrors the Secretariat of SPREP regional Whale and Dolphin Action Plan, illustrating a successful model of streamlined efforts between CMS and existing regional agreements. Similar MOUs could be created in other regions, provided funds and capacity to implement are provided.

CMS Resolution 10.4 on Marine Debris[14] highlights the negative impacts of marine debris on migratory species, whether caused by ingestion, entanglement and habitat degradation. It calls for the identification of hotspots where

[12]The Convention for the Protection of the Marine Environment of the North-East Atlantic.

[13]Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area.

[14]*http://www.cms.int/bodies/COP/cop10/resolutions_adopted/10_04_marinedebris_e.pdf.*

marine debris accumulates and originates, encourages Parties to develop and implement their own national plans of action to address this problem, and to report available information on the amounts, impacts and sources of marine debris within their waters in their national reports. Because so much of the Workshop's conversation included reference to bycatch and entanglement, Thiele also shared CMS Resolution 10.14 on Reducing Bycatch from Gillnets which calls for national assessments of the risk of bycatch arising from gillnet fisheries and urges the implementation of best practice mitigation measures tailored to each particular situation.

Thiele presented an overview of UNEP's Global Initiative on Marine Litter, including the Regional Seas Reports and Assessments on Marine Litter, the Fifth International Marine Debris Conference, 20-25 March 2011[15] and respective conference outcomes. Major conference outcomes included the Honolulu Strategy and the Honolulu Commitment, the Global Partnership on Marine Litter (GPML), which was launched at the 3rd Intergovernmental Review of the Global Programme of Action (GPA), and associated online tools such as the Marine Litter Network which was created to help track progress on the implementation of the Honolulu Strategy. The Global Environment Facility Scientific and Technical Advisory Panel (GEF/STAP) produced a workshop summary report (STAP, 2011).

Another example of the growing global attention to marine debris is a specific reference to it made at the UN Conference on Sustainable Development ('Rio+20') (A/66/L.56, para. 163). UNEP's Regional Office of North America together with the Natural Resources Defence Council (NRDC) convened a Marine Litter Workshop on 'Legal, Policy and Market-Based Approaches to Prevent Marine Litter at the Source.' Lastly, a technical report commissioned by the Convention on Biological Diversity (CBD) and GEF/STAP called 'Impacts of Marine Debris on Biodiversity' played an important role in informing the 11th CBD Conference of Parties decision to formally recognise the impacts of marine debris on marine and coastal biodiversity (Section I, para. 25-27). These activities provide just a snapshot of what is happening globally. It is important for the IWC to build on the existing platforms and information-gathering efforts of institutions like UNEP and others so as not to be duplicative in its good efforts to address marine debris impacts on cetaceans specifically.

DISCUSSION

The discussion that followed considered ways to better include developing countries in the IWC's conservation and management activities, and the relevance of the West African Marine Mammal MOU was noted along with the other CMS daughter agreements and MOUs that relate to cetaceans. Thiele on the behalf of CMS encouraged support from IWC on capacity building efforts in the area of marine mammal disentanglement and training strategies.

The Workshop noted the availability of numerous Regional Seas Marine Litter Assessments and UNEPs Global Initiative on Marine Litter.

A participant noted that there were many international frameworks and conventions during the presentation, but not much information on status of implementation. Thiele noted that the Global Partnership on Marine Litter will help track these efforts in the future and pointed out that money and collaboration are needed to get action on many of the initiatives that had been discussed.

[15]*http://www.5imdc.org.*

It was noted that the Fifth International Marine Debris Conference in Honolulu (5IMDC) had recognised a globally accepted definition of marine debris and the Workshop **recommended** that this discussion about comparisons between marine debris terminology might be considered by the next IWC Workshop on marine debris.

9.1.3 GESAMP structure

The Workshop noted that the Transboundary Waters Assessment Programme (TWAP; a Large Size Project of the Global Environmental Facility[16]) included two components relevant to the interests of the Workshop participants: (i) mapping the distribution of plastics in the open ocean; and (ii) describing the distribution of persistent, bio-accumulating and toxic compounds in beached plastic resin pellets (linked to the International Pellet Watch Programme[17]), based on Large Marine Ecosystems. Responsibility for completing these components lies with the Joint Group of Experts on Scientific Aspects of Marine Protection[18] (GESAMP), an inter-agency body of the United Nations comprised of independent scientists working under the direction of UNESCO-IOC. In addition, GESAMP has a working group on 'Sources, fate and effects of micro-plastics – a global assessment', running from 2012-15 that receives support from several UN Agencies, NOAA, Plastics Europe and the American Chemistry Council. GESAMP welcomes closer collaboration with IWC on the effects of plastics on cetaceans, including the potential impacts of micro-plastics on baleen whales.

DISCUSSION

Discussion followed on the types of collaboration being sought by GESAMP. It was clarified that, secondary to budgetary constraints, GESAMP was looking for collation and analysis of existing literature/data only and that they would not be gathering new data on priority contaminants.

