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CETACEAN RESEARCH AND MANAGEMENT



Introduction

This supplement to the Journal contains the Report of the Scientific Committee from its Annual Meeting held from 27 April – 9 May 2002 in Shimonoseki, Japan. The meeting was attended by almost 200 participants (including some 60 invited participants); 31 member nations were represented. In addition, it contains the Report of the Fourth Workshop on the Development of an Aboriginal Subsistence Whaling Management Procedure held in Seattle, USA in January 2002 and the Report of the Workshop on North Pacific common minke whale *Implementation Simulation Trials*, also held in Seattle in January 2002.

Several major topics were discussed in Shimonoseki and a more detailed summary of these is given in the Editorial to Issue 2 of Volume 4 of the Journal.

Discussion of the Revised Management Procedure for baleen whales (RMP) centred on: consideration of general issues related to abundance estimation and stock identity; preparation for implementation of the RMP for North Pacific minke whales; and measures to ensure that total anthropogenic removal limits (including direct harvesting and the estimation of numbers of bycaught animals) calculated by the RMP are not exceeded. The Committee also considered other management issues (including the tracking of whale products) related to the use of molecular techniques in the context of identifying species, stocks and individuals. As well as considering genetic techniques, it also considered the question of the collection and archiving of samples from catches and bycatches and the use of non-genetic data for stock identification.

High priority has been placed on the development of a management procedure for aboriginal subsistence whaling (AWMP). The AWMP will comprise both generic and case-specific components and the Committee recommended a *Bowhead SLA* (strike limit algorithm) to the Commission for the management of the Bering-Chukchi-Beaufort Seas stock. Work is continuing on the other species.

Current aboriginal subsistence whaling operations are reviewed annually and the review included the Bering-Chukchi-Beaufort Seas bowhead whales, the eastern North Pacific stock of gray whales and the humpback whales off St Vincent and The Grenadines. Work to develop a research programme for fin and minke whales off Greenland continued. The Committee completed an in-depth assessment of North Atlantic humpback whales.

Continuing concern was expressed over the status of a number of small populations of large whales, particularly the North Atlantic right whale (*Journal of Cetacean Research and Management (special issue 2) - Right Whales: Worldwide Status*) and the western North Pacific gray whale.

A major review of the abundance estimates of minke whales in the Antarctic began in 2001 so that an accepted estimate of current abundance can be obtained and any trends can be identified should they exist. The last accepted estimates were for the period 1982/83 to 1989/90. This work continued as a high priority item in 2002. Work on the differentiation of blue whale sub-species continued as part of the SOWER programme south of 60°S.

In recent years, the Committee has paid increasing attention to the relationship between cetaceans and their environment and developed two major initiatives, the SOWER 2000 programme and the POLLUTION 2000+ programme (see *Journal of Cetacean Research and Management (special issue 1) – Chemical Pollutants and Cetaceans*). The former formed the priority topic at the 2002 meeting.

At the 2002 meeting, the Committee considered the status of humpback dolphins (genus *Sousa*) and reviewed progress on recent recommendations by the Committee on small cetacean species.

G.P. DONOVAN
Editor

Supplement Contents

This supplement to the Journal contains the Report of the Scientific Committee from its Annual Meeting held from 27 April – 9 May 2002 in Shimonoseki, Japan and the Reports of the Workshop on North Pacific Common Minke Whale Implementation Simulation Trials and of the Fourth Workshop on the Development of an Aboriginal Subsistence Whaling Management Procedure, both held in January 2002 in Seattle, USA.

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Report of the Scientific Committee

The meeting was held at the Kaikyo Messe Conference Centre, Shimonoseki, Japan, from 27 April – 9 May 2002 and was chaired by J.E. Zeh. A list of participants is given as Annex A.

1. INTRODUCTORY ITEMS

1.1 Chair's welcome and opening remarks

Zeh opened the meeting and introduced Hatanaka who welcomed the participants to Shimonoseki. After the customary introductions, Zeh brought to the Committee's attention the sad death of Dr Fujio Kasamatsu the previous year. Dr Kasamatsu played a significant role in the IWC Scientific Committee for many years. He made significant contributions to the Southern Hemisphere minke whale assessment cruises, participating from 1979/80 to 1988/89, acting as senior scientist from 1983/84 and cruise leader from 1988/89. A moment of silence was observed in his memory.

In regard to the participation of Iceland, Zeh read the following statement on behalf of the Chairman of the Commission:

Iceland's instrument of adherence to the International Convention for the Regulation of Whaling is expressly conditioned on a reservation with respect to paragraph 10(e) of the Schedule. This Committee is not an appropriate forum to discuss this or issues related to this. The participation of Iceland in this meeting does not prejudice the positions of individual members of the International Whaling Commission regarding the issue of Iceland's adherence to the International Convention for the Regulation of Whaling.

1.2 Appointment of rapporteurs

Donovan was appointed rapporteur with assistance from Last, Perrin, Smith and other members where appropriate. Chairs of sub-committees appointed rapporteurs for their individual meetings.

1.3 Meeting procedures and time schedule

Grandy described the meeting arrangements, the facilities available to participants and various housekeeping items. The Committee agreed to a work schedule prepared by the Chair.

1.4 Establishment of sub-committees and working groups

The meeting was preceded by a two-day (25-26 April) Working Group to continue to review Southern Hemisphere minke whale abundance estimates. As last year, the agenda items covered by this meeting were subsumed into the main agenda and the report of the sub-committee on In-Depth Assessments (Annex G). A number of sub-committees and Standing Working Groups were established:

Annex D – Sub-committee on the Revised Management Procedure;

Annex E – Standing Working Group on the Development of the Aboriginal Whaling Management Procedure;

Annex F – Sub-committee on Bowhead, Right and Gray Whales;

Annex G – Sub-committee on the Comprehensive Assessment of Whale Stocks – In-Depth Assessments;

Annex H – Sub-committee on the Comprehensive Assessment of North Atlantic Humpback Whales;

Annex I – Working Group on Stock Definition;

Annex J – Standing Working Group on Environmental Concerns;

Annex K – Standing Sub-committee on Small Cetaceans;

Annex L – Sub-committee on Whalewatching;

Annex M – Working Group on Estimation of Bycatch and Other Human-Induced Mortality;

Annex N – Working Group to Review Sanctuaries and Sanctuary Proposals.

Working groups (under Zeh and Bjørge) dealt with DNA testing and the review of JARPN II, respectively. Their reports appear in this report under Items 15 and 16, respectively.

1.5 Computing arrangements

Allison outlined the procedures for participants requesting computing work from the Secretariat, and the printing facilities available for delegate use.

2. ADOPTION OF AGENDA

The adopted Agenda is given as Annex B1. Statements on the Agenda are given as Annex R. The Agenda took into account the priority items agreed last year and approved by the Commission (IWC, 2002d, pp.69-71). Annex B2 links the Committee's Agenda with that of the Commission.

3. REVIEW OF DATA, DOCUMENTS AND REPORTS

3.1 Documents submitted

The list of documents is given as Annex C.

3.2 National progress reports on research

Progress reports presented at the 2001 meeting are now accessible on the IWC website. Reports from previous years will also become available in this format.

The Committee reaffirmed its view of the importance of national progress reports and **recommends** that the Commission continues to urge member nations to submit them following the approved guidelines (IWC, 1998f). It was also noted that non-member nations wishing to submit progress reports are welcome to do so.

As discussed under Item 7, the Committee also **recommends** that the Commission:

- (1) encourages member nations to report details about the type of fishing gear involved in large whale bycatches (Item 7.1.4) and;
- (2) again encourages member nations to submit more complete records of ship-strikes (Item 7.3).

A summary of the information included in the reports presented this year is given as Annex O.

3.3 Data collection, storage and manipulation

Borodin requested that the following statement appear in the report.

For the last few years (IWC, 1997b, pp.137-8; IWC, 1998d, p.177; IWC, 2002d, p.2) the Russian delegation has made a statement about the necessity for independent experts with primary information of whaling (vessel logbooks, scientific reports, etc.) to present these materials at the national level so that they may undergo an expert review. This has not been done. This year we repeat our statement and the need for it to be included in reports.

3.3.1 Catches and other statistical material

Table 1 lists data received by the Secretariat since the 2001 meeting.

3.3.2 Progress of data coding and validation projects

Allison reported that the format of the IWC catch database had been amended to allow inclusion of data from the year 2000, and that the opportunity had been used to add new fields to allow additional reproductive and maturity data to be incorporated into it. During the year, coding of the outstanding pre-1945 individual catch data from the North Pacific had been completed and was being validated. Work had begun on encoding the revised Soviet catch data, the first phase of which is anticipated to take about two years to complete.

The backlog in validation of the SOWER sightings data had been overcome, thanks to the hard work of Marion Hughes in the Secretariat. Data from both the 1999/00 and 2000/01 SOWER sightings cruises had been validated and incorporated into the DESS database. The validation process has been speeded up with the use of new validation software developed within DESS in 1999/2000 under contract, and assistance from another member of staff who is being trained in this work.

Hedley is undertaking validation of the 1999/2000 joint IWC/CCAMLR cruise data as part of the DESS contract, and is developing new software for that purpose. It is hoped this software will also be of use in validation of the IWC/SO-GLOBEC cruise data.

Smith expressed his appreciation to the people involved in the data encoding work.

3.3.3 Progress on program verification and other computing tasks

Allison reported on progress with the computing work identified last year (IWC, 2002d, p.71).

The Common Control Program implementing the Fishery type 2 model had been amended to implement changes agreed last year and at the Interessional meeting of the

Table 1
List of Data and Programs received by the IWC Secretariat since the 2001 meeting.

Date	From	IWC ref.	Details
Catch data			
1-3-02	Norway: N. Øien	E35	Individual catch records from the Norwegian 2001 commercial catch. Access: restricted.
27-4-02	Japan: T. Sakamoto	D172	Individual catch records from the Japanese 2001 North Pacific Special Permit catch (JARPNI) and 2001/02 Antarctic Special Permit catch (JARPA).
21-4-01	T. Miyashita	E37	Japan 2000 minke bycatch data by sub-area.
Sightings data			
25-2-02	L. Burt	CD25	New version of DESS database: version 3.2 (includes 1999/2000 + 2000/01 data).
15-3-02	L. Burt	CD26	New version of DESS database: version 3.2 rev (corrects year 2000 problem).
25-2-02	P. Ensor	D171	2001/02 SOWER cruise data (sightings, effort, weather, ice-edge, inter-stratum & way pts.). 2002 report with figures and tables (including blue whale cruise data).
8-2-02	D. Thiele	CD15-24	SO-GLOBEC 2001 cruise data, USA + German boats (sightings, biopsy data, behaviour logs, reports + scanned photos).
25-4-02	D. Thiele	CD27-28	SO-GLOBEC 2002 cruise data.
16-10-01	S. Hedley	CD14	Data checking program DAS check (for possible use in CCAMLR and GLOBEC data validation).
Data for North Atlantic Minke Implementation Review			
1-11-01	Norway: N. Øien	E32-33	1996-2001 Norwegian sightings survey data – Access: <i>IR</i> only.
20-12-01	Norway: N. Øien	E34	Dive time data for 2 VHF radio tagged minke, Aug/Sept 2001 – Access: <i>IR</i> only.
13-12-01	Norway: H. Skaug	D170	Norway 1997-99 minke genetic data: DNA micro satellite, MtDNA + catch positions. Access: <i>IR</i> only.
25-3-02	Norway: H. Skaug	E36	Norway 2000-01 minke genetic data. Access: <i>IR</i> only.
Other Programs			
30-4-02	A. Punt	D173	Programs developed under contract for North Atlantic humpback assessments (see Item 10.5.1).
12-4-02 + 17-4-02	G. Givens	E38	G-G Candidate <i>SLA</i> program.
9-4-02 + 17-4-02	E. Dereksdottir	E39	D-M Candidate <i>SLA</i> program.

Standing Working Group (SC/54/Rep2). The changes included both amendments to the bowhead whale trials and the new factors for use in the gray whale trials. The code for the five potential SLAs had been forwarded to Allison and she had applied the *Evaluation* and *Robustness Trials* to each of them. Results are discussed under Item 8.2.

The Control Program for the North Pacific minke whale trials had been amended as specified in IWC (2001e, pp.114-125) and used during the Intersessional Workshop (SC/54/Rep1). During the Workshop, modifications were made to the trial structure and two new baseline models added. The work to implement these changes within the control program for two baselines had been carried out together with some initial conditioning runs. This is discussed under Item 6.1.

Allison expressed her gratitude to Punt for his great assistance with modelling issues.

There had not been time to make progress on the Control Program for North Pacific Bryde's whale trials because of the additional work arising from the intersessional meetings noted above.

Progress made on the DESS contract is reported and discussed under Item 10.1.1.

4. COOPERATION WITH OTHER ORGANISATIONS

4.1 Convention on the Conservation of Migratory Species (CMS)

4.1.1 Scientific Council

The 2002 meeting of the Scientific Council had not occurred during the IWC intersessional period. Perrin will attend as IWC observer at the meeting in September.

4.1.2 Agreement on Small Cetaceans of the Baltic and North Sea (ASCOBANS)

The 2002 meeting of ASCOBANS had not occurred during the IWC intersessional period. Donovan will attend as the IWC observer in June. Reijnders informed the Committee that a Workshop to Draft a Recovery Plan for Harbour Porpoise in the Baltic had taken place in Jastarnia, Poland in January 2002 (this is discussed under Item 13.2.3).

4.1.3 Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS)

The report of the IWC observer at the 1st Meeting of Parties to ACCOBAMS held in Monaco is given as IWC/54/10H. A Scientific Committee was established and will include on it a representative from the IWC Scientific Committee. A number of resolutions were adopted including: (1) establishment of a stranding network and database; (2) establishment of Guidelines for the regulation of whalewatching; and (3) conservation of bottlenose dolphins in the Black Sea. The Committee thanked Allison for attending this meeting and providing the report.

The first meeting of the ACCOBAMS Scientific Committee is provisionally scheduled for September 2002; Donovan will represent the IWC.

4.2 International Council for the Exploration of the Sea (ICES)

The report of the IWC observer at the ICES Annual Science Conference (ASC) held in Oslo, Norway is given as IWC/54/10B. The ICES Working Group on Marine Mammal Population Dynamics and Habitats (WGMMPH) met in April 2001 and addressed the status and ecology of

marine mammals in the North Sea, in particular questions concerning ecological quality objectives (EcoQO) and possible indices. Other topics included the impact of fisheries on marine mammals, contaminants and diet.

Development and implementation of EcoQOs for marine mammals were discussed by the Working Group on Ecosystem Effects of Fishing Activities (WGEEO), and the Study Group on Ecosystem Assessment and Monitoring (SGEAM) at their 2001 meetings.

A new action plan developed for the Living Resource Committee (LRC) includes marine mammals as an integral part. LRC theme sessions at the ASC meeting contained several marine mammal papers including ageing of minke whales and reproduction and growth in harbour porpoises. Suggested future theme sessions of relevance to marine mammals include titles such as 'Environmental Influences on Trophic Interactions' and 'Biological Effects of Contaminants in Marine Pelagic Ecosystems'.

The Committee thanked Haug for attending the meeting on its behalf. He will be unable to attend the next ICES meeting, but the Norwegian delegation agreed to provide an IWC observer.

4.3 Inter-American Tropical Tuna Commission (IATTC)

The reports of the IWC observer at the 68th Meeting of the IATTC and the 5th Meeting of the Parties to the International Dolphin Conservation Program held in San Salvador, El Salvador are given as IWC/54/10A.

Items of relevance to cetaceans at the IATTC meeting were the International Dolphin Conservation Program (AIDCP) and bycatch issues.

The main topic addressed at the International Dolphin Conservation Program (AIDCP) meeting was adoption of a new certification and labelling system for 'dolphin safe' tuna, under the definition 'Dolphin safe tuna is tuna captured in sets where there is no mortality or serious injury of dolphins'. Several resolutions addressing new government-administered regimes for verifying and tracking tuna catches to be labelled as dolphin safe were adopted. Other topics included placing observers on vessels transiting the eastern Pacific *en route* to the western Pacific (where dolphin-based fishing is reported not to occur), fishing by non-members of the IDCP and development of a system for implementing per-stock per-year mortality caps.

For the year 2000, the total dolphin mortality from tuna purse-seine fishing was reported as 1,636, from eight species/stock categories. The reported levels of take are less than 1% of the estimated abundance for all stocks.

4.4 International Commission for the Conservation of Atlantic Tunas (ICCAT)

The Committee had no observer's report from the most recent ICCAT meeting, but Kell agreed to act as observer at the next meeting.

4.5 Convention for the Conservation of Atlantic Marine Living Resources (CCAMLR)

The report of the IWC observer at the 12th meeting of the CCAMLR Commission held in Hobart, Australia is given as IWC/54/10D. No discussions were specifically related to the cetaceans. The Committee thanked Fernholm for attending the meeting on its behalf.

The report of the IWC observer at the 20th meeting of the CCAMLR Scientific Committee held in Hobart, Australia is given as IWC/54/10C. The main items of relevance to the

IWC were the Ecosystem Monitoring Program, management of krill and ecosystem management.

The Ecosystem Monitoring Program meeting began work on defining 'Small Scale Units' for exploitation (based on the needs of predators) for better management of the krill fishery. The expertise accumulated by members of the IWC during its own discussions on this subject may be helpful to CCAMLR. It was suggested that IWC members with knowledge of Small Scale Unit development could attend the forthcoming meeting of the CCAMLR Working Group on Ecosystem Monitoring and Management.

The Total Allowable Catches (TACs) calculated for the CCAMLR western Atlantic Ocean sector in July 2000 were 4 million tonnes. The annual krill catch is anticipated to rise from the current catch of around 100,000 tonnes to 150,000 tonnes. No TACs were available for the eastern Atlantic Ocean sector, and it was suggested that old datasets are analysed to achieve first estimates of the standing stock of krill that may serve as the basis for the estimation of preliminary TACs.

Regarding ecosystem management, the CCAMLR Scientific Committee encouraged its working groups to focus on ecosystem models rather than single species models, a first step being the estimation of temporal and geographical scales of environmental variables and their relationship to krill distribution and abundance. New methods to better estimate the consumption of krill were also presented. It was noted that the effects of water and air temperature increases on ecosystems in the Antarctic Peninsula region, the Scotia Sea and the peripheral parts of the Southern Ocean need to be considered. It was thought that development of a management strategy for the krill-based system may take another 5-10 years.

In regard to collaboration between the IWC and CCAMLR, a paper reporting the results of cetacean sightings made on the CCAMLR 2000 krill survey was submitted at the meeting. A combined IWC-CCAMLR workshop linking cetacean distribution and krill abundance is envisaged to take place in 2002/2003. Further discussion of IWC-CCAMLR collaboration is given under Item 12.1.1 and in Annex J.

The Committee thanked Kock for attending the meeting on its behalf and agreed that he should represent the IWC at the next meeting of the CCAMLR Scientific Committee.

4.6 Southern Ocean GLOBEC (SO-GLOBEC)

Matters relating to IWC collaboration are discussed under Item 12.1.2 and in Annex J. The Committee thanked Thiele for her work in promoting the collaboration.

4.7 North Atlantic Marine Mammal Commission (NAMMCO)

The report of the IWC observer at the 11th meeting of the NAMMCO Council held in Ilulissat, Greenland is given as IWC/54/10E. Agenda items of relevance to the IWC included: the NASS-2001 synoptic survey; white whales and narwhals; and marine mammal-fisheries interactions. Concern was expressed regarding the status of white whale stocks. The importance of continued research into marine mammal-fisheries interactions was stressed and priority recommendations included estimates of consumption by minke whales.

The Committee thanked Fischer for attending the meeting on its behalf.

The report of the IWC observer at the NAMMCO Scientific Committee meeting held on board the Norwegian coastal steamer *MS Nordkapp* is given as IWC/54/10F. Items

of relevance to the IWC included the role of marine mammals in the marine ecosystem; marine mammal stock status and advice; and North Atlantic Sightings Surveys.

A conference due to be held in January 2003 will aim to facilitate the incorporation of user knowledge into management advice provided by the Scientific Committee. The preparation of Stock Status Reports has begun so that users can supply information to these Reports.

The Working Group on the Economic Aspects of Marine Mammal-Fisheries Interactions concluded that significant uncertainties remain in the calculation of consumption by marine mammals, and that this uncertainty is the most important factor hampering the development of models linking consumption with fisheries economics. A further workshop was convened to investigate the methodological and analytical problems associated with estimating marine mammal consumption. Two approaches were considered: (1) analyses of stomach contents in combination with estimates of stomach evacuation rates; and (2) analyses of stomach or intestinal contents or faeces scaled to satisfy the estimated energy expenditure of the animals. Problems with both were discussed and a series of research need recommendations were made. IWC plans to convene a Workshop on a similar theme were noted. Results from this workshop would be taken into account in preparations for an ecosystem modelling workshop planned to investigate the ecological role of minke whales, harp and hooded seals in the North Atlantic.

The NASS-2001 synoptic survey covered the areas around Iceland, the Faroe Islands and west Norway including parts of the North Sea. The priority target species were minke and fin whales. The Icelandic coastal shelf was covered by an aerial survey, whilst the Faroese and Icelandic portions were ship borne and used identical survey methodology for the first time. The abundance estimates from these surveys were reviewed by a NAMMCO Working Group in March 2002. Preliminary estimates for minke whales concluded that the abundance of minke whales around Iceland has been stable or shown a moderate increase over the period 1986-2001. Abundance estimates for fin, humpback, sperm whales and dolphins were also presented.

The Committee thanked Øien for attending the meeting on its behalf. Øien will be unable to attend the next meeting of the NAMMCO Scientific Committee. The Committee thanked Walløe for agreeing to represent it at that meeting.

A number of papers (SC/54/H2, O8, O9, O10, O12) concerning abundance estimates from the NASS surveys were presented and discussed at the relevant sub-committee.

4.8 FAO – Committee on Fisheries (COFI)

The report of the IWC observer at the FAO COFI conference on Responsible Fisheries in the Marine Ecosystem, held in Reykjavik, Iceland is given as IWC/54/10I. The Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem was adopted at the conference. The Declaration is relevant to the work of the IWC Scientific Committee in relation to the Commission's decision to make the study of interactions between whale and fish stocks a priority topic. The Declaration incorporates the belief that including ecosystem considerations in fisheries management provides a framework to enhance management performance. It also affirms that the incorporation of ecosystem considerations implies more effective conservation of the ecosystem, sustainable use and an increased attention to interactions,

such as predator-prey relationships, among different stocks and species of marine living resources. Areas identified for investigation include the structure, components and functioning of relevant marine ecosystems, diet composition and food webs, species interactions and predator-prey relationships, the role of habitat and the biological, physical and oceanographic factors affecting ecosystem stability and resilience.

The Committee thanked Komatsu for attending the meeting on its behalf and agreed that he, or an alternate member of the Japanese delegation, should represent it at the next meeting.

4.9 United Nations Environment Programme (UNEP)

During the intersessional period the Secretariat received a letter from UNEP documenting plans to produce a World Digital Atlas on Marine Mammals (SC/54/O24). Zeh summarised the initiative, the objective of which is to create a global overview and information resource on the conservation and sustainable management of marine mammals. The Committee noted the ambitious nature of the plan and the difficulties encountered in establishing population estimates and trends. It **agreed** that the IWC should send a letter suggesting guidelines and advice on how the objectives could be achieved. Individual members of the Committee wishing to be involved should contact the organisation directly.

4.10 Other

4.10.1 North Pacific Marine Science Organisation (PICES)

Kato introduced the current activities of PICES. Following on from the Working Group convened to assess the feeding impact of marine birds and mammals, PICES have established a Bird and Mammal Advisory Panel whose aim is to send experts to other committees and organisations to provide scientific advice on ecosystem modelling and other information relevant to marine birds and mammals. At the 2001 Annual Meeting held in Victoria, Canada a workshop was convened entitled 'Changes in prey availability to mammals, seabirds and fish: mechanisms and effects'. The 2002 meeting will be held in October and has scheduled a symposium entitled 'Responses of upper trophic level predators to variation in prey availability: an examination of trophic linkages'. Further information on the activities of PICES is available from its website (www.pices.ios.bc.ca).

The Committee thanked Kato for this report. It was agreed that he should serve as IWC observer at the 2002 meeting and that his report should be included in the compendium of observers' reports at the next and future meetings.

4.10.2 Eastern Caribbean Cetacean Commission (ECCO)

The Committee also agreed that it should have an observer at meetings of ECCO. Rambally agreed to represent the Committee at future ECCO meetings.

5. REVISED MANAGEMENT PROCEDURE (RMP) – GENERAL ISSUES (ANNEX D)

5.1 Adjustment of the convergence criteria for the CATCHLIMIT program

Last year, one of four tasks remained incomplete: adjustment of the convergence criteria to be robust when less precise integration is used, possibly optimising the two-level convergence criteria (IWC, 2002d, p.5, item 5.1, task (3)).

This year Allison reported that lack of time had prevented her from examining the convergence criteria. She suggested that this work was best done in conjunction with using the program for *Implementation Simulation Trials*. The Committee **agreed** that this item should be carried forward to next year's meeting.

5.2 Population component to which MSYR, MSYL and density-dependence should apply

This issue is related to both the RMP and AWMP. The calculations specified at the 2000 meeting to inform discussions on this issue (IWC, 2001d, pp.91-2 and p.106) had not been conducted owing to time constraints. However, Allison reported that many of the preparatory changes to programs had been done. The Committee **recommends** that these calculations be conducted intersessionally and reported to next year's meeting.

5.3 Evaluation of abundance estimators against simulated datasets

5.3.1 Report of the intersessional working group on abundance estimation

The intersessional working group (IWC, 2001c, p.6) had continued its work of expanding the existing set of simulated datasets to enable evaluation of performance over a wider range of potential survey and biological conditions. Its report is given in Annex D (Appendix 2).

The program used to create simulated line transect abundance data had been expanded to include responsive movement and the models of measurement error used in the analytical methods to estimate abundance of North Atlantic minke whales (SC/54/RMP5). Evaluating the performance of new methods to estimate abundance is an ongoing process and the Committee **agreed** that the item should be a standing item on its agenda. In addition, it **recommends** that existing simulated datasets and associated documentation should be archived with the Secretariat.

5.4 Work plan

The Committee **agreed** to re-establish the Working Group, under Palka, with the priority task of expanding the existing set of simulated datasets with the features needed to evaluate the new methods being developed to estimate the abundance of Southern Hemisphere minke whales using IDCR/SOWER data (see Annex G, Appendix 5). In addition, the Committee **recommends** that existing simulated datasets and associated documentation should be archived with the Secretariat.

6. RMP – PREPARATIONS FOR IMPLEMENTATION (ANNEX D)

6.1 North Pacific minke whale Implementation

6.1.1 Report of Implementation Simulation Trials group

6.1.1.1 REPORT OF THE INTERSESSIONAL WORKSHOP

Donovan summarised the results of the Workshop, held in Seattle on 19-22 January 2002 (SC/54/Rep1). In its deliberations, note had been taken of the Committee's strong desire for the *Implementation* to be concluded at its 2002 meeting. Decisions had been taken on diagnostics for conditioning of trials and abundance estimates had been reviewed. The question of data availability had been raised and was referred to the Committee for further consideration (see Item 6.5.4). Genetic data analysis had been discussed at length, including hypothesis testing methods, a Bayesian approach and the Boundary Rank method. However, there was not complete agreement as to the plausibility of four resultant hypotheses on stock structure, involving from two

to four stocks. Japan had advised on its harvest plans, and these had been taken into account in the conceptual specification of a number of revised trials. A number of other issues requiring Committee consideration had been identified, and an ambitious work plan had been developed to complete the trials in time for the 2002 Committee meeting.

Thanks were expressed to Donovan and the other Workshop participants. It was noted that some of the stock-related issues raised at the Workshop would require consideration under Agenda Item 11, Stock Definition.

6.1.1.2 REPORT OF THE IMPLEMENTATION SIMULATION TRIALS GROUP

Butterworth presented this report (Annex D, Appendix 3). It had not been possible to have trial results ready for consideration at this meeting, mainly because further consideration of the genetic analyses in terms of the Group's mandate had led to the necessary development of substantial new hypotheses, which required further trials to be conducted to be able to report that any RMP variant recommended had been tested under trials that adequately spanned the plausible range of uncertainty.

As part of the Group's activities, a small group of US and Japanese genetics experts had met in Tokyo in December 2001; the participants were thanked for their contributions. However, attention was drawn to certain problems that had arisen, ascribed to lack of clarity in the meeting's Terms of Reference.

Taylor commented that overburdening of the Secretariat and inadequate time allocations for meetings were major reasons for the failure to complete the trials by the deadline. Kawahara remarked that the Terms of Reference for the Workshop mentioned only modification of trials, whereas two quite new scenarios had been put forward, consideration of which, he felt, should have awaited the next *Implementation Review*.

Miyashita had been asked by the Workshop to prepare revised abundance estimates (see Annex D, Appendix 4).

6.1.2 Consider relative plausibility of trials

Given the concerns raised under Item 6.1.1, particularly the inability to complete the *Implementation* as originally determined (see IWC, 2002d, p.8), this item and Items 6.1.3 and 6.1.4 were discussed after Item 6.2.

Under this item, the Committee reviewed the trial structure as well as the relative plausibility of trials. Because of its inability to complete the trials prior to the meeting, the Committee established three small groups to:

- (1) consider the initial results from conditioning of the *Baseline-A* trials (convened by Allison);
- (2) examine the specifications for the distribution of putative W stock in sub-areas 12SW and 12NE (convened by Allison);
- (3) work on details of the specification for the *Baseline-D* trials (convened by Smith).

The Committee endorsed the conclusions of small group (2), contained in Annex D (Appendix 5). However, lack of time prevented the other two small groups from completing their work during the meeting, and they will be taken further by the intersessional Steering Group set up under Item 6.1.4.

6.1.2.1 PLAUSIBILITY OF DIFFERENT STOCK STRUCTURE HYPOTHESES

SC/54/RMP15 gave the results of an AIC (Akaike's Information Criterion)-based evaluation of the plausibility of baseline stock scenarios defined in SC/54/Rep1. They were

based exclusively on mtDNA data derived from JARPN and JARPN II surveys. The four mtDNA haplotypes that presented the highest frequencies in sub-areas 7, 8 and 9 were used as independent parameters in the AIC. Different combinations of these haplotypes were used in evaluating the baseline scenarios and some of their variants. In addition, five groups of haplotypes, defined by a phylogenetic approach, were used for the AIC-based evaluation. The relative weighting of the model was assessed following the methodology of Burnham and Anderson (1998). Results of the AIC for the different combinations of haplotypes used were consistent, providing the best evaluation for *Baseline-A*. That scenario suggests that sub-areas 7, 8 and 9 comprise a single stock (O) with sporadic occurrence of individuals from a different stock (W) in part of sub-area 9. Although the AIC revealed that *Baseline-A* was the most consistent with the available mtDNA data in those areas, the authors noted that a more comprehensive evaluation of stock structure in the western North Pacific was still needed. Such comprehensive evaluation should consider the results of several approaches, both genetic and non genetic.

In response to a question for clarification, the authors indicated that the analyses in SC/54/RMP15 were based on all the genetic samples from sub-areas 7, 8 and 9, including possible J-stock animals.

There was extensive discussion of this paper with respect both to the appropriateness of using AIC criteria in this situation for assessing relative plausibility, and to the implication of the results of the analyses for the trials. Details are given in Annex D (item 6.3.1). In summary, there was general agreement that developing objective measures for evaluating plausibility and assessing relative plausibility or weightings is highly desirable. However, there was substantive disagreement about the general applicability of the AIC approach used in SC/54/RMP15, its application to genetic data with a large number of haplotypes and its relevance for assessing the plausibility of the different scenarios being considered in the trials. Nevertheless, the Committee **agreed** that further simulation testing of the other methods is desirable. It also **agreed** that the baseline scenarios defined in SC/54/Rep1 should be retained.

Information and analyses on the proportion of immature animals by sex taken in the JARPN and JARPN II surveys from sub-areas 7W, 7E, 8 and 9 are given in Annex D, Appendix 8. The results indicated that the proportions of immature and mature animals by sex in sub-areas 7E, 8 and 9 are similar, and different from the proportions in sub-area 7W. The main source of the difference is the occurrence of a higher proportion of immature males in sub-area 7W than in the other areas. Sub-area 7W was consistent with the inshore waters where many immature animals had been taken by small-type whaling. The authors believed it reasonable to conclude that immature animals are distributed in coastal sub-area 7W and that mature males are distributed in offshore waters from 7E to sub-area 9. They concluded that the results are consistent with the occurrence of a single stock in sub-areas 7, 8 and 9 which aggregates by sex and reproductive status.

In discussion, Butterworth suggested that the high proportion of immature males within sub-area 7W compared to sub-areas 7E to 9 raised the question of whether there could in fact be many separate stocks to the east of Japan. The most parsimonious interpretation of the data on maturity status and sex is that there are not.

It was pointed out that there was a very low proportion of immature females in all of the samples from areas 7, 8 and 9 and that there was no difference in the proportion of

immature females by longitude. Thus, the lower proportion of immature females in areas to the east of 7W indicates that sampling is missing a high proportion of the population no matter what stock structure model is assumed. Taylor, Martien and Polacheck considered that the information provided in Annex D, Appendix 8 was consistent with the hypothesis of only a single stock in the areas to the east of Japan; however, it was not inconsistent with the existence of more than one stock in those areas either. They further noted that if there are two or more stocks in the area east of Japan, the habitats for the more coastal and pelagic ones are substantial and very different. In such circumstances, it would not be unexpected that the latitudinal, spatial and temporal distributions of mature and immature animals by sex within each stock might be quite different, even though there may be substantial segregation by maturity state and sex within each stock.

The Committee also briefly reviewed Hatanaka and Miyashita (1997) which provided data on the proportion of mature animals by sex taken in the commercial coastal catches along the eastern side of Japan. It reported a similar pattern to the pattern found in the JARPN and JARPN II samples. The authors concluded that immature females as well as males were found in the western part of Area 7 early in the season (April to May) as well as in Area 11 in May and June. Hatanaka considered that these results further confirmed the consistency of the single stock hypothesis. There was limited time for further discussion of this question but there was no agreement about whether the available data on the proportion of immature animals by area and time were consistent only with a single stock hypothesis.

SC/54/RMP16 considered stock archetypes for North Pacific minke whales. Five archetypes were depicted: panmixia (corresponding to *Baseline-B*); maternal feeding ground site fidelity (*Baseline-C*); isolation-by-distance (*Baseline-C*); intrusion (*Baseline-A*); and broad mixing (*Baseline-D*). The authors discussed how these models relate to genetic measures. They emphasised that there were a number of reasons that no signal would be detected using nuclear data when a signal was detected using mtDNA data, including the fact that the effect size is much smaller for nuclear data, resulting in much lower statistical power and male biased dispersal estimates. As long as statistical power remains low, it is not possible to distinguish between maternal feeding ground site fidelity and actual separation of breeding grounds without data from the breeding ground. They also noted that the performance of analytical methods using genetic data to define stock structure has not been tested for any method other than Boundary Rank (Martien and Taylor, 2001).

In discussion, the difficulty of making inferences about breeding stocks simply based on detected differences in mtDNA frequency on the feeding grounds was further noted. There was general agreement on the importance and need to obtain data from the breeding grounds in order to make conclusive inferences about stock structure.

SC/54/RMP17 explored use of the trend in *p*-values as sample size increases to assess the probability that the observed trend in *p*-values for North Pacific minke whale samples taken in sub-areas 7 and 8 came from a panmictic population. Following detailed discussion, reported in Annex D (item 6.3.1), Taylor concluded that the results in SC/54/RMP17 provided support for hypotheses which included a potential coastal stock. Further, it was important to consider the power of the statistical tests to distinguish a difference in hypothesis-testing when considering the plausibility of different hypotheses.