9.2 Proposals for future actions by the IWC and opportunities for intergovernmental collaboration

Brockington commented upon the strategic opportunities for the IWC to engage in the marine debris issue. He recalled that the Commission's Conservation Committee had discussed marine debris at its meetings in 2011 and 2012, and that the welfare concerns associated with entanglement of large whales had been considered separately through the Welfare sub-Committee. Following these discussions the Commission had established an intersessional programme of working to develop applied research and management actions to reduce the impacts of marine debris on cetaceans.

At the international level there is an absence of a single overarching agreement or Convention dealing with the issue of marine debris. The lack of a central document led to calls for increased partnership working between intergovernmental organisations (IGOs), and this was especially relevant for the IWC. Accordingly, the IWC may wish to form partnerships with IGOs in the following categories:

(1) Fisheries management organisations, including for example FAO and CCAMLR;
(2) Multilateral environmental agreements, e.g. CMS, CBD, UNEP;
(3) Regional Seas agreements; and
(4) other Conventions competent in the management of debris including for example MARPOL and the Basel Convention.

[16]*http://www.twap.iwlearn.org.*
[17]*http://www.pelletwatch.org.*
[18]*http://www.gesamp.org.*

In addition to greater interlinkages with other IGOs, partnerships working with the full range of stakeholders including industry groups, NGO observer organisations and national governments would also be essential to progressing action on marine debris.

Brockington noted that the IWC was in a key position to contribute scientific knowledge on the extent and severity of the impacts of debris on cetaceans through the work of its Scientific Committee. This knowledge base could be further enhanced by expansion of national government progress reports to include actions taken to measure and mitigate the impacts of debris on cetaceans. With knowledge as a basis for action, the IWC possessed considerable strategic opportunities for creating partnerships to progress action on marine debris

DISCUSSION

The Workshop suggested an exchange of personnel and information between the IWC and other IGOs (i.e. UNEP/CMS). It was noted that the IWC presently maintains observer status at several Conventions and with regard to interacting has recently expanded its activities into new partnership actions on entanglement and other human impacts in the Caribbean and South Pacific, for example the UNEP Caribbean Environment Programme concerning Specially Protected Areas and Wildlife (UNEP-CEP-SPAW), South Pacific Regional Environment Programme (SPREP), Permenant Commission for the Pacific (CPPS), etc. It was also noted that this mechanism seems to work best when IWC brings its particular expertise to a joint activity. It was noted that IWC and CMS has an existing collaborative agreement. An inquiry as to mechanisms for reporting into UNEP/CMS was made: specific recommendations and suggested mechanisms such as participating in meetings and respective working groups (i.e. the CMS Aquatic Mammals Working Group) were shared.

A number of intergovernmental organisations including ICES, NOAA, CCAMLR and the North Pacific Marine Science Organization (PICES) were identified as potentially important in future collaborative efforts.

It was noted that, in addition to the second Workshop on marine debris, there is an Entanglement Prevention Workshop being planned by IWC, and it was **recommended** that the Marine Debris Workshop coordinate with them on recommendations and cross-Workshop impacts of recommendations.

The unique strengths of the IWC's Scientific Committee were mentioned, including its range of expertise, experience with environmental threats and regular Annual Meeting cycle.

The Workshop encouraged IGOs with overlapping mandates to work together collaboratively on common goals.

It was noted that the identification of priorities by the IWC Scientific Committee could potentially help NOAA prioritise the marine debris work it funds, and help local governments to more fully recognise the marine debris problem and implement response activities, acknowledging the current lack of funding and infrastructure. The CMS resolution on marine debris was noted[19].

The Workshop **agreed** that a brief document summarising priority recommendations for potential funders was a good idea and stressed that they ideally should be prioritised, brief and feasible.

[19]*http://www.cms.int/species/pacific_cet/pacific_cet_bkrd.htm.*

9.3 Recommendations for the 2nd IWC Workshop on Marine Debris

- The Workshop **recommended** that the Second Marine Debris Workshop perform a careful review of recommendations from this Workshop in order to determine if they were acted upon and, if not, identify the factors related to the failure of implementation.
- The Workshop **encouraged** greater outreach to the public and scientific community; the next Workshop is urged to carefully consider its audience and how best to engage.
- The Workshop also **recommended** increased engagement with intergovernmental bodies and industry (plastics, fisheries etc.) prior to and during the next Workshop, and better representation/good engagement with representatives from developing countries. This would bring increased presence from those involved in non-industrial/artisanal fisheries, which were felt to be an underrepresented component of the marine debris problem at the current Workshop (include a session specific to this problem). Related to this, conveners of the next Workshop should seek additional funding in order to be able to provide support to participants from developing countries.
- The Workshop recognised the utility of the IWC web portal and **encouraged** the further use of portal and development of an updated bibliography of material relevant to the next Workshop, including mitigation. It was also noted that it will be provided in ample time for review by attendees.
- The Workshop **recommended** that the turtle modelling work currently performed by CSIRO be presented at the second Workshop.
- The Workshop noted the significant challenges in communicating scientific information about the impact of marine debris on cetaceans, with interactions typically occurring far removed from the lives of most people. There is an urgent need for scientists to relay information about the detrimental impacts of marine debris to a variety of audiences, including decision-makers, industry officials/representatives, policymakers and the public. Thus, the Workshop **recommended** dedicating significant time and resources at the next Workshop to develop effective communications strategies to address this need. Consideration could also be usefully given to educational programmes for adults and children.
- Consideration should be given to reviewing programmes that are currently removing derelict fishing gear in different parts of the world. These projects provide immediate benefits to marine animals, including cetaceans, by removing gear that is a threat to entanglement and ingestion. The knowledge and experience from these on-going programmes could be beneficial to other countries that have not yet tackled the problem of derelict fishing gear.
- The Workshop **recommended** that a programme be initiated and supported through the IWC that would provide an effective transfer of information and methods from on-going programmes to countries interested in beginning new derelict gear removal programmes and stimulate the adoption of official programmes for removing fishing gear as debris. This could be modelled after the IWC's disentanglement training programme with guidance from the IWC SC and supported through the IWC.
- The Workshop acknowledged that natural but catastrophic climatic or seismic events (e.g. hurricanes/