6.1.2.2 DISCUSSIONS RELATED TO DETAILS OF THE TRIAL SPECIFICATIONS

SC/54/RMP18 raised detailed concerns from one Workshop participant who had been unable to attend the final part of the meeting when much substantive agreement had been reached. They related to: inter-annual variability in mixing proportions; assignment of W stock whales between Areas 12NE and 12SW; *Small Area* definitions and RMP variants; and finality of the specifications. They were referred for consideration, respectively, to the relevant groups already established to deal with: (a) finalising the *Baseline-D* trial specifications; (b) finalising the trial specifications with respect to the distribution of putative W stock animals within Area 12; and (c) considering further various aspects of the *Baseline-D* trial specifications. The Committee **agreed** that, as in the past, an intersessional Steering Group is required to oversee the finalisation of the trial specifications (see Item 6.1.4).

6.1.2.3 DISCUSSIONS RELATED TO THE BYCATCH LEVELS TO USE IN THE TRIALS

SC/54/RMP8 reported results from market surveys of North Pacific minke whale products conducted in Korea from May 1999 to November 2001, and from market surveys in Japan from February 1999 to January 2002. A total of 315 products were identified as North Pacific minke whale, based on sequencing of the mtDNA control region and by DNA profiling. Eight market surveys in Korea over the period yielded 193 separate North Pacific minke whale products, comprising at least 126 individual whales, 95% of which showed the characteristic mtDNA haplotype of the J-stock. In Japan, five market surveys yielded 122 North Pacific minke products, representing at least 97 individuals, 42% of which showed the characteristic mtDNA haplotype of the J-stock. Relatively few replicate products were found, indicating that products from many other individuals probably remained unsampled. Replicate samples of a small number of individuals were detected in consecutive survey periods, 2-7 months apart, but very few replicate samples of individuals were shared between surveys more than seven months apart, suggesting that products from an individual whale are not stored long-term and are sold in less than seven months. The duration of products from an individual on the Korean market was probably much less. Given the conservative nature of these censuses, it appeared that the total yearly Korean bycatch of North Pacific minke whales remains high, as does the Japanese catch of J-stock minke whales. This indirect evidence of high bycatch is confirmed by the reported bycatch (SC/54/ProgRep Japan; SC/54/ProgRep Korea).

As well as comparing the genotypes of all products within each of the markets sampled, SC/54/RMP8 also compared genotypes of products between markets. Surprisingly, two individual multi-locus genotypes were also shared between the Korean and Japanese market samples. Using the conservative Korean allele frequencies, the probability of these particular genotype matches occurring purely by chance was less than 0.05. Additional data are needed to ascertain with more confidence if these products represent the same individual whales in both markets. However, the small number of potential matches between the two countries indicate that bycatch products from Japan and Korea must be considered additive rather than overlapping.

There was extensive discussion on the possible implications of the information in SC/54/RMP8 and of other new information on what values to use for the level of

bycatch in the simulation trials. It was noted that the plausible range of values to use in the trials has been the subject of considerable debate.

Annex D, Appendix 9 reviewed changes in specifications over time and the new information available at the meeting, and proposed a range of plausible values for consideration in the trials. However, full agreement on the proposals could not be reached. There was lack of agreement on procedural aspects. Most members agreed that it was appropriate to consider revising the values to use for the level of bycatch in the simulation trial; in their view such a decision was fully consistent with the general procedures and timeframes recommended for conducting future implementations (see Item 6.2 and Table 2). Hatanaka and Kawahara disagreed because of the extensive amount of time spent on this issue in the past and because the trials are in their final stage of specification. Kim believed that new information had to be considered later, at the time of the in-depth assessment as the RMP reached its almost final stage. The sub-committee had not been able to reach consensus on this question and its Chair determined that it would consider possible revision to the level of bycatch to be used in the *Implementation Trials*.

Details of the sub-committee's lengthy discussions on this subject, and the decisions reached, appear in Annex D (item 6.3.1).

6.1.3 Consider Implementation options

SC/54/Rep1 included consideration of an RMP variant involving 'partial-cascading' (item 10.2). In this option, two *Small Areas* are defined (one comprising sub-area 9 and the other comprising sub-areas 7, 8, 11 and 12). In addition, these two *Small Areas* are defined as a combination area for the purpose of cascading. However, the catch cascades into the *Small Area* 7+8+11+12 are all taken from sub-areas 7W and 11. This 'partial cascading', as noted in SC/54/Rep1, is not in accord with the definition of *Catch-cascading* included in the RMP specifications. The Workshop had recommended that the Scientific Committee should review the concept of 'partial-cascading' and, if deemed appropriate, should develop any necessary additions to the RMP annotations.

There was general agreement that the issue of partial cascading and appropriate *Small Area* definitions for situations involving coastal whaling needed further discussion and consideration, and that a solution to this general problem was not possible at this meeting. However, a decision was required in terms of the North Pacific minke *Implementation Trials*, to allow work to proceed. For pragmatic reasons, the Committee **agreed** to use the RMP management variants defined in SC/54/Rep1 in the simulation trials. It emphasised that this decision should not be considered a precedent for future trials and that the issue will need to be further considered next year. Acceptable performance could still be achieved (in part relying on some of the conservative features within the *CLA*). However, this would mean that a solution to the multi-stock problem for any proposed 'RMP' implementation would be highly dependent upon the specific details and set of assumptions about mixing and migration. SC/54/RMP18 considered that such a change would represent a fundamental change in how the RMP was conceived to be implemented and would impose a substantially larger burden upon the *Implementation Trial* process.

There was extensive discussion about the partial cascading concept and the concerns raised in SC/54/RMP18 about the appropriateness of the *Small Area* options that

would intentionally allow for and probably result in the catches within a *Small Area* being taken not in proportion to the stocks contained within it.

There was general agreement that the concept of partial cascading and the definition of a number of the *Small Area* variants being considered in the North Pacific minke whale *Implementation Trials* were not fully in accord with the definition of *Small Areas* in the RMP. There was also agreement that the definition of *Small Areas* created problems in the application of the RMP to whaling on the migration route, particularly in the context of coastal whaling and the North Pacific minke whale situation. This is because synoptic abundance estimates used to calculate the catch limits for a *Small Area* are from the feeding and migration areas when a large proportion of the animals are on the feeding grounds, as this is the best time for conducting such surveys.

6.1.4 Specify intersessional work to permit completion of Implementations

The Committee recognised that substantial intersessional work was still required if final *Implementation Trial* results were to be available at next year's meeting. While some of the work may be possible to complete via e-mail, there was general agreement that it was impractical to complete most of the substantial work required in this way and that an intersessional Workshop would be necessary. The Committee noted that two of the small groups concerned with substantive issues related to the *Implementation Trials* had been unable to report on progress directly to the plenary. In those circumstances the Committee agreed that the Terms of Reference for the intersessional Workshop should be similar to those adopted last year, (see SC/54/Rep1) apart from term of reference (1). It therefore **recommends** that such a Workshop be held as proposed. A Steering Group chaired by Butterworth was set up to prepare for the Workshop (see Annex S).

With respect to the small group looking into the conditioning of the *Baseline-A* trials, it was reported that technical problems were being encountered in conditioning. There were indications of minimisation problems in the estimation of the parameters as well as concerns about lack of fit to some of the abundance estimates. Since these problems had not been solved before the end of this year's meeting, the Committee **recommends** that Punt and Allison collaborate to try to find an acceptable solution. Once this was achieved, the results would be circulated to the small group reviewing the conditioning results (under Allison, see Item 6.1.2 above) for comments and suggestions. A final review and agreement on the conditioning will take place at the proposed intersessional Workshop.

Concerns were expressed about the problems being encountered with the conditioning of the *Baseline-A* trials and possible implications for completion of the simulation trials. It was agreed that the same procedure as outlined in the preceding paragraph be followed to complete the conditioning of *Baseline-C* and *D* trials and the sensitivity trials to each of these baselines.

6.2 Procedures and scheduling of Implementations (Implementation Reviews)

As already noted (Item 6.1.2) the sub-committee on the RMP had discussed this item before considering Items 6.1.2-6.1.4.

6.2.1 *Proposals from last year and experience to date*

Last year, the Committee expressed concern about the length of time taken to complete the RMP *Implementation* for North Pacific minke whales, and made some preliminary proposals for expediting the conduct of future *Implementations* (*Implementation Reviews*), noting that they should be considered further this year (IWC, 2002d, pp.12-13).

This year, the Committee noted that, once again, its own timetable for the completion had not been met (Item 6.1.1). In view of the fact that the *Implementation* Trial process for North Pacific minke whales had taken longer than envisaged, the Committee first heard individual members' comments on the causes for the delays, then went on to draw lessons as a Committee from the experience gained and finally proposed a procedure for ensuring that future *Implementations* be completed on schedule once the prerequisites are met. Details of the lengthy discussions on this subject are given in Annex D (item 6.2.1).

The Committee noted that expeditious completion of RMP *Implementations* was possible, because this had been achieved in the case of North Atlantic and Southern Hemisphere minke whales in the early 1990s. However, both biologically and operationally, North Pacific minke whales were a more difficult case because: (1) coastal whaling was concentrated into limited areas; (2) harvesting took place on migration routes, as well as on the feeding grounds, so that the temporal as well as the spatial dimension needed to be taken into account in understanding and modelling stock structure; and (3) related to the temporal dimension, the clear evidence of stock differentiation, e.g. between J and O stocks, did not automatically make area delineation easy because of the seasonally-dependent overlap proportion in different areas. Past exploitation and potential depletion of some stocks was also an exacerbating factor. However, it was noted that to a greater or lesser extent some of these factors also applied to the Southern Hemisphere case, and more to the North Atlantic.

The reasons why the *Implementation* had proved so difficult to complete were manifold, but nine issues were identified in this context, and are detailed in Annex D (item 6.2.1).

With respect to determining plausible scenarios, some members considered that a hypothesis must be supported by some data to be considered plausible. Others noted that this left the question as to what is the appropriate null hypothesis in the absence of informative data. Assuming a single stock for an entire region may not be a reasonable null hypothesis; experience with other species and areas shows that this is rarely the case. The Committee **agreed** that there needs to be a minimum level of information to start the *Implementation* process, so that the question of choosing null hypotheses in the total absence of suitable information would not arise (see recommendations below). However, a choice must be made regarding how wide a range of hypotheses to begin with, and whether the intention should be that hypotheses should only be narrowed as the *Implementation* process progresses.

The Committee also identified issues that arose after the results of initial *Implementation Simulation Trials* were available, where these suggested problems with the *Implementation*.

Hatanaka noted that in some cases, the results implied very small RMP catch limits for stocks from which several hundred animals had been taken annually over several decades without signs of depletion. This would be difficult to explain to those with an interest in the harvesting whales in the area.

The Committee recognised that this could occur, but noted that the RMP is designed to be conservative in cases where the data are insufficient. The option of basing catch limits on estimates of abundance in *Small Areas* at one time of year would tend to be the one selected when data are sparse, and could often result in rather low catch limits in areas where the historical harvest had been high. The Committee felt that in such cases it was necessary to explain the reasons for this and to identify what improvements to the data could change the outcome (such as more appropriate abundance data, better information on stock structure to enable the more conservative hypotheses to be excluded, etc). It may also be possible to identify changes in harvesting strategy that would solve the problem without the need for additional data. The experience had shown that it would not generally be appropriate to continue postponing completion of the *Implementation* indefinitely until such data were forthcoming.

There was considerable debate over whether an alternative version of the RMP needed to be developed to cover 'difficult' coastal whaling cases such as the North Pacific minke whale. The Committee noted that management of coastal whaling was clearly one of the main interests of the Commission in developing the RMP. It was also noted that none of the specific problems associated with the North Pacific minke *Implementation* were caused by specific provisions of the RMP. However, the problem of defining *Small Areas* for whaling on migratory corridors will be a recurring problem.

After considerable discussion of the issues involved, the Committee agreed that the RMP could be implemented for coastal whaling, taking advantage of the flexibility already provided for in the RMP provisions, and the potential to consider operational measures, such as spreading catches spatially with *Small Areas*.

6.2.2 *Proposed process*

The Committee went on to consider solutions to the problems identified. They could be usefully divided into two types: (1) general policy and scientific issues; and (2) process issues (as discussed in Annex D, item 6.2.2) as listed below:

- (1) General policy and scientific issues, e.g.
 - (a) What level of population structure merits conservation?
 - (b) What constitutes plausible hypotheses, and how to rank or weight these?
 - (c) How should *Small Areas* initially be chosen, i.e. how should the RMP definition be converted to a more applicable working definition?
 - (d) How should balance in trials be achieved, in particular to avoid excessive emphasis on scenarios which are more difficult in a conservation context?
 - (e) How should abundance estimates be calculated for cascading when the main synoptic survey estimates for the total stock size are not very applicable to the size of a (sub-) stock migrating through a coastal whaling area?
- (2) Process issues, e.g.
 - (a) Where and when is the dividing line between an In-Depth Assessment and the start of an *Implementation*?
 - (b) How to ensure that the In-Depth Assessment results in a suitable range of hypotheses about stock structure?

- (c) How and when to determine whether a sufficient baseline of information exists to begin the *Implementation* process?
- (d) How and when to select factors of sufficient potential relevance to include in hypotheses for *Implementation Simulation Trials*?
- (e) When and how should plausibility of hypotheses be assessed in order to narrow down the range?
- (f) What arrangements are required to ensure adequate access to the data by Committee members?
- (g) What data should be used for conditioning and how precise does the conditioning need to be?
- (h) When should it be determined that new data cannot be considered for the current *Implementation*?
- (i) How can it be ensured that final specification and conduct of trials proceeds expeditiously after this point?
- (j) How can the description and results of the trials be presented in a sufficiently transparent manner to be comprehensible to non-specialist Committee members?
- (k) What kind of accompanying advice/information/explanation should be included with the final recommendation for an *Implementation*?

Suggestions for dealing with each are given in Annex D (item 6.2.2).

The Committee **agreed** that the *Implementation* process should proceed expeditiously once it had been ascertained that the basic requirements to proceed had been met. However, it was emphasised that decisions made in order to complete the *Implementation* should not set an immutable precedent for future *Implementations* and *Implementation Reviews*. To proceed expeditiously with an *Implementation*, it is often necessary to make provisional decisions about certain factors, that should not be taken as final judgements that bind future *Implementations*.

Whatever the results of an *Implementation*, they should be presented to the Commission. It may also be appropriate to include recommendations as to how the *Implementation* might be improved in the future, particularly with respect to new information. It was noted that the RMP provides for the subsequent *Implementation Review* to be brought forward in the event of major new data becoming available.

The Committee **recommends** that *Implementations* and *Implementation Reviews* be conducted according to the schedule shown in Table 2.

In that context, the assessment that precedes an *Implementation* is termed *Pre-Implementation Assessment* to distinguish it from the In-Depth Assessments conducted for species on which whaling is not currently envisaged. The *Pre-Implementation Assessment* should take account of all relevant knowledge on the species in the region. The proposed schedule does not define the length of time required for this assessment. As part of that assessment, the Committee would decide whether to proceed with an *Implementation*. Once the decision to proceed is made, the process should be completed according to the schedule in Table 2.

Annex D (item 6.2.2) lists five general issues requiring serious consideration: (1) issues related to stock structure; (2) plausibility and levels of uncertainty; (3) spatio-temporal considerations; (4) data availability and transparency; and (5) levels of information needed both for conducting a *Pre-Implementation Assessment* and for proceeding to an *Implementation*. Action to resolve items (1), (2) and (4) had already been initiated at this meeting. A report from the

sub-group established to advise on (2) is attached as Appendix 13 to Annex D. The Committee **recommends** that items (3) and (5) should be discussed next year; papers or submissions on each are encouraged.

6.3 North Atlantic minke whale *Implementation Review*

6.3.1 *Report of steering group*

An e-mail correspondence group under Smith was established last year under terms of reference given in IWC (2002d, p.12). Working from the six items described there, the group identified data sources and analysis steps required for preparations to conduct an *Implementation Review*. The timing requirements for data and analysis availability under the RMP were noted.

The following identified items are described more fully in Annex D (item 6.4.1):

- (1) new data from sightings surveys, and information on dive times;
- (2) new abundance estimates, together with analyses of surfacing rates;
- (3) information on stock structure from DNA studies;
- (4) potentially relevant ecological information.

The correspondence group had noted that the availability of new estimates of abundance did not meet the three months' lead-time required under the RMP. The delay in making estimates from the new data available was necessitated by the need for 'quality control of the analyses'.

6.3.2 *Implementation Review*

Annex D (items 6.4.2.1-6.4.2.3) reports information provided to the meeting on stock structure and abundance, based on analyses of genetic data (SC/54/RMP6); a sightings survey in 2001 (SC/54/RMP1); radio tracking experiments (SC/54/RMP2); estimation of bias and variability in radial distance (SC/54/RMP3); and spatial distribution (SC/54/RMP4). SC/54/RMP5 presented an analysis of data from Norwegian annual surveys 1996-2001.

The Committee concluded that the analyses suggest that animals in the North Sea *Small Area* may be differentiated from animals in other areas. Further, there is the possibility that the distinction made between *Medium Areas* E and C may need to be reconsidered. The Committee was interested in seeing further application of the boundary rank method to the genetic samples collected from catches since the last *Implementation* was completed. Further, Walløe indicated that Norway was interested in removing the Lofoten Island *Small Area* distinction and combining that area with surrounding areas.

Examination of the previous *Implementation Simulation Trials* indicated that these possibilities had not been completely considered then. Further, the RMP specification suggests that *Implementation Simulation Trials* may be required when *Small Area* definitions are changed.

Given the limited time available, further consideration of this item was left to a small group under Cooke (Annex D, Appendix 14). The Committee noted that any decisions concerning *Implementation Simulation Trials* would be taken next year.

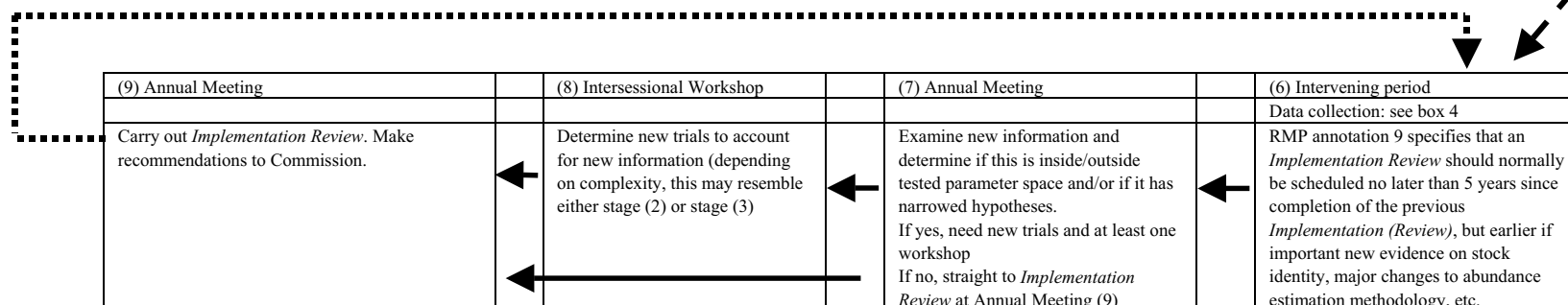
The Committee noted Norway's plans to continue undertaking surveys in the North Sea, and **recommends** that the Commission requests the relevant UK Government authorities to grant permission in timely fashion for the Norwegian vessels to undertake surveys in its EEZ.

Kell reported that at the Commission meeting in 2001 the UK had indicated that it had regretted denying access but had

Table 2

Recommended schedule for an *Implementation* and subsequent *Implementation Reviews*.

(1) x+ Annual meetings		(2) Intersessional workshop		(3) Annual Meeting		(4) Intersessional workshop		(5) Annual meeting
'Pre-implementation assessment' ¹	→	Trial structure development	→	Conditioning and final trial structure	→	Review results of final trials	→	Committee oversight
The assessment will be geared towards answering specific questions agreed by the RMP Scientific Committee, including: (a) plausible stock hypotheses consistent with the data (taken <i>inter alia</i> from the agreed list of archetypes); (b) abundance estimates; and (c) level of information available in the context of 'likely' whaling operations - taking into account the complexity of the situation with regard to spatio-temporal issues. Will use a 'simple model filter' (à la Punt) to assess importance of hypothesised factors in terms of management. (d) specification of plausible hypotheses should be inclusive enough that it is deemed unlikely that the collection of new data during the <i>Implementation</i> process would suggest a novel hypothesis not already specified in the basic trial structure. On the basis of this the Committee will recommend whether or not to move to the IST stage (2) or not. If not it will make research recommendations to try to obtain necessary information.		To determine the appropriate trial structure. This will include a precise specification of the plausible hypotheses and 'units to conserve' arising from stage (1), and elimination of those inconsistent with the data. This will interact with more detailed information in operations, including whether coastal, pelagic, on migration, on feeding, on breeding or combinations of these – comments from 'users' and scientists (who may suggest modifications). The basic building blocks for constructing <i>Small Areas</i> will be determined, along with options for <i>Small Areas</i> and management variants. Data and methods for conditioning of trials will be specified (but e-mail group can adapt them if problems). After this stage, there shall be no changes to the agreed trials structure that implements the agreed plausible hypotheses.		The meeting will review the results of conditioning. <i>Trials</i> may be modified based on these results, but trial structure will not change. If an otherwise plausible hypothesis is poorly implemented, modify its implementation. Results of new analyses of data presented at stages (1) or (2) may be considered as part of this process. Final <i>Trials</i> will be determined following further consideration of plausibility: ranking or weighting of hypotheses. Specification of scenarios, management areas, and cascading variants to include in the final trials. Updates to standard data series (e.g. abundance, catches, bycatch) will be included in the final <i>Trials</i>. Include discussion of what research may reduce range of uncertainty and likely time frame of such research.		The meeting will review the results of final <i>Trials</i> and make recommendations on: (a) management areas; (b) RMP options, e.g. cascading, capping; (c) associated operation restrictions (e.g. in time) (d) research needs (either within or outside operations) to narrow range of plausible hypotheses. If more than one RMP implementation variant is supported, it might be appropriate to link recommendation for 'less conservative' option with recommended research. If results not forthcoming to support this by next <i>Implementation Review</i>, then limits will be set at that time on the more conservative variant.		Review and agree recommendations for implementation, and final abundance estimates.² Calculate catch limits using CLA for the recommended management options. Make recommendations to the Commission. This might include more than one management option with advice on the implications of each and recommendations regarding appropriate research. (At this stage the Commission may wish to amend the Schedule and establish catch limits.)



¹ It is anticipated that the Pre-Implementation Assessment (which is similar to an in-depth assessment, but is more management-oriented) will be conducted with broad-based participation, and will ensure that all relevant knowledge about the species in the region is taken into account. Once the Assessment phase is completed, much of the work will be done by smaller groups, whose mandate is to ensure that the results of the Assessment are adequately reflected in the design and selection of trials.

² Definitive abundance estimates, for the management areas being considered, for calculating catch limits (as opposed to conditioning trials) must be available under RMP rules at least 3 months prior to stage (5). Allowing for 3+ months to prepare them, they should be requested at stage (3), since the time following stage (4) may be insufficient.

A number of assumptions are made for this process (see Discussion in report). These include:

- (1) Agreement within the Scientific Committee of what are the minimum information requirements for a *Pre-implementation Assessment* to occur.
- (2) Availability to the Committee of the data on abundance and stock identity at the beginning of the *Pre-implementation Assessment* (see item 6.6.4). This will also be linked with agreed processes to validate new collection/analysis methods before accepted for providing management advice (e.g. abundance estimates, stock-id).
- (3) Agreement that once Stage (2) begins, the process will continue until Stage (5) and a recommendation to the Commission on the *Implementation* will occur about 1.5 yrs later.
- (4) Agreement on a set of stock structure archetypes for consideration when developing stock hypotheses – will include an initial proposal for appropriate ‘units to conserve’ (see stage (1)).
- (5) Broader agreement on issues surrounding plausibility, appropriate levels of uncertainty – in effect, when is it acceptable to implement.

done so after careful consideration for reasons outlined in IWC (2002b). The UK had noted the request to reconsider its decision and had given an undertaking to do so.

6.3.3 Specify intersessional work to permit completion of Implementation Review

The intersessional work required is specified in Annex D, Appendix 14.

6.4 Western North Pacific Bryde’s whales

6.4.1 Report of Implementation Simulation Trials group

Allison reported that because of other priorities, there had not been time to code and run any trials as recommended last year. She planned to establish a process for examining catch data prior to trials taking place. The data would be tabled by areas small enough such that any future trials would only use combinations of the prepared datasets and not require any further disaggregation.

In considering the above, the Committee noted its discussions below, concerning the need to reconstruct the past catches. It agreed that Allison’s proposals for examining catch data should be held over until that reconstruction had been completed.

6.4.1.1 CATCH DATA TO BE USED IN THE TRIALS

Last year, the Committee had been provided with information on unreported catches of large whales, including Bryde’s whales, in Japanese coastal whaling operations, and had encouraged further investigation of the issue. SC/54/O13 had been prepared in response. It contained further information on such catches by species, region and month for limited operations by one whaling company between 1965-78, and compared them with official statistics. The senior author of SC/54/O13 was Mr I. Kondo, whose book on the subject had been drawn to the Committee’s attention last year (Kondo, 2001).

SC/54/O13 described major under-reporting of sperm, sei and Bryde’s whales taken off the Pacific coast of northern Japan; with catches often over twice the officially reported catch. There were problems with species identity: some fin whales taken in the Sea of Japan and the Okhotsk Sea, for example, had been recorded as sei whales. Sei and Bryde’s whales were not completely separated in the record. The information had been derived from operation summary charts of one company, covering monthly whaling operations by geographical region, giving positions of whales taken, monthly catches by species and cumulative catches by season. Figures derived from those charts differed in some minor aspects from those given in Kondo (2001), but were regarded by the authors as true figures. Kondo (2001) recorded under-reporting of Bryde’s whales off the Bonin Islands in 1981-1987 but the original records have been lost.

In discussion, Sakamoto noted that verification of information is essential before the Committee uses it because the accuracy of the information is unknown.

The Committee **agreed** that further work is needed to reconstruct past catches in more detail. An intersessional Working Group under Brownell (members: Kasuya, Smith) was given the task of investigating the quality and nature of data provided in the past, including requesting data from additional whaling companies, and suggesting methods of dealing with it, for use in the *Implementation Trials*. Given that unreported catches are experienced in finfish fisheries investigations, the group was authorised to seek advice from, and as necessary co-opt, someone outside the Committee with relevant expertise. It was also authorised to co-opt

Committee members with relevant expertise, as appropriate. Copies of the operation summary charts should be lodged with the Secretariat.

Komatsu stated that Japan disagreed that the operation summary charts should be lodged with the Secretariat since the information on the charts has neither been verified nor endorsed by the Government of Japan. He further stated that Kondo had refused to make contact with Japanese Government officials who had requested to see him to provide the information on the past whaling data. Therefore, the Government of Japan was unable to check and verify the information and maintains its position at this time that the statistics already provided are still the official data. Komatsu also indicated that Japanese scientists would not serve on the intersessional group.

Kasuya responded that Mr Kondo saw no reason to meet with the Government of Japan because he had already made details of the statistics available in his book, and because he was making these details available to IWC in the paper written with Kasuya (SC/54/O13).

Smith expressed his considerable regret at the lack of response from Japanese scientists in assisting with the work of the intersessional group.

6.4.1.2 STOCK STRUCTURE

SC/54/O17 (appendix 10) provided information on mitochondrial DNA control region sequencing and microsatellite analyses conducted on samples of the ordinary form Bryde's whales from different localities of the western North Pacific. A total of 58 unique mtDNA sequences (haplotypes) were discriminated in the total samples. No significant differences among the three localities in the North Pacific were revealed. In contrast, striking mtDNA differences were found among oceanic regions. Additional analyses found some degree of heterogeneity between historical samples from Ogasawara and recent JARPN II samples but the same test found no significant heterogeneity between JARPN II and the central western North Pacific (CWMP) or between Ogasawara and CWNP. Microsatellite analysis gave no significant deviation from the Hardy-Weinberg equilibrium or significant differences in allele frequencies. In contrast, striking nuclear DNA differences were found among samples from the western North Pacific, the western South Pacific and the eastern Indian Ocean, confirming the occurrence of different genetic populations in those three regions. Overall the results provided support for the stock structure scenario defined by the Committee during the Comprehensive Assessment (IWC, 1997a, p.83). The authors noted that the mtDNA heterogeneity found between Ogasawara and JARPN II is difficult to interpret at this stage and that other information (apart from genetics) should be considered in future to provide a better interpretation and conclusion.

The Committee noted that sample sizes in the above study remain small, and it was suggested that genetic and pollutant analyses (see SC/54/O17, appendix 13) might be coupled to provide useful information.

It was **agreed** that the results reported in SC/54/O17 provided no reason to change the stock structure in the existing trials, but that as much work as possible should be undertaken before the next meeting to allow a full and detailed discussion at that time.

In discussion of the Implementation Schedule (Table 2) in this context, it was noted that activities so far were still within the *Pre-Implementation Assessment* referenced in 'Box 1'; it would be necessary to review progress at next

year's meeting to determine exactly what point had been reached on the schedule. Hopefully by that time, meeting the criteria in Box 1 would be well advanced.

The Committee noted that it may be in a position at the next meeting to complete the *Pre-Implementation*. If so, any new data after that meeting that might indicate additional hypotheses would only be considered in the subsequent *Implementation Review*. Coding of the trials, as specified (IWC, 2000c), would accordingly be suspended until next year's meeting.

6.4.2 Sightings surveys

Information on two Bryde's whale surveys conducted in the western North Pacific, in July-August and August-September 2001, was provided in SC/54/RMP10 and RMP13. Details are summarised in Annex D, item 6.5.2.

Plans for a Bryde's whale survey in the western North Pacific in August-September 2002 were given in SC/54/RMP14. It will only take place if the planned minke whale survey (see Item 6.5.1) does not receive permission to operate in the Russian Federation EEZ.

The Committee **endorsed** the proposal in SC/54/RMP14 and asked Shimada to provide Committee oversight for the survey should it take place.

6.5 Other

6.5.1 Sightings survey plans for North Pacific minke whales

SC/54/RMP9 detailed plans for a sightings survey for minke whales in the Sea of Okhotsk in summer 2002. It will take place from 23 July-20 September, using two vessels, with the objective of estimating abundance using IO passing mode. Biopsy samples for assessing stock structure will be collected opportunistically. Training and experiments in distance and angle estimation will be conducted.

The Committee **endorsed** the proposal and **recommends** that the Commission requests the relevant authorities of the Russian Federation to grant permission in timely fashion for the Japanese vessels to undertake surveys in its EEZ.

SC/54/RMP12 described joint Japan/Korea sightings surveys in the Sea of Japan in 2002. Using two vessels, the main objective is to obtain information on distribution and density of the East China Sea-Yellow Sea-Sea of Japan minke whale stock, using normal closing mode. One vessel will conduct opportunistic biopsy sampling. One survey has already been undertaken (10 April – 9 May) and the other will take place from 13 May – 1 July. Kim reported that one Korean scientist will be participating.

The Committee **endorsed** the proposal and asked Miyashita to provide Committee oversight for the surveys.

SC/54/RMP19 provided information on plans to conduct a sightings survey from 20 August – 19 September 2002 in western Korean waters. Its objective is to estimate minke whale abundance in terms of the RMP, in both closing and passing mode, and to obtain general information on seasonal cetacean distribution.

SC/54/RMP20 detailed a Korean sightings survey in the Yellow Sea, undertaken in September 2001. Due to bad weather, only 49.5% (621.6 out of 1,255.7 n.miles) could be undertaken on effort. Minke whales were aggregated in the southern part of the offshore area.

SC/54/RMP21 described a revised plan for a sightings survey in eastern Korean waters. It had been revised in accordance with discussions at last year's meeting, particularly in terms of coverage probability and randomness of start points. One vessel will operate from 14 May – 18

June. The survey area is divided into seven rectangular blocks taking account of land shapes, with a total predetermined transect distance of 1,370 n.miles (see also Kim, 2001).

The Committee **endorsed** the proposals in SC/54/RMP19 and RMP21 in terms of the RMP and asked Miyashita to provide Committee oversight for the surveys. It **recommends** that the survey report and plans be elevated to full paper status to ensure they are entered into the record (SC/54/RMP19, 20, 21).

6.5.2 Initial planning for an in-depth assessment of North Pacific minke whales

The Committee judged that work on this assessment should be delayed until the North Pacific minke whale *Implementation* is complete. However, members noted with concern the information it had received about much higher levels of bycatch (reported as 148 from Korea in 2001) in the region of the J-stock (see Annex D, item 6.3.1), which, on the basis of some of the current trials, could lead to severe depletion on a short time scale. Some members commented that an updated assessment could lead to a reappraisal of this possibility. The Committee **agreed** that there is a need to address the assessment of North Pacific minke whales as a matter of urgency at next year's meeting, but noted that the *Implementation Simulation Trials* would provide some information on this issue.

6.5.3 Revision of RMP annotations

There were no matters requiring attention at this time.

6.5.4 Data availability

The Intersessional Workshop (see Item 6.1.1 and SC/54/Rep1) had encountered difficulties over access to genetics data important to the development of trials. It had noted that the matter of data availability is complex and sensitive, involving the need to strike a balance between the Committee's needs and the rights of scientists who had collected the data, and the great importance of the issue to the Committee's work in the context both of the development of *Implementation Simulation Trials* and in discussions of their relative plausibility. It had strongly recommended that the question of data availability should be considered at this meeting.

The matter was referred to a working group under Donovan (Baker, Cooke, Hammond, Hatanaka, Perrin, Smith, Walløe). The Working Group had the task of reviewing the question further and recommending possible courses of action, for agreement by the Commission.

Donovan reported that the group had only a limited time to meet and discuss what is clearly a vital issue to the work of the Committee (see SC/54/Rep1 and Annex D, item 6.6.4).

The Working Group had agreed to address issues under two headings: (1) data access and safeguards to protect the rights of data providers; and (2) arrangements for analysis. There was consensus that the data required to develop plausible hypotheses and develop appropriate *Implementation Simulation Trials* are as important as those required for the *CLA* itself in the overall implementation process. Although some useful clarifications were made, no agreement as to how to solve the question of data access had been reached in the time available.

The Working Group also agreed that it would be unhelpful to try to rush through any proposed solution to this issue at the present meeting. The Committee **agreed** that the group should continue to work intersessionally with a view to providing the Committee with either a consensus

recommendation, or a limited number of options to consider at the next meeting. It was recognised that a decision on this important issue must be taken at the next meeting.

The Committee also **agreed** that, in order to obtain a better understanding of the current system established in Japan for access to genetic and other data, it would be helpful if members of the Committee requesting data copied both their requests and the replies received to the intersessional group (via Donovan).

6.5.5 Comparison between CLAs and SLAs

Walløe and Hatanaka commented on the comparison of the catch trajectories between the *Bowhead SLA* (recommended by the Committee for the management of the aboriginal subsistence fishery for bowhead whales in Alaska) and the RMP's *CLA* reported in Annex E (Appendix 6). They noted that under the base-case (BE01) trial, the *CLA* did not allocate catches until 2030 and that the catch did not reach the current need level in the 100 year simulation period. They believed that this emphasised that the *CLA* was far too conservative.

The Chair of the SWG on the AWMP drew attention to the reasons why a direct comparison of the *Bowhead SLA* and the *CLA* was inappropriate as summarised under Item 8.2.1.3.

6.6 Work plan

The work plan agreed by the sub-committee on the RMP is given in Annex D (item 6.7). The discussion of the Committee's overall work plan is given under Item 19.

7. ESTIMATION OF BYCATCH AND OTHER HUMAN-INDUCED MORTALITY (ANNEX M)

7.1 Estimation of bycatch based on fisheries data and observer programmes

The Committee reviewed records of large whale bycatch in National Progress reports for the statistical year 2001. Common minke whales were the most recorded species (over 230); the records were very clumped, notably in Japan and in eastern Korea. This raises the question as to whether this is due to better reporting in these areas, or whether there is some aspect of the fisheries in these two regions which made bycatch more likely than elsewhere.

SC/54/ProgRep Japan records that all minke whale bycatches occurred in trap nets. Similar nets in other parts of the world (e.g. Newfoundland, Canada) are also known to entrap large whales (Lien, 1994). The Committee had no information regarding the use of trap nets in other countries and **agreed** that a request from the Commission to member states and other states asking for details of fishery categories might help elucidate this point (see Item 7.1.4).