typhoons, earthquakes, tsunamis) can result in pulses of tremendous amounts of debris into the ocean. The Workshop **recommended** that the IWC support a globally applicable but scale-able contingency plan for assessing impacts of such events on cetaceans, which offers member states guidance on mitigation options.

10. CONCLUSION: PRIORITY RECOMMENDATIONS

Given that legacy and contemporary marine debris have the potential to be persistent, bioaccumalative and lethal to cetacean populations and represent a global management challenge, and entanglement in and intake of active and derelict fishing gear and other marine debris have lethal and sub-lethal effects on cetaceans, the Workshop **agreed** that marine debris, and its contribution to entanglement, exposures including ingestion, and associated impacts, including toxicity, is both a welfare and a conservation issue for cetaceans on a global scale.

Therefore, the Workshop **recommended:**

- research and experimentation to develop and evaluate the efficacy of alternative fishing practices, including innovative methods, gear and management regimes, because fishing gear, both active and derelict, is a major cause of injury and mortality in cetaceans;
- microplastics, their associated chemical pollutants and microbes, and macrodebris ingestion should be prioritised for research because they represent a potentially significant but poorly understood threat to cetacean populations; and
- that, while governments, industry groups and organisations are making progress to address the threat of marine debris on local/regional scales, due to the migratory nature of cetaceans; these efforts should be advanced globally.

11. CLOSE OF MEETING

All recommendations included in this document were reviewed and agreed before the Workshop closed and a small editorial team (consisting of Simmonds, Gilardi, and Landrum) was appointed to tidy up the text before it was submitted to the IWC Scientific Committee.

Simmonds thanked everyone for their contributions and especially the rapporteurs for their hard work.

He also thanks the IWC Secretariat team who had done so much to make the Workshop a success, including Julie, Sandra, Brendan, Jessica and Kate. He also thanked Michael Moore for the kind invitation to use the excellent WHOI facilities at no charge and Andrew Daly and Michael for the support they provided during the meeting. Simmonds was thanked for chairing the meeting and at 16.20 on 17 May 2013 he brought the gavel down and closed the meeting.

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WEB-BASED RESOURCES

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Annex B

Agenda

1. Introductory items
    1.1 Welcome and opening remarks
    1.2 Procedural matters
    1.3 Documents
2. Keynote presentations
    2.1 Introduction to the work of the International Whaling Commission on environmental issues
    2.2 Marine debris in our oceans – an overview
    2.3 Cetacean entanglement: detection and impacts
    2.4 Cetacean entanglement: scope and response
    2.5 Microplastics
    2.6 Closing the loop: repackaging plastic debris as a hazardous substance
    2.7 Overview of cetacean interactions with marine debris
3. Entanglement
    3.1 Overview of papers relating to entanglement
    3.2 Review of the available marine debris entanglement data – consideration of species and data-types
    3.3 Distinguishing active fishing gear entanglements from entanglement in marine debris
    3.4 Pathology protocols: recommendation for diagnosis of entanglement and ingestion impacts of fishing gear and aquatic debris in cetaceans
    3.5 Classification of debris types
4. Ingestion
    4.1 Papers relating to ingestion
    4.2 Review of the available marine debris ingestion data
    4.3 Recommended pathology protocols
    4.4 Categorisation of ingested debris types
    4.5 Toxicological effects of plastic additives
5. The distribution of debris
    5.1 Request for papers relating to investigating the distribution of marine debris
    5.2 Modelling approaches to identify spatial overlap between cetaceans and harmful debris
    5.3 The application of quantitative field sampling techniques to investigate prevalence of marine debris in cetacean habitats, including seas
6. Population level impacts of marine debris
7. Cetaceans in freshwater habitats
8. Overarching evaluation of data and recommendations
9. The IWC response
    9.1 Work being undertaken by other IGOs
    9.2 Proposals for future actions by the IWC and opportunities for intergovernmental collaboration
    9.3 Recommendations for the 2nd IWC Workshop on Marine Debris
10. Conclusion: priority recommendations
11. Close of meeting

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