Issues of reporting efficiency and how current reporting schemes are implemented were discussed in detail, as such matters are crucial to providing advice to the Commission on how best to estimate total large whale mortalities in fishing gear.

In the Republic of Korea, all large whales whether bycaught, stranded or floating at sea, have been subject to a national reporting scheme since 1996. All such animals have to be reported to the marine police agency located in every port. The marine police assess the cause of death and make a thorough report. The Prosecutor then judges whether the law has been breached based on the report. Domestic disposition of bycatch is only allowed through this system,

which now works routinely. It was queried whether marine police officers were qualified to make pronouncements on the cause of death of cetaceans, noting that this requires specialist experience.

Biological sampling has proved difficult because it requires appropriate expertise. Starting this year, a biological sampling programme is being implemented by hiring experts to sample carcasses in collaboration with the regional authorities and the marine police. Furthermore, guidelines on bycatch reporting will soon be incorporated into the fisheries law. Sohn asserted that the existing mandatory reporting scheme in Korea made any further attempts to estimate bycatch unnecessary there. He further pointed out that the bycatch is highly sporadic in a range of coastal fisheries and occurs mainly within three miles of the coast. Fisheries operating in this area are small scale and there are few relevant data that could help in any bycatch estimation methods.

All bycatches of large cetaceans must also be reported in Japan. Recent changes in domestic legislation (since 1 July 2001) now make it possible for Japanese fishermen to market bycaught whales, provided each was recorded and a DNA sample taken (IWC, 2002j, p.363). Prior to 1 July 2001, it had not been compulsory to report bycaught whales, but Ministry guidance encouraged the reporting of any such events.

The number of bycaught minke whales recorded in Japan in 2001 (79) was considerably higher than in 2000 (29). In 2001, there had been 54 minke whales reported over the six months since the new legislation was introduced compared to 25 in the preceding six months. There was some discussion as to why there had been an apparent increase since the introduction of the new legislation, but Nagatomo stated that it was not clear if this was a significant increment, and that several more years of data would be needed to determine this.

Bycatch reports in Japan and Korea might be more complete than in other countries because there was no disincentive for reporting. In the USA and some other countries, penalties for reporting bycaught whales might impede accurate reporting. Mattila confirmed that in the USA, records of bycaught whale numbers seemed to be declining in some fisheries, possibly because fishermen were becoming aware of the potential threat to their livelihood posed by the accidental capture of whales.

There was some discussion as to whether incentives for reporting bycatch might actually lead to increases in whale mortalities. Last year, it had been reported that the new fisheries Ministerial Ordinance and related guidelines would allow fishermen to kill animals that could not be released from nets in order to market them (IWC, 2002d, p.15). Nagatomo stated that even though fishermen are now able to market whale meat from bycatches, they must still make best efforts to release whales from nets when caught, and only if they cannot be released can they be killed. It was not known how many bycaught minke whales had died as a direct result of entanglement and how many had been killed in order to remove them from the nets; the operating body itself can decide how to deal with an entangled whale. Japanese fishermen are able to apply for compensation for nets damaged by bycaught whales.

The Committee **agreed** that there is no clear explanation as to why recorded bycatches of minke whales are so much more frequent in some areas than others. The aggregated total number of bycatches in National Progress Reports are unlikely to represent a complete estimate of the total bycatch mortalities, since not all countries are IWC members and not

all members submit bycatch records to the IWC. Recommendations regarding this issue are given under Item 7.1.4.

Komatsu stated that Japan cannot agree with the above conclusion and recommendations. He pointed out that Japan voluntarily submits bycatch data in Japan's National Progress Report since this is a matter of responsibility of national governments. He expressed the view that any inference that these data are inaccurate is unacceptable. He also noted that the apparent increase in bycatch may reflect an increase in the stock.

Perrin noted that no data are available to the Committee on the minke whales bycaught but released. If this number has decreased since the fishermen were authorised to kill and market bycaught whales, that could explain the increase in reported bycatches.

7.1.1 Collation of information from fisheries

Last year, the Committee reviewed a list of categories of information that might appear on a form that could be distributed to identify certain fisheries where bycatch is thought to take place, in order to assist in the future design of appropriate sampling schemes (IWC, 2002d, p.13). An intersessional group was established to take this matter further (IWC, 2002k, p.413). The success of this exercise will depend on how the first field of the query (fishery category) is interpreted. Each country is likely to categorise fisheries in an individual manner, based on some combination of target species, gear type and geographical area. A recommendation to help address this issue is given under Item 7.1.4.

This information gathering exercise could be used to identify fisheries for which there is little or no information on bycatch but which share common characteristics with fisheries where bycatch has been monitored. The Committee **agreed** that it is important to consider such fisheries, as well as fisheries where bycatch is known to occur. Consideration of these data might suggest the relative priority of monitoring programmes to assess incidental takes for different fisheries.

The Committee **recommends** that modelling studies should be encouraged to try to estimate how much observer coverage of a particular fishery would be required to allow reliable estimates of large whale bycatch. Such studies should assist in assessing how best to utilise data as they become available from the information gathering process. The Committee encourages papers on these types of statistical studies to be submitted.

Kim questioned the need to consider estimation of bycatch given that he believed the mandatory bycatch reporting system in the Republic of Korea resulted in all bycatch being reported. He suggested that if there was reason to believe that bycatch was occurring in a particular fishery within a country, then the Commission could ask that member government to establish a bycatch reporting system rather than ask for fisheries information. Other members noted examples where independent observer schemes had been established for fisheries that already had reporting schemes. In several cases these revealed much greater levels of bycatch than had previously been reported.

7.1.2 Fatality rates of large whales entangled in fishing gear

The issue of disentangling large whales was raised in Resolution 2001-4 (IWC, 2002c) and is considered in detail under Item 12.3.5. Discussion of this topic under the present

agenda item focused on the entanglement and freeing of large whales from fishing gear, especially in the Northwestern Atlantic. Large whales are sometimes seen at sea entangled in fishing gear and the experiences of researchers in that region working with several species of large whale might be useful in providing a photographic or diagrammatic catalogue of the types of damage likely to prove ultimately fatal and the types that might be reasonably assumed to be non-fatal. Mattila responded that there were some types of damage that were clearly potentially fatal, including those where young animals were entangled and could be expected to 'grow into' ropes that could ultimately result in their death. Minke whales, as one of the smallest of the baleen whales are the most likely to die as a result of entanglement in the short term, whereas larger whales may swim away with gear attached and succumb at a later date if feeding is impaired or if the entanglement leads to serious infection.

The Committee considered whether there is information on the proportion of entangled animals that are ultimately known to have died as a result, and whether there is any relationship with fishing effort or gear density. Researchers at Memorial University in Newfoundland have been involved in such research for over 30 years and may have relevant information. It was **agreed** that the Committee should contact this group to request a paper for next year's meeting.

SC/54/BC6 reported on a bycatch reduction strategy emanating from a Workshop held in Annapolis in January 2002. The strategy includes a suggestion that formal national Plans of Assessment to estimate bycatch rates should be developed. Such Plans would include collection and analysis of data to describe fishing fleets, including the size of the fleet (number of vessels), fishing methods, fishing areas and measures of fishing effort. They should also include, where appropriate and possible, bycatch monitoring schemes based on independent observations. The strategy is currently in draft form for review and is intended to be presented at FAO's next Committee on Fisheries (COFI) meeting.

7.1.3 Other

Last year, the Committee recommended that a request be made for further information about a planned cetacean strandings scheme in China. No information was available at this meeting but the Secretary of the Commission will contact Chinese authorities to ask if some written document on the proposed scheme, together with methods of necropsy that would be used, might be submitted to a future meeting of the Committee.

7.1.4 Recommendations to the Commission

Given the discussions above on information needs, the Committee makes the following **recommendations** to the Commission.

- (1) The Secretary be asked to write a letter to the relevant authorities in each member country requesting a list of fisheries, broken down by gear type, target species and geographical area, to the extent to which this is routinely done in each country. This would provide a first step that might assist in developing a sampling strategy for monitoring bycatch.
- (2) Member nations are urged to include more specific information on large whale bycatches in the National Progress Reports such that they ideally include not only gear type, but the way in which this gear is being used

and the target species. As a minimum, the gear description should correspond to an item listed in the response to the request for information given in (1) above.

In order to encourage cooperation, the objectives of collecting this information must be clearly specified. Data will also be welcomed from non-member states that may be willing to volunteer information even if a formal request from the IWC is not appropriate.

7.2 Estimation of bycatch based on genetic data

SC/54/BC1 updated previous work listing the species of cetaceans determined from DNA analysis from market samples in both Japan and Korea. Several species were found that the authors believed were unlikely to have been derived from either scientific whaling or bycatch.

In Dalebout *et al.* (2002), microsatellite DNA profiling of North Pacific minke whale products from the Japanese and Korean market was used to determine the minimum number of whales available for sale and to track the movements of products from individual whales through these markets. The same methods were used in SC/54/RMP8 and SC/54/BC3, and are very similar to those used in tagging and recapture studies to investigate populations of living animals. Six microsatellites were used to profile market products identified as derived from North Pacific minke whales through phylogenetic analyses of mitochondrial DNA control region sequences. These loci are a subset of those specified in the Norwegian DNA registry and those used by Japanese researchers. These six microsatellite loci, in combination, gave a reasonably low probability of a match (identity) between products by chance for the Japanese market. The probability of a match by chance was higher for the Korean market due to the lower genetic diversity of the J-stock (East Sea/Sea of Japan).

SC/54/RMP8 reported on eight market surveys conducted in the Republic of Korea between March 1999 and November 2001. Products were purchased in southeastern coastal cities in short periods of a few days in each survey. Surveys yielded a total of 122 minke whale products representing at least 97 unique individuals. Over 90% of these animals were J-stock based on diagnostic nucleotide substitutions at the mtDNA control region (e.g. Baker *et al.*, 2000). Products from the same individuals were generally only found within the same survey. These results suggest that products from individual whales are not stored long-term in the Republic of Korea, and in general pass through the market in a period of less than seven months. Given the conservative nature of these censuses, it appears that the total yearly Korean bycatch of minke whales remains high. This is consistent with SC/54/ProgRep Korea in which 148 North Pacific minke whales are reported as bycatch, 132 of which were taken off the East Sea/Sea of Japan coast.

In SC/54/BC3, 167 minke whale samples, purchased in Japanese markets between December 1997 and January 2002, were found to represent 142 individuals. J-stock products, presumed to come from bycatch in the Sea of Japan, contributed 41% of these, while the remainder were O-stock animals assumed to have come from scientific whaling in the North Pacific. There was no significant difference in the proportion of products from the two stocks among different prefectures.

Pastene noted that the interpretation of market samples is very difficult and referred to Pastene *et al.* (2001) from last year that summarised several molecular surveys conducted in the Japanese retail market. It had identified several factors

affecting the estimation of the mixing proportion between O and J-stocks in the market: (a) randomness of the survey; (b) geographical variation in the distribution of J/O stock products across Japanese prefectures; (c) duplicate sampling; (d) period in which products from an individual remain in the market. On point (d) it was recognised that processed products will stay in the market for a longer period than fresh meat. It was further noted that samples obtained in surveys should be weighted according to the availability of the whale products across the different prefectures.

In response, Baker noted that SC/54/BC1 and SC/54/BC3 had also conducted analyses to evaluate biases. For example, after eliminating replicate products from the sample of Japanese markets there were no significant differences in the ratio of J:O stock animals by prefecture. It was suggested that a larger sample size would still be helpful, but concluded that bycaught whale meat appears to be treated by the market in the same way as JARPN products.

The Committee **agreed** that sample design requires attention, and that a purpose of the proposed workshop (see Item 7.2.1) will be *inter alia* to develop appropriate sampling strategies for the Japanese whale meat market.

There was general agreement that there were currently too few reference samples to assign the sei whale samples in SC/54/BC1 to individual populations or geographical areas. Concern was expressed as to where any such samples might have come from, with no current legal whaling of sei whales. The sei and Bryde's whale products uncovered in the sampling had mostly been unique individuals. This does not support the suggestion that these samples could have been in the supply chain for a longer period of time than the minke whale products, as might be expected for stockpiles.

Morishita noted that in Japan, meat from pre-moratorium whaling is still held in cold stores, as shown in SC/54/BC5, so that meat from such animals is still being marketed, although there are decreasing amounts of it available. It was further noted that the data in SC/54/BC5 on whale meat stockpiles had been updated in 2001. He stated that verification of the origin of sei and other larger whale products in the stockpile has been conducted but the report on this was not yet available.

There was some discussion about the apparent increase in bycatch of minke whales including J-stock animals. Trends in the population size of J-stock minke whales are unknown and J-stock population size has not been estimated.

It was suggested that if samples from reported bycaught minke whales could be compared with samples found in the market, it would be possible to determine what proportion comes from undocumented sources. The Committee **agreed** that this is a promising approach to improve estimation of total bycatch over time.

Kasuya commented on the surprisingly high proportion of J-stock whales in the market samples. Many members noted that the availability of data on the annual proportion of J-stock animals taken in the North Pacific, from incidental catches and JARPN, would allow better estimation of bycatch. They also reiterated that estimation of bycatch would be improved by the ability to compare market samples with a register of all legally caught whales. However, Nagatomo stated that monitoring, control and management of the domestic whale meat market is the sole responsibility of the government based on its sovereign right, and that matters related to their domestic market are therefore outside the jurisdiction and competence of the IWC. The Government of Japan is consequently in no position to provide its market-related genetic data to the IWC. However, Nagatomo indicated that if data from DNA sequence

analyses from parties concerned were forwarded to the Institute of Cetacean Research they would compare the data with their database and provide the results.

Funahashi and Kasuya clarified that the request to the Government of Japan was not for market-related genetic data, but for information on the numbers and locations of J-stock animals from bycatch and JARPN II. This information is required to improve estimates of total takes over time from the J-stock, as required for the RMP. Funahashi also stated that she and colleagues would be glad to discuss cooperative research projects involving an exchange of genetic data. Such an exchange would require third party oversight to resolve possible conflicts in identification as already proposed in 2000 by Baker *et al.* (2000).

Komatsu stated that Japan is willing to provide data and receive collaborative scientists following review of any applications. He noted however that as a sovereign government, Japan does not accept the proposal that this should be subject to third party oversight.

7.2.1 Report of bycatch workshop feasibility Steering Group

The use of market survey data to improve on minimum estimates of bycatch and provide more realistic unbiased estimates of whale bycatch will require information not only on reported bycatch rates but also on market structure and product pathways, as well as design input for the collection, storage and analysis of genetic samples in an appropriate manner. To investigate the feasibility of holding a workshop to address these issues, the Committee **concluded** that it would be helpful to: (1) outline the types of information needed in order to design an effective sampling scheme; (2) begin locating potential sources of such information; (3) develop contacts with access to the required information or who could assist in developing methods to obtain such information; (4) locate experts in the design of market surveys; and (5) locate experts who could actually conduct the surveys. It was recognised that such a process would have to be iterative and that a full list of information needed for design of such a system would require the assistance of experts as noted in points (4) and (5) above. SC/54/BC5 lists companies with such expertise who can give advice on best practice to design an appropriate market sampling strategy in Japan, plus an initial bibliography. SC/54/BC3 also contained information available from earlier DNA identification market surveys on sample and market distribution in Japan.

The Committee **agreed** that it appears feasible to hold such a workshop. However, more information should be gathered and the experts from the companies with market sampling expertise contacted; with this additional information it should be possible to develop a draft proposal for the Workshop at the 2003 meeting of the Committee.

The Committee **agreed** that the work in this area should be continued intersessionally and reported next year. Morishita reiterated his concern that the workshop would be unlikely to achieve anything useful, and stated that Japan does not endorse the workshop.

7.2.2 Analytical tests for assignment to stocks and/or areas

The Committee was informed that assignment procedures are becoming more widely used now, so that the geographical provenance of individual samples could be determined, although it was cautioned that this is only possible where there has been sufficient directed sampling to

ensure a baseline of comparative genetic samples. The Committee **agreed** that there are insufficient reference samples to take this very much further at present.

7.2.3 Other methodological advances

SC/54/SD2 described a web-based programme for phylogenetic species identification. This software arose after a forensic identification workshop (La Jolla, California, 1999) at which the need for a database of DNA sequences had been highlighted (Dizon *et al.*, 2000). The web-based software (<http://www.dna-surveillance.auckland.ac.nz>) provides sequence matches, but keeps the reference sequences hidden unless permission is granted by the owner. The sequences are held in a hierarchical structure and the software will provide a closest match. One of the advantages of this approach is that it overcomes the need to export and import samples for comparison, thereby avoiding lengthy permit application procedures. It is discussed further under Item 15.1.

7.3 Further review of information and methods to estimate mortality from ship strikes

There were 10 ship strikes (definition includes hull strikes and propeller strikes) recorded in National Progress Reports for 2001. Additional strikes were also listed for 1999 and 2000. A number of factors might lead to ship struck animals being unrecorded, including: offshore winds and currents; sharks; large ships would be unlikely to notice hitting a whale; even if a struck whale was noticed it would be unlikely to be recorded by many mercantile naval officers, unless noticeable damage had been caused, as striking an obstacle is the fault of the officer on watch, and he would be held responsible. The Committee **agreed** that the existing records of ships strikes, as reported in National Progress Reports, were probably gross underestimates of the total number of actual ship strike mortalities among large whales globally.

In the UK, the Royal Navy had agreed in principle to collate records of naval ship strikes annually and report them to the UK's responsible ministry with a copy to the IWC. US Navy protocol includes routine recording and reporting of whale collisions.

Since the USA has introduced necropsy protocols that included 'flensing to the bone', an increased number of severe traumas and suspected ship strikes have been uncovered among stranded whales. As this work progresses, it may be possible to ascertain whether the ratio of known to cryptic ship strike casualties among stranded animals is consistent enough to use this as an estimator of cryptic ship strike mortalities among stranded animals elsewhere.

The Committee received data on shipping levels in South African waters in relation to ship strikes of right whales. This showed very high levels of shipping activity in South African waters including those adjacent to KwaZulu Natal and the southern Cape in the austral winter when right whales are most numerous locally, with 1,574 ships recorded passing through territorial waters around the southern Cape during the months of peak right whale abundance (July to November). However, despite the high levels of shipping, only four known and seven suspected ship strike mortalities of right whales had been recorded in 30 years, although full necropsies had not been undertaken (Best *et al.*, 2001). It was suggested that right whales were mainly confined to coastal waters and that the main shipping lanes are further offshore, thereby reducing the likelihood of ship strikes. In South

African waters the most likely area for ship strikes would be off the eastern Cape and coast of Natal, where migrating humpbacks would cross shipping lanes.

SC/54/BC4 presented a simple modelling approach to ship strikes which attempts to predict a maximum likely strike rate for a given density of ships and whales, assuming a random orientation of the whales and no behavioural response to an approaching ship. Applying the model to the Canary Islands, where ship strikes, mainly on sperm whales, have been recorded for several years, the model predicted a maximum of seven large whale strikes per year in the Tenerife-Gran Canaria Channel. There have been seven large whales recorded as struck and killed by fast (30 knots and above) ferries in this location during the last three years of observation, but this may be a minimum estimate as not all would have been noticed or recorded as stranded animals. The behavioural responses of a whale would greatly influence the predicted strike rate. Ship avoidance would likely be prompted by acoustic cues but sound propagation from an approaching ferry will depend on water depth and stratification. If avoidance responses to such cues are learned over time, then calves and recent immigrants to an area (such as this migration zone) would be most at risk of collision.

The Committee recognised the value of this approach for setting an upper bound on likely strike rates, and also noted that the work in the Canary Islands probably represented the best such dataset in the world, and encouraged it to continue to collect this type of data to improve understanding of ship strikes, and to provide a basis for quantifying actual collision rates. Although priority is given to estimating ship strike mortality in the western North Pacific and the Northeast Atlantic, the Committee recognised that by examining other areas of the world and even protected species such as northern right whales, useful insights into the rates at which animals are struck might be gained.

Some years ago, a fast-ferry line had been introduced between one of the islands in the Sea of Japan and a western Japanese port. Jet-foil ships had suffered collisions with whales. The ship owners had tried to avoid collisions by introducing acoustic warning systems. It was not clear whether this method had worked, but they had also increased the number of people watching out for whales and the numbers of collisions had decreased. The report of this work was published in Japanese. The Committee welcomed this information and asked whether it might be made available to the Committee next year.

The Committee **recommends** that data be collected interessionally on the amount of high speed ferry and other similar fast-moving vessel traffic. Weinrich agreed to chair a group to collate this information. Emphasis will be placed on two areas, the Northeast Atlantic and western North Pacific. Additional information will be gathered in the western North Atlantic, South America (with a special emphasis on Venezuela where there are reports of collisions with high-speed vessels) and Southeast Asia. It was noted that data relevant to estimating mortality due to ship strikes are so sparse, that data from all areas would contribute to understanding the various factors involved. In addition, a list of areas where high-speed vessels are used for whalewatching should be developed, along with a catalogue of known collisions between vessels and whales where data on the type of vessel involved in the collision are available.

The Committee recalled two suggestions from last year's meeting that biopsy samplers might be fitted to vessels in high-risk areas, and secondly that a decelerometer might be developed that could detect whale strikes on large vessels,

including fast ferries (IWC, 2002d, p.17). Tregenza reported that he had formulated the technical specifications for a decelerometer and that he was in consultation with engineers about its construction. He would report back to the Committee next year.

The Committee **reiterated** its request last year that necropsies on stranded animals should examine animals as thoroughly as possible for evidence of ship strikes. It was suggested that some technical innovations, perhaps through the use of ultra-sound, might be sought to look for evidence of ship strikes on stranded animals without having to remove all the muscle of a large whale during autopsy.

The Committee also repeats its **recommendation** that member nations ensure more complete records of ship strikes in the National Progress Reports.

7.4 Methods for estimating additional human-induced mortalities

As last year, the Committee briefly discussed other sources of human induced mortality including entanglement in marine debris, mortality resulting from acoustic trauma, mass die-offs due to disease that might be induced through the immuno-suppressive action of pollutants, or kills due to oil spills. The Committee recognises that those matters were outside the terms of reference as currently drafted but **agreed** that to the extent that these additional human-induced mortalities could reasonably be estimated, they should be flagged for future consideration.

7.5 Work plan

The work plan agreed by the sub-committee on estimating bycatch and other human-induced mortality is given as Annex M (item 9). The Committee's overall work plan is discussed under Item 19.

8. ABORIGINAL SUBSISTENCE WHALING MANAGEMENT PROCEDURE (ANNEX E)

This Item continues to be discussed as a result of Resolution 1994-4 of the Commission (IWC, 1995, pp.42-43). The report of the Standing Working Group (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. A glossary of terms is given in Annex E, Appendix 2. Full trial structure specifications are given in Annex E, Appendix 3. For ease of reading, 'last meeting' refers to the intersessional meeting held in Seattle in January 2002 (SC/54/Rep2). The primary topic for discussion at this year's meeting was the final selection of a candidate *Strike Limit Algorithm* (SLA) for the Bering-Chukchi-Beaufort (B-C-B) Seas bowhead whales. Last year, the Committee had reported that it had two excellent procedures available (four variants) which exhibited very similar performance. It had identified some additional work and informed the Commission that it would be able to make a recommendation for an SLA for the B-C-B Seas stock of bowhead whales to the Committee at the 2002 Annual Meeting (IWC, 2002d, p.23).

8.1 Review intersessional progress

The intersessional workshop (SC/54/Rep2) continued the work of the SWG as given in table 6 of IWC (2002d, p.27). The main topics discussed were: moving towards finalising the *Evaluation, Robustness and Cross-validation trial* structure and specification for gray whales; reviewing results

of trials for the available revised variants of the G-G and D-M SLAs for bowhead whales; moving towards selection of a final recommendation to the Commission; and further consideration of aspects of the Aboriginal Subsistence Whaling Management Scheme (AWS). Discussion of these items is part of the ongoing process and such discussions are referred to throughout this report where appropriate. A major proposal emerged at the workshop with respect to the selection of an SLA. This referred to the possibility of setting the strike limits by taking a simple mean of the G-G and D-M block strike limits. Such an averaged SLA (hereafter termed the GUP¹ SLA) would have a number of advantages, and it was agreed at the Workshop to pursue this idea further for consideration of results at the Annual Meeting. A large number of computing and other tasks were agreed at the Workshop, and excellent progress was made with these by both Allison and the developers.

8.2 Bering-Chukchi-Beaufort Seas stock of bowhead whales

8.2.1 Selection of SLA

8.2.1.1 MODIFICATION TO CANDIDATE SLAS SINCE THE FOURTH WORKSHOP

Five candidate SLAs were tested, the G-G (2 variants), D-M (2 variants) and GUP. These are described in some detail in Annex E (Appendix 4) and are summarised here. The Committee thanked the developers and Allison for their extensive intersessional work, noting, in particular, that the intersessional development period following the January 2002 workshop had been very short.

8.2.1.1.1 G-G SLA

SC/54/AWMP3 provided a complete description of the G-G SLA. At the core of this SLA is a penalised maximum-likelihood estimator that generates estimates of three predictor variables: carrying capacity, net yield and stock size. An optimal Bayes rule linear model is then fit to these predictors and one interaction term using the statistical merging and optimisation strategy published by Givens (1997; 1999; 2000). The goal of this fit is to best match the strike limits provided by the idealised catch control law *H* (IWC, 1998e, p.208) on a weighted subset of *Evaluation Trials*. The final strike limit also includes variability dampening and snap-to-need features². Included in the SLA are two protection levels: a 30% reduction in strike limit if the stock is believed to be moderately reduced from the current (i.e. 2002) level and a zero strike limit if the stock is believed to be below 2,000 whales. Several tunings are described.

SC/54/AWMP3 described how the resulting SLA generally focuses on safely satisfying moderate need, while favouring stock protection by setting strike limits below what would be required to fully satisfy need in the final portion of this century in extreme scenarios where need might triple from present levels. When faced with plausible data suggesting risk to the stock, the SLA is constructed to reduce the strike limit, thereby undesirably reducing need satisfaction when the data are misleading but desirably protecting the stock when the data reflect reality. In terms of need satisfaction, the SLA incrementally downweights the importance of greater need satisfaction as the absolute level

¹ Grand Unified Procedure.

² The 'snap-to-need feature' involves setting the strike limit equal to the need level if the 'raw' strike limit from an SLA exceeds 95% of need.

of need satisfaction increases. In other words, as need approaches full satisfaction, the *SLA* focuses increasingly on risk avoidance.

8.2.1.1.2 D-M *SLA*

SC/54/AWMP5 described the D-M *SLA* and recent modifications. The *SLA* is based on well-established methods (Adaptive Kalman Filtering (AKF)). The *MSYR-K* parameter space is represented by a two-dimensional grid of values that are initially assumed to be equally likely. For each point in the parameter grid an Extended Kalman Filter is applied, which is appropriate when the underlying dynamics are non-linear. Every time a new survey estimate becomes available, the stock estimate is updated and, furthermore, a posterior probability is calculated by Bayesian methods for each point in the parameter grid. A catch control law (of a general form used in the past by the IWC) is specified, and a strike limit then calculated, conditional on the values of the two parameters (*MSYR*, *K*) and the stock estimate, and with its associated posterior probability. A cumulative probability distribution is then constructed from the sequence of strike limits and their associated posterior probabilities. The final strike limit is based on a pre-specified percentile of this distribution. The *SLA* is tuned by specifying the steepness of the catch control law and the percentile in the cumulative distribution function for the conditional strike limit. Before the final strike limit is given, a 20% maximum change in strike limits between blocks is imposed and a snap-to-need feature is incorporated.

This version of the D-M differs from that presented last year because: (1) a more flexible catch control law is used instead of the H-rule, resulting in removal of any discontinuities; (2) the number of *MSYR*-filters has been increased from four to seven giving a smoother cumulative distribution function for the strike limit; and (3) two tuning parameters are used instead of one.

The (*MSYR*, *K*) grid for the D-M *SLA* is discrete and was deliberately made fairly coarse for computational reasons. Filters corresponding to seven *MSYR* values are used and this can give the cumulative distribution function a shape of alternating flat and steep parts where the 'plateaus' correspond to the different *MSYR* values. This feature can be removed by using a finer *MSYR* grid, giving a smoother cumulative distribution function. The snap-to-need percentage can be lowered at the beginning of management and then increased to 95% over time if required.

8.2.1.1.3 GUP *SLA*

This *SLA* is based on applying the baseline variants of the D-M and G-G *SLAs*, ignoring their 'snap-to-need' features, to obtain two strike limits. These strike limits are then pooled by simple arithmetic averaging and the 'snap-to-need' feature applied.

8.2.1.2 REVIEW OF RESULTS

The complete set of results for the *Evaluation*³, *Robustness*⁴ and *Cross-validation*⁵ *Trials* (see Tables 3-5, for details see Annex E, Appendix 3) are available from the Secretariat. A selected set of the most informative tables and plots in terms of the relative performance of the *SLAs* can be found as Appendices 5-7 of Annex E. The Committee **agreed** that the

Chair of the SWG, in consultation with the intersessional Steering Group, should decide on an appropriate selection of results for publication. At a minimum, this will include the results of all of the *Evaluation Trials* in some combination of graphical and tabular presentation.

8.2.1.2.1 FINAL SELECTION OF AN *SLA*

Before considering the formal trials, a series of technical trials ('x' trials) were examined that had been proposed at the intersessional Workshop (SC/54/Rep2). These are discussed in detail in Annex E.

The Committee has spent a considerable amount of time considering the issue of the selection of an *SLA* (e.g. IWC, 2002e, pp.151-2). A variety of factors (e.g. design considerations, structure, elegance and performance) should be considered when selecting an *SLA*, but performance is the key factor. The SWG examined the results for each of the *Evaluation Trials* in detail to assess differences in performance among five *SLAs* (G-G, GUP, D-M, G-G low and D-M low).

The SWG **agreed** that the major conclusion from the examination of the results of the *Evaluation Trials* is that all *SLAs* exhibited extremely good performance. Even where differences were identified these were generally minor. These are noted below:

- (i) As expected, the G-G *SLA* achieves greater need satisfaction in the first 20-40 years than the D-M *SLA*.
- (ii) The G-G *SLA* is generally (though not always) more precise (in the sense of narrower 90% intervals) than the D-M *SLA*.
- (iii) The D-M *SLA* outperforms the G-G *SLA* on trial BE04.
- (iv) The emphasis by the G-G *SLA* on need satisfaction in the first 20-40 years leads to wider intervals for strike limits in the last 50 years compared with the D-M *SLA*.
- (v) The GUP never performs worse than both of the G-G and D-M *SLAs*, and sometimes outperforms both (e.g. BE07-SE).
- (vi) The G-G *SLA* has an undesirable feature in that, for some trials (e.g. BE04, BE14), the strike limits increase in the first 50 years then decrease. This behaviour occurs because of the emphasis placed on satisfying need in the short-term. Givens noted that it would be possible to modify the G-G *SLA* to reduce this effect.
- (vii) On the pessimistic set of BE12 trials, median stock increase after 100 years was higher for G-G than D-M. On the risky high need trials (BE16, 16SE), median increase was higher for D-M than G-G.
- (viii) Given the use of discrete levels for *K* and *MSYR* in the D-M *SLA*, the strike limits for some of the trials (e.g. BE14) are stratified into several bands. Magnússon commented that increasing the number of filters could be used to remove this feature of the results.
- (ix) The 'low' tuning of the G-G *SLA* does not always incur a lower need satisfaction than the baseline tuning of this *SLA* (e.g. BE12, BE12a, BE04).

Although slight, both the G-G and D-M *SLAs* exhibited the undesirable features mentioned above. Both developers indicated that their *SLAs* could be modified in the future to remove these. Various members attached lesser or greater importance to these factors and some members favoured one procedure over the other. Schweder indicated his preference

³ Trials used for formal comparisons of candidate *SLAs*.

⁴ Trials to examine *SLA* performance for a full range of plausible scenarios.

⁵ Case-specific trials to be held aside from *SLA* development so that resulting *SLAs* can be subjected to a subsequent independent test.

Table 3

The *Evaluation Trials* for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. (For further details of the factors involving a time lag in density dependence, strategic surveys and the inertia model, see Appendix 3 of Annex E) (10 year surveys unless otherwise specified; differences from the base case are shown in **bold**).

Trial No.	Description	Model	$MSYR_{1+}$	$MSYL_{1+}$	Final need	Historical survey bias	Future survey bias	Survey CV (true, est)	Age data [#]	Other
BE01*	Base case	D, S _E	2.5%	0.6	134	1	1	0.25, 0.25	Good	
BE02	Constant need	D	2.5%	0.6	67	1	1	0.25, 0.25	Good	
BE03	Future +ve bias	D, S _E	2.5%	0.6	134	1	1→1.5 in yr 25	0.25, 0.25	Good	
BE04	Future -ve bias	D	2.5%	0.6	134	1	1→.67 in yr 25	0.25, 0.25	Good	
BE04a	Future -ve bias	D	2.5%	0.6	134	1	1→.67 in yr 25	0.25, 0.25	Good	5yr surveys
BE05	Underestimated CVs	D	2.5%	0.6	134	1	1	0.25, 0.10	Good	
BE07*	$MSYL_{1+} = 0.8$	D, S _E	2.5%	0.8	134	1	1	0.25, 0.25	Good	
BE08	5 yr surveys	D	2.5%	0.6	134	1	1	0.25, 0.25	Good	5yr surveys
BE09*	$MSYR_{1+} = 1\%$	D, S _E	1%	0.6	134	0.67 → 1	1	0.25, 0.25	Good	
BE09a	$MSYR_{1+} = 1\%$	D, S _E	1%	0.6	134	0.67 → 1	1	0.25, 0.25	Good	5yr surveys
BE10*	$MSYR_{1+} = 4\%$	D	4%	0.8	134	1	1	0.25, 0.25	Good	
BE10a	$MSYR_{1+} = 4\%$	D	4%	0.8	134	1	1	0.25, 0.25	Good	5yr surveys
BE11	Bad data	D	2.5%	0.6	134	1	1→1.5 in yr 25	0.25, 0.10	Poor	
BE12*	Difficult 1%	D, S _E	1%	0.6	134	1 → 1.5	1.5	0.25, 0.10	Poor	
BE12a	Difficult 1%	D, S _E	1%	0.6	134	1 → 1.5	1.5	0.25, 0.10	Poor	5yr surveys
BE13	Difficult 1%; constant need	D	1%	0.6	67	1 → 1.5	1.5	0.25, 0.10	Poor	
BE14	Need increases to 201	D	2.5%	0.6	201	1	1	0.25, 0.25	Good	
BE16	$MSYR_{1+} = 1\%$; 201 need	D, S _E	1%	0.6	201	0.67 → 1	1	0.25, 0.25	Good	
BE20	$MSYR_{1+} = 4\%$; 201 need	D	4%	0.8	201	1	1	0.25, 0.25	Good	
BE21*	Integrated	D	U[1.4%]	U[.4-.8]	134	1	1	0.25, 0.25	Good	
BE22*	20yr time lag	D, S _E	2.5%	0.6	134	1	1	0.25, 0.25	Good	20yr lag
BE23	Strategic surveys;	D	2.5%	0.6	201	1	1	0.25, 0.25	Good	Strategic surveys
BE24*	Inertia Model	D	0.6% [§]	0.6	134	1	1	0.25, 0.25	Good	Inertia model

*Requires conditioning; [#]Age data: good (no bias or extra variance): $\gamma_{12.9}=1$; poor: $\lambda_{12.9}=2$, $\lambda_{12.9}=1.5$; [§] $MSYR_{1+}$ here refers to $MSYR$ in the absence of inertia dynamics. The value of 0.6% was set intersessionally by the Email correspondence group following inspection of trajectories.

for the D-M *SLA* on the general issue that it is based on the well-known Kalman filter technique and thus took appropriate account of new data (Annex E, items 2.2 and 2.3).

The GUP *SLA* does not exhibit undesirable features to nearly the same extent as the G-G and D-M *SLAs* because it averages the strike limits from the component *SLAs*. For example, although the GUP does not always satisfy need in the first 20 years perfectly under all scenarios, it almost never drops the strike limit below the current level of need.

For the *Robustness Trials*, all of the candidate *SLAs* performed well and there was little to choose between them. Attention was drawn to the relatively poor performance of the *SLAs* under the scenario where mortality rate is doubled over the period. Although it was noted that such a scenario might seem extreme (see discussion of SC/54/E11 in Annex E, item 2.2 and in Annex F, item 6.1.1), the Committee **agreed** that mortality should be monitored when conducting the *Implementation Review* process in the long-term. The value of photo-identification results was noted in this case. In accordance with his views on the overall philosophy and the 'x' and *Robustness* trials, Schweder believed that the D-M *SLA* performed slightly better overall. However, there was general agreement that the GUP *SLA* performed better than the other two *SLAs* for most of the *Robustness Trials* although either the D-M or G-G *SLAs* slightly outperformed the GUP for a very small number of these trials. The results of the *Cross-validation Trials* gave no cause for concern.

Given the excellent overall performance of the GUP *SLA*, the Committee considered the implications of selecting it from other perspectives.

There was some discussion of the 'elegance' of choosing the average of two procedures rather than one of the components. Comments were made supporting the view that

from that perspective, choice of a single procedure might be considered more elegant, less complex to tune should that ever be required, and easier to explain to the wider scientific community. Other comments were made noting that when an MCDM (multiple-criteria-decision-making) expert was invited to participate in the development of the RMP, he had recommended averaging the results of different management procedures. Furthermore, members noted that averaging two results obtained from very different approaches had the possibility of reducing bias and reducing variability. It was also noted that the excellent performance and innovative nature of both *SLAs* warranted their exposure to the wider scientific community.

After considerable discussion, the Committee **agreed** that the improved performance of the GUP over the other candidate *SLAs* more than compensated for any increased complexity and reduced elegance. It was noted that the GUP *SLA* included a built-in check-and-balance system because, if one of its component *SLAs* behaved somewhat erratically in one instance, the effect would be muted by the better performance of the other *SLA*.

Finally, the Committee noted its agreement early in the development process (IWC, 1999a, p.31) that the goal was to develop an *SLA* that fully met the Commission's management objectives, and that once it had achieved that, it would not waste resources attempting to achieve some hypothetical level of 'perfection'. Whilst the SWG recognised that further work could be undertaken to refine and 'polish' the constituent *SLAs* of the GUP *SLA* (as noted by the developers themselves), it **strongly believes** that these resources should be dedicated to completing the *SLA* for the management of the gray whale harvest and addressing the serious issue of the Greenland fisheries, for which the Committee has recognised that it has never been able to provide satisfactory advice.

Table 4

The *Robustness Trials* for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. (For further details of the factors involving a time lag in density dependence, strategic surveys, time-dependent factors and episodic events, see Annex E, Appendix 3.)

Trial	Factor	Basic trials (Table 7)	Factor Level
BR01	A: Density-dependence	1, 1 ^S , 9, 9 ^S	Density-dependence on mature (BE trials use 1+)
BR02	B1: Stochastic dynamics	8 ^S , 13 ^S	Stochastic dynamics (with serially-correlated environmental variation)
BR04	E: Survey frequency	9, 13, 14, 16, 20	a) 15 yrs b) 5 yrs
BR05	F: Strategic surveys	16, 20 9	a) Yes + CV = (0.25, 0.25) b) Yes + CV = (0.34, 0.25)
BR06	G: Survey bias time dependence	9 1 1 9, 9 ^S 12, 12 ^S 14	a) Historic bias (1978-2002): 1.5 constant; Future bias: decreasing (1.5→1) b) Historic bias (1978-2002): 0.67 constant; Future bias: increasing (0.67→1) c) Future bias: sinusoidal from base value in yr 0 to maximum of 150% in yr 40 d) Future bias: decreasing (1.5→1) from year 0 to 100 e) Future bias: increasing from 1→1.5 in year 25 and constant thereafter (former BE15)
BR07	H: Future survey CV	1 1 ^S 9	a) CV = (0.1, 0.1) b) CV = (0.34, 0.25) c) (0.1, 0.1) + sinusoidal survey bias
BR08	I: Historic catch bias	14, 16 ^S 14, 16, 16 ^S	a) 0.5 bias from 1848-1914 b) 1.5 bias from 1848-1914
BR09	K: Time dependence in <i>K</i>	1, 9, 10 1, 9, 10 1 1, 21 1, 9	a) <i>K</i> halves linearly over 100 years b) <i>K</i> doubles linearly over 100 years c) <i>K</i> sinusoidal from base value in year 0 to maximum of 150% in year 40 d) Tent <i>K</i> : <i>K</i> doubles linearly from years-50 to 0 and halves from years 0 to 50 e) <i>K</i> halves linearly over 100 years + strategic surveys
BR10	L: Time dependence in <i>MSYR</i>	10 9 1, 8 1, 8	a) Resilience (<i>A</i>) halves linearly over 100 years, b) Resilience (<i>A</i>) doubles linearly over 100 years c) Resilience steps 2½%→1%→2½% every 33 yrs over 100 years d) Resilience steps 2½%→1%→2½% every 33 yrs over 100 years in sync with <i>M</i> (compute <i>MSYR</i> first) – if it is practical halve <i>M</i> for each age class e) <i>K</i> and <i>A</i> halve linearly over 100 years f) <i>K</i> and <i>A</i> vary as tent (see BR09)
BR11	M: Time dependence in <i>M</i>	1 1, 21 1, 9, 10	a) Natural mortality <i>M</i> halves linearly over 100 years (and calculate resulting <i>MSYR</i>) b) <i>M</i> doubles linearly over 100 years
BR12	N: Episodic events	1, 9, 10 1, 1 ^S , 9, 9 ^S	2 events occur, between years 1-50, in which 20% of animals die
BR13	O: Integrated	1, 11, 14 11, 14 1, 1 ^S , 11, 11 ^S , 14 1 ^S , 11 ^S	a) <i>MSYR</i> ₁₊ ~U[0.01, 0.04]; fixed <i>MSYL</i> ₁₊ =0.6 b) <i>MSYR</i> ₁₊ ~U[0.01, 0.04]; <i>MSYL</i> ₁₊ ~U[0.4, 0.8] c) <i>MSYR</i> ₁₊ ~U[0.01, 0.04]; <i>MSYL</i> ₁₊ ~U[0.4, 0.8]; historical catch bias ~U[0.5, 1.5]; Serial correlation ~U[0.47, 0.95] d) <i>MSYR</i> ₁₊ ~U[0.01, 0.04]; <i>MSYL</i> ₁₊ ~U[0.4, 0.8]; historical catch bias ~U[0.5, 1.5]; Serial correlation ρ ~U[0.47, 0.95], time delay in density-dependence ~U[0, 30]
BR14	P: 1 st year of population projection	1, 9	1940 (reference or base case level is 1848 or 1748 for stochastic trials)
BR15	<i>MSYL</i> ₁₊ =0.9	1, 9, 10	
BR16	B2: Different stochastic parameters	1 ^S 1 ^S 1 ^S , 9 ^S , 10 ^S 1 ^S 9 ^S	a) Negative correlation in recruitment $\rho = -0.75$ b) High correlation in recruitment $\rho = 0.9$ c) High correlation in recruitment $\rho = 0.9$; + Episodic events d) Change σ_e^2 to give 3* variation in population size at equilibrium e) $\rho = 0.9$ + change σ_e^2 to give 3*equilibrium variation +episodic events

^SStochastic.

Table 5

Factors and ranges for constructing *Cross-validation* trials for the Bering-Chukchi-Beaufort Seas stock of bowhead whales.

Factor	Range
<i>MSYR</i> ₁₊	1 – 4%
<i>MSYL</i> ₁₊	0.4 – 0.8
Final need	67 – 201
Survey bias in future year 25	0.67 – 1.5
Estimated survey CV	0.1 – 0.4
Time-lag	0 – 20

8.2.1.2.2 CONCLUSION AND RECOMMENDATION

After careful consideration of the results of the trials and the consideration of the other factors noted above, the Committee **strongly recommends** that the GUP *SLA* (hereafter the ‘*Bowhead SLA*’) be forwarded to the Commission. It believes that this *SLA* meets the objectives of the Commission set out in 1994 (IWC, 1995, pp. 42-43) and represents the best scientific advice that the Committee can offer the Commission with respect to the management of the B-C-B Seas stock of bowhead whales. In making this recommendation, it refers to its comments regarding the nature of the *Implementation Review* process and the other aspects of management discussed under Item 8.5.

The Committee noted that this is the first of the *SLAs* that it has recommended. The Commission endorsed the concept of an aboriginal subsistence whaling scheme with case-specific and generic components in 1999 (IWC, 2000d, p.125) and is expecting to receive a recommended *SLA* for this stock at this year's meeting based on the Committee's report last year.

The Committee particularly wishes to acknowledge the outstanding contribution made by all of the developers to the final recommended *SLA*. It notes that the *Bowhead SLA* contains elements of all of the procedures originally considered. It formally wishes to thank Eva Dereksdóttir, Kjartan Magnússon, Geof Givens, Andre Punt, Sue Johnston and Doug Butterworth for the enormous amount of thought and effort put into developing their candidate procedures and the generosity of spirit in sharing ideas evident throughout the process. It also wishes to acknowledge the tremendous support offered by Cherry Allison, without whom the whole process would have ground to a standstill. Finally, it thanked Greg Donovan for chairing the SWG since 1997.

8.2.1.3 COMPARISON WITH THE RMP

The Committee recalled that early in the development process, some members of the Commission had indicated an interest in a comparison of the AWMP with the RMP. That request predated the decision of the Commission to accept case-specific *SLAs* as part of an AWS. A strict comparison of the *Bowhead SLA* with the *CLA* is not possible for a number of reasons, particularly with respect to: (1) the different objectives of each, notably the difference between management aimed at producing the highest possible continuing yield and management aimed at satisfying a limited need requirement in perpetuity; and (2) the case-specific nature of the *Bowhead SLA* that was tailored to manage a data rich population as opposed to the generic *CLA*, that had to be able to cope with a variety of situations.

The results of the comparison revealed, not unexpectedly (e.g. see Punt and Butterworth, 1997), that the *CLA* whilst performing satisfactorily on the risk-related statistics performed poorly in satisfying need. Comments on this issue from an RMP perspective are given under Item 6.5.6.

8.3 Gray whale trial structure

The SWG discussed gray whale trial structure at its Workshop in Seattle in January 2002 (SC/54/Rep2) where it made a number of modifications regarding structure and conditioning.

8.3.1 Model-related issues

The results of the assessment of eastern gray whales (Annex F) were examined, and the Committee **agreed** that these do not require changes to be made to the basic biological model or parameters used to simulate gray whale dynamics for AWMP trials. However, it noted that two new abundance estimates are available. With respect to the use of stochastic models, based on the results of the bowhead whale trials, it **agreed** that it is sufficient to use 'episodic event' trials as a simple surrogate for truly stochastic dynamics. By allowing frequent, small stochastic events (either positive or negative) with potential correlation (either positive or negative), a wide variety of stochastic dynamics can be approximated.

8.3.2 Trial specifications

Consideration was given as to whether future calf count data should be generated as part of the common control program to be available for use by potential *SLAs*. The Committee

agreed that this should not be done because: (1) a suitable *SLA* can be developed without reliance on these data; and (2) therefore it could not justify making such data collection a future data requirement. Most of the aboriginal harvest is taken in the Russian Federation whilst smaller catches and the censuses are undertaken in the USA. It is hoped that cooperation between these two countries will continue. Breiwick noted that it is expected that these surveys will continue in the future.

However, it was **agreed** that *Evaluation Trials* should be conditioned on the calf count data, whereas *Robustness Trials* should provisionally ignore the calf count data at this stage. If changes in software or hardware speeded the conditioning process, then Allison would review this decision with a view towards conditioning all trials on the calf count data.

The two most recent abundance estimates for eastern gray whales presented at this meeting (see Annex F) were notably lower than the previous one. The Committee **agreed** that the recent variations in surveyed abundance must be taken into account in its trial structure and that the plausible explanations for the results of the recent survey (Annex F, item 4.1.2) should be covered in the trials and conditioning process as discussed in Annex E.

The anomalies in the CVs of the recent time series of eastern gray whale abundance estimates were considered and it was **noted** that the existing trial structure captured all of these important aspects of the abundance series and its CVs.

The Committee **agreed** that trials with episodic events should play a substantial role in GE/GR trials, to model a plausible biological possibility and as a surrogate for stochastic dynamics as discussed in Item 8.3.1. It was also **agreed** that the episodic event trials should consider episodic changes in mortality rates and/or productivity.

Finally, it was **noted** that further issues related to trial structure (e.g. those raised in SC/54/AWMP2) will be discussed more thoroughly at the proposed intersessional Workshop (see Item 8.7).

8.4 Greenlandic fisheries and the Greenlandic Research Programme

In 1998, the Committee had informed the Commission that it would be extremely difficult, if not impossible, to develop an *SLA* for the Greenlandic fisheries that will satisfy all of the Commission's objectives. To this end the Committee recommended, and the Commission accepted, the need to develop a cooperative research programme. This has been discussed at recent meetings (e.g. IWC, 2001j) and is further discussed under Item 9.1.3.

8.4.1 Stock structure, range and movement

Last year, the Committee provided funds towards an annual programme of satellite tagging, based on a target of four informative tracks per year (IWC, 2002e, p.156). It received SC/54/O21 that reported on the successful tagging of two fin whales in September 2000 and August 2001. The tags transmitted for 76 and 32 days, respectively and the results are discussed in Annex E (item 5.1.1). The movements of the animals suggested that the fin whales off West Greenland are part of a single stock and that previous surveys did not encompass the whole range of fin whales off West Greenland.

The Committee welcomed this report and noted that further work would be carried out in the coming season with IWC funding. It was suggested that, if possible, marking later in the season would provide more information on

migratory routes and wintering areas. Five tags are available and the Committee **agreed** that equal importance be given to tagging minke and fin whales.

The Committee was informed that, dependent upon the year, between 25 and 65% of the harvested minke whales and between 15 and 42% of the fin whales have been sampled. For logistical reasons, last year had not been particularly successful. There had been no new effort to analyse genetic samples collected later than 1999.

The Committee repeats its previous **recommendation** that every effort be made to obtain tissue samples for genetic analysis from the catch and that efforts to compare these samples with those from neighbouring countries be continued.

8.4.2 Abundance and trends

In the original research programme, it had been envisioned that use of coastguard vessels in the inshore waters might provide a time series of index of abundance data, at least for minke whales. These surveys were to have begun in late summer 2002 (IWC, 2002e, p.156). Witting reported that unfortunately these surveys have proved unsatisfactory and have not been pursued further.

The Committee was disappointed to receive this news, noting that the possibility of developing a management procedure that used a combination of an annual relative index and infrequent absolute abundance estimates had been discussed at last year's meeting (IWC, 2002e, p.156).

SC/54/AWMP1 reported that an aerial survey for large cetaceans is to be conducted off West Greenland from July to September 2002. The survey area and effort is similar to the aerial cue-counting survey conducted in 1993 (Larsen, 1995), but the 2002 survey will be an aerial strip-transect survey based on digital photos. There was considerable discussion of this survey and the new methodology by the SWG, and this is given in Annex E (item 5.1.4.2).

The Committee welcomed the fact that a new abundance survey is to be undertaken and hopes that this innovative approach proves successful, not least because any *SLA* will require periodic abundance estimates if strikes can safely be allowed. It noted that whatever approach is used, the primary factor involved in determining the success of surveys in Greenland is the weather. It looks forward to receiving a full report of the survey at its next meeting.

8.4.3 Biological data

In response to a question regarding the collection of other biological samples, it was noted that hunters have forms to record length, sex, pregnancy status, etc.; logistical difficulties regarding timing and location of the flensing of the hunt make sampling by biologists impractical. It was suggested that training hunters to take specific biological samples might prove fruitful if allied to some type of reward system.

8.4.4 Preliminary consideration of management procedures

Last year, the Committee had nominated a small group to conduct exploratory simulation studies involving the use of an annual index of abundance and an infrequent absolute abundance estimate. In light of the decision not to pursue the index of abundance cruises above, this approach became unnecessary. However, the Committee **agreed** that the small group should correspond intersessionally on possible future approaches.

8.4.5 Conclusion

Given the extreme importance of the Greenlandic Research Programme to the Committee's ability to provide management advice to the Commission, the Committee **agreed** that reviewing progress and developing further recommendations should be a high priority item for discussion at the next annual meeting (and see Item 9.1.3).

8.5 Scientific aspects of an Aboriginal Subsistence Whaling Scheme

8.5.1 Carryover

The Commission has requested the Committee to include provisions for carry-over in its consideration of an AWMP. In IWC (2001c, p.18), the Committee presented the Commission with an illustration regarding block quotas and carryover. The Commission considered this and agreed

...that blocks of five years with an interannual variation of fifty percent were satisfactory in terms of allowing for the likely variability in hunting conditions. It therefore agreed that these values are appropriate for use in trials. It was recognised that this does not commit the Commission to these values in any final aboriginal whaling management procedure. (IWC, 2001a, p.20).

In order to allow the Commission to consider this further, the Committee notes that if under a recommended *SLA*, current need is met (and there is no indication from the present results that this will not be the case), then a revised Schedule paragraph for bowhead whales might look something like:

For the years [2003-2007] inclusive, the total number of strikes shall not exceed [335]. The Strike Limit in any one year shall not exceed [100⁶].

The Committee had also agreed that the same 50% allowance may be carried over between the last year of one block and the first year of the next. It is emphasised that from a scientific perspective, the *Bowhead SLA* is robust to such a scenario with respect to carryover provisions and the harvest at such a level.

In order to illustrate this, a number of examples are given in Annex E (item 6.1). The Committee agreed that a full explanation of these examples be presented to the Commission by the Chair of the SWG (see Item 8.6).

8.5.2 Grace period and survey interval

In considering this item last year, the Committee had discussed what process it might need to follow in the absence of data essential to the *SLA*, notably a lack of a new abundance estimate. It was **agreed** that the concept of phaseout (also present in the RMP) was appropriate, i.e. the process by which strike limits are reduced in the absence of new abundance data. In presenting the Committee's report to the Commission (including representatives of the AEWC — the Alaska Eskimo Whaling Commission) last year, the Chair noted that this concept was the most contentious.

Some views were expressed that the phase-out concept should apply only to commercial whaling and is overly harsh, and even suggests mistrust of aboriginal whalers and hunters. The AEWC believed that AWMP 'rules' should provide hunters with as much freedom as possible to cope with environmental variability, since it has such a significant effect on surveys and hunting success.

⁶ The Commission's present paragraph also includes a limit on the number of landed animals. This is outside the scope of the SWG whose simulation exercises assume that all strikes result in death.

At the intersessional Workshop, the SWG noted these concerns (SC/54/Rep2). It referred to its earlier discussions of the difficulties in carrying out successful censuses⁷ (and hunting) in the Arctic environment and its efforts to take this into account both by using a survey interval of 10 years and in the carryover provision described above. However, it noted that it was not possible to successfully manage in the absence of data; it is *not* acceptable for strikes to be allowed to continue at level of need if there is no new abundance information for long periods, should such an unlikely situation arise. Under the grace period scenario, it would be up to 15 years after the previous survey that the *SLA* will set strikes to zero. This certainly does not imply mistrust of hunters and in the case of the bowhead whale situation, the cooperation and major contribution of the AEWG in the census effort is well recognised and greatly appreciated. Whilst it is hoped and expected that any 'grace period'⁸ rule will never need to be utilised, it is important that any comprehensive management procedure includes rules for such an eventuality. The Committee **strongly endorsed** these views and the principles developed in SC/54/Rep2 given below:

- (1) the grace period should not exceed five years (after which time, the *SLA* will set strikes to zero and it is likely that an *Implementation Review* will be initiated);
- (2) for the five-year grace period, the block limit shall be reduced by 50%;
- (3) carryover from the last block is permissible (the same conditions that can render a survey unusable can also preclude the hunt);
- (4) the use and distribution of strikes during the grace period is the responsibility of the user (for example it may be decided to place no restrictions at the beginning of the period – but in the absence of an estimate in that period the catch will be reduced to zero in less than the five years – see Annex E, table 4, for example);
- (5) when a survey is successfully conducted during the grace period, the *SLA* is applied and a quota generated – the quota is then applied retroactively to the current block and the 'used' strikes subtracted from the resultant block limit.

It was also noted in discussion that the Scientific Committee could offer advice about the best strategy to use in the event of a series of poor surveys or similar problem, so that action can be taken well ahead of any grace period deadline.

A number of examples of scenarios where the grace period is invoked are given Annex E (item 6.2.1). The Committee agreed that a full explanation of these examples be presented to the Commission by the Chair of the SWG (see Item 8.6).

In SC/54/Rep2, it was recognised that setting limits by five-year blocks could result in some scenarios where there was a period of greater than 10 years between survey intervals (although it is not possible to have more than one such lengthy period in succession). Childerhouse commented that a greater than 10-year period between surveys was too long. A number of different scenarios incorporating survey interval, carryover and grace period are illustrated in Annex E (item 6.2.2). The Committee, noting the results of the strategic survey trials and those with a

15-year survey interval, **agreed** that there is no need to set any further 'rules' to accommodate these scenarios. It also draws attention to the guidelines for surveys discussed under Item 8.5.4 in which survey plans must be submitted to the Committee in advance; it will expect attempts to survey to begin at least by year seven. It also noted that it will be happy to provide advice on survey related issues if required.

8.5.3 Implementation Reviews

It has been recognised from the start of the development process that any individual factor or combination of factors that occurred in the future which suggested that the range of explored parameter space covered in the present trials might have been exceeded will result in an *Implementation Review*. It was noted that there are many potential outcomes from an *Implementation Review* including recommendations to continue use of the current *SLA*; to set a zero strike limit; to carry out an abundance estimate immediately; and/or to establish further trials. It is possible to examine through simulation any 'meta-rules' that might be developed in conjunction with the *Implementation Review* process. Such an examination would necessarily consider the probability of: (1) unnecessarily initiating an early *Implementation Review*; and (2) not initiating an early *Implementation Review* when this is, in fact, needed.

8.5.3.1 REGULAR IMPLEMENTATION REVIEWS

Implementation Reviews will be scheduled every five years and will normally contain at least the following elements: (1) a review of information required for the *SLA* (i.e. catch data, abundance estimates); and (2) a review of information (e.g. biological and genetic data) to ascertain if the present situation is as expected and within tested parameter space (thus the review may result in the need to determine new trials). In order to account for the need for further action (e.g. before agreeing an abundance estimate or running new trials), the Committee **recommends** that *Implementation Reviews* are initiated the year before advice on a new block limit is expected. It is not expected that every such review will entail a large amount of work. This will of course depend on a number of factors, largely dependent on the level of information available. This latter factor is related to discussions under Item 8.5.4.

8.5.3.2 UNSCHEDULED IMPLEMENTATION REVIEWS

Throughout its discussions, the Committee has also seen early *Implementation Reviews* as a safety feature to enable swift reaction if new information arrives that causes concern. It is recognised that calling such a review does not necessarily mean revising the Committee's advice to the Commission, although it may do so. The Committee did not believe it appropriate to try to compile a formal list of what factors might 'trigger' such an early review (by its very concept it implies unexpected/unpredictable factors). The following list is thus provided to give examples of some possible factors:

- (a) major mortality events (e.g. suggested by large numbers of stranded animals);
- (b) major changes in whale habitat (e.g. the occurrence of natural or anthropogenic disasters or changes, such as an oil spill, dramatic change in sea-ice);
- (c) major ecological changes resulting in long-term changes in habitat or biological parameters;
- (d) a dramatically lower abundance estimate (although the *SLA* has been tested, the Committee would review the potential causes of unexpected very low estimates);

⁷ Weather and ice conditions often prevent the completion of a successful bowhead abundance survey even when all the best efforts are made. Since 1988, three successful censuses have been made (1988, 1993, 2001) in six attempts.

⁸ This seems to more accurately reflect the philosophy than the term phaseout.

- (e) information from the harvest and hunters (this might include very poor harvest results, reports of low abundance despite good conditions, reports of large numbers of unhealthy animals);
- (f) changes in biological parameters that may result in changes to management advice (e.g. reproduction, survivorship);
- (g) if there are cases when need is not being satisfied, significant positive information that might narrow the plausibility range and allow an increase in block limits.

8.5.4 Guidelines for surveys

The Committee reviewed and reconfirmed the principles for surveys developed at last year's meeting and agreed by the Commission regarding: survey/census methodology and design; Committee oversight; and data analysis. It **agreed** that it is not necessary to develop these into a formal document for inclusion in the overall AWS at the present time. It noted that if the *Bowhead SLA* is adopted at the present meeting, some consideration will be need to be given to the fact that some of the criteria (e.g. submission of data by a particular time) may need to be relaxed (see Item 8.6.2).

8.5.4.1 SURVEY/CENSUS METHODOLOGY AND DESIGN

The Committee **agreed** that plans for undertaking a survey/census should be submitted to the Scientific Committee in advance of them being carried out, although prior approval by the Committee is not a requirement. This should normally be at the Annual Meeting before the survey/census is due to be carried out. Sufficient detail should be provided to allow the Committee to review the field and estimation methodology. Considerably more detail would be expected if novel methods are planned. Survey timing should be such that successful surveys occur at no more than 10-year intervals.

8.5.4.2 COMMITTEE OVERSIGHT

The Committee **agreed** that it could nominate one of its members to observe the survey/census to ensure that proposed methods were adequately followed. This would be more important if novel methods were being used.

8.5.4.3 DATA ANALYSIS AND AVAILABILITY

The Committee **agreed** that it is appropriate that all data to be used in the estimation of abundance were made available to the Scientific Committee suitably in advance of the Annual Meeting at which an estimate was to be presented. If new estimation methods are used, the Committee may require that computer programs (including documentation to allow such programs to be validated) be provided to the Secretariat for validation.

8.6 Presentation of results to the Commission⁹

8.6.1 General presentation

The Committee noted that this was a particularly important meeting for the presentation of results to the Commission. In accordance with the Commission's instructions it was presenting the first case-specific *SLA* as part of the overall

AWS. It noted that this was part of a long process that involved continual consultation with (and feedback from) the Commission.

It **recommends**, as in previous years:

- (1) a presentation of the Committee's report by the Chair of the SWG; and
- (2) informal discussions among the Chair of the SWG and interested Commissioners.

The Committee also noted the success of informal discussions with interested members of the Commission's sub-committee on aboriginal subsistence whaling (including hunters' representatives) and **agreed** that this would be valuable.

In terms of the presentation, the Committee gave considerable freedom to the Chair of the SWG to decide the format but **agreed** that it should include aspects of the following: the history of the development process (including the concept of the need envelope); explanation of the factors examined in the *Evaluation and Robustness Trials* (see Table 6); graphical presentation of results (including catch and population size trajectories) for *inter alia* the *Bowhead SLA* from Trials BE01, BE09 and BE14 encapsulating a range of scenarios; and description and illustrations of the aspects of the AWS (see Appendix 8 of Annex E) described above.

8.6.2 Management advice and incorporation into the Schedule

The Commission is aware that the Committee will be presenting it with an *SLA* for bowhead whales at the forthcoming annual meeting. It is also noted that the Commission will be establishing catch limits for bowhead whales at this year's meeting. Some time was spent considering the procedural aspects of how to present its results.

It was noted that from a purely scientific viewpoint, the *Bowhead SLA* represents the best tool for providing management advice to the Commission¹⁰ on the bowhead whale harvest. On these grounds alone it would be prepared to use the *SLA* to calculate block strike limits and present that advice to the Commission. However, it recognised that there are some procedural issues that need to be considered (i.e. that the Commission has not formally approved the approach) and that the strict conditions for the Guidelines for Surveys would not have been met in terms of data provision for the 2001 abundance estimate, if that is to be used (see Item 8.5.4). Given this, it requested that the Secretariat be prepared to use the *SLA* to calculate block strike limits, should the Commission request it. This can easily be done at the Commission meeting.

To do this, in addition to incorporating the latest catch and strike data, a decision needs to be taken on whether to include the new 2001 abundance estimate discussed in Annex F and partially referred to in the management advice provided in that Annex. Whilst this represents a good estimate (and certainly within the tolerance covered in the trials), a revised estimate using different methodology is expected to be received next year. It was unlikely that this would be very different from the present estimate. The Committee **agreed** that the Secretariat should be prepared to run the *SLA* both with and without the latest estimate if required.

⁹ In plenary, Childerhouse asked for an appropriate costing of the development process. Donovan noted that was not a trivial task but that he would try to develop such an estimate.

¹⁰ It was also noted that the sub-committee on bowhead, right and gray whales had provided management advice based on the present situation but had also noted that the SWG was expecting to complete its work on an appropriate *SLA*.

Table 6
Factors tested in bowhead trials. Reference levels shown bold and underlined.

Factors	Other levels
$MSYR_{1+}$	1%, <u>2.5%</u> , 4%
$MSYL_{1+}$	0.4, <u>0.6</u> , 0.8
Density dependent component	<u>1+</u> or mature
Population dynamics model	Deterministic , Stochastic (demographic), <u>Stochastic (demographic + serially corr.env.var.)</u> , Inertia model
Time dependence in K^*	<u>Constant</u> , Halve linearly over 100yr, Double linearly over 100yr, Sinusoidal from a base value in year 0 increasing to a maximum of 150% in year 40 Tent K : K doubles linearly from years-50 to 0 and halves from years 0 to 50 K halves linearly over 100 years + strategic surveys
Time dependence in resilience *	<u>Constant</u> , Halve linearly over 100yr, Double linearly over 100yr, Step $MSYR$ 2½%→1%→2½% every 33 yrs Step $MSYR$ 2½%→1%→2½% every 33 yrs, in sync with halving / doubling M K and A halve linearly over 100 years K and A vary as tent
Time dependence in natural mortality, M^*	<u>Constant</u> , Halve linearly over 100yr, Double linearly over 100yr.
Episodic events *	<u>None</u> , 2 events occur, between years 1-50, in which 20% of animals die
Initial year of population projection	<u>1848</u> , (or 1748 for stochastic trials), 1940
Stochastic parameters	
i) correlation in recruitment	<u>$\rho = 0.752$</u> ; Negative ($\rho = -0.75$); High ($\rho = 0.9$); High + Episodic events
ii) variation in population size	<u>$\sigma_e^2 = 0.0254$</u> ; σ_e^2 changed to give 3* variation in pristine population size $\rho = 0.9$ + change σ_e^2 to give 3*pristine variation + episodic events
Time lag in density dependence	<u>None</u> ; 20yr time lag in density dependence
Need in final year (linear change)	<u>67</u> , 134, <u>201</u>
Survey frequency	5yr, <u>10 yr</u> , 15 yr
Strategic surveys	<u>No</u> , Yes
Survey bias	0.67, <u>1.0</u> , 1.5
i) constant	
ii) historical time dependence	<u>None</u> , Increase by 50% from 1978 to 2002 (0.67→1, 1→1.5)
iii) future time dependence	<u>None</u> , Decrease by 50% from year 0 to year 100, Increase by 50% from year 0 to year 100, Sinusoidal
Survey CV: (true, estimated)	(0.1, 0.1), (0.25, 0.1); (<u>0.25</u> , <u>0.25</u>); (0.34, 0.25)
Historic (1848-1914) catch bias	0.5, <u>1.0</u> , 1.5
Integrated	<u>NA</u> , priors for $MSYR$, $MSYL$, historical catch bias, extent of environmental variation in the probability of birth, time lag in density dependence

* Effects of factors begin in the year 2003 (i.e. at the start of management).

With respect to incorporation into the Schedule, the Committee **agreed** that this should not be seen as a necessary prerequisite of use of the *Bowhead SLA*. In or out of the

Schedule, it represents the best method for the Committee to provide advice and could be used as the basis for modification of the current Schedule provisions with respect to bowhead whales which refer to catch and strike limits. This issue of whether (and how) to incorporate the use of the *SLA* into the Schedule is not a Scientific Committee matter and is the responsibility of the Commission.

8.7 Work plan

The Committee noted that without intersessional workshops, it would have taken at least three more years to develop the *Bowhead SLA*. It believes that work to complete a similar exercise for gray whales and make progress on the Greenland fisheries case requires a similar strategy. With such a workshop it may be possible to recommend a gray whale *SLA* at next year's meeting; without one it will certainly not. The Committee therefore strongly **recommends** that a four-day intersessional workshop be held, probably in December, and thanks Breiwick and DeMaster for once again offering the facilities of the National Marine Mammal Laboratory in Seattle. The Workshop will concentrate on reviewing the first results of *Evaluation* and *Robustness Trials* for gray whales and initiating the major review of the Greenland Research Programme.

Similarly, the Committee notes the vital importance of continuing the Developers' Fund, if it is to make progress on the remaining issues. Details of the work plan agreed by the SWG are given in Annex E. The Committee's final work plan is discussed under Item 19.

9. ABORIGINAL SUBSISTENCE WHALING STOCK ASSESSMENTS (ANNEX F)

Annual review of catches and catch limits

9.1.1 Bering-Chukchi-Beaufort Seas stock of bowhead whales

9.1.1.1 NEW SCIENTIFIC INFORMATION

The last successful census of this stock was in 1993. Two census attempts (1999 and 2000) failed due to unstable ice and closed leads, respectively.

SC/54/BRG5 described the results of a bowhead whale census conducted near Barrow in 2001. Observers recorded a total of 3,295 'new' (not seen before) and 532 'conditional' (possibly seen before) bowhead whales during 1,130 hours of watch effort. Only half of the watch period (572 hrs) was scored as 'fair-excellent' visibility, compared to 74% in 1993. The number of calves counted in 2001 ($n = 121$, 3.7% of the new whales) was nearly twice the 1993 count ($n = 66$) and the highest ever recorded. Passive acoustic surveillance was used to estimate the proportion of whales within viewing range.

The estimated number of whales within 4km (N_4) of the perch was 8,637 (SE = 1,019). The preliminary estimate of the proportion of whales within 4km of the perch (P_4) was 0.876 (SE = 0.033). Combining these, the preliminary (N_4/P_4) abundance estimate for 2001 is 9,860 (SE = 1,222; 95% CI 7,700-12,600). Generalised least squares was used to estimate rate of increase (ROI), taking into account the correlations among the pre-2000 abundance estimates given by Punt and Butterworth (1999). The estimated annual ROI from 1978-2001 was 3.3% (95% CI = 2%, 4.7%). This was almost the same as the ROI estimated from 1978-1993 data (3.2%), but the addition of the 2001 estimate improved the precision. While the N_4 portion of the estimate will not change, further acoustic data and analysis may change the P_4

and variance estimates. Therefore, although the estimates of abundance and ROI are preliminary, they are not expected to change substantially.

An acoustic survey was performed as part of the bowhead census off Point Barrow in 2001 (SC/54/BRG18). The basic methods used to record and analyse array recordings were the same as in previous years. Analysis of 757 out of 1,044 hours of acoustic array data resulted in the detection of over 73,000 bowhead sounds and 26,606 reliable locations. Of these, 13,637 were used to calculate the offshore distribution of vocal animals throughout the season. These results indicate that most (88%) vocal whales were within 4km of the perch. This is slightly less than in 1993 (93%), a year with exceptionally good ice, visibility and acoustic conditions.

SC/54/BRG15 presented the results of the shore-based counts of bowhead whales along the Chukotka Peninsula, Russia between 1999 and 2001. The purpose of this work was to determine the number of whales migrating along the western shore of the Bering Sea, where they were probably missed by counts from Point Barrow, Alaska. In spring 2001, 149 bowhead whales were counted, which is similar to the results from 1999 ($n = 115$) and 2000 ($n = 162$).

The Committee discussed the issue of climate change and its relevance to the bowhead whale assessment. Tynan summarised relevant climate oscillations, trends and predictions for the Arctic, particularly changes in sea ice extent and area. On shorter time scales (e.g. four-year period), the Arctic Oscillation (Thompson and Wallace, 1998) greatly affects the sea ice distribution in the Chukchi and Beaufort Seas (Wang and Ikeda, 2000). On decadal time scales, a trend of loss of sea ice area of 11% is reported for the Chukchi and Beaufort Seas. Models of sea ice show that by 2080 only a 'speck' of seasonal winter ice will remain in the Arctic (Vinnikov *et al.*, 1999).

SC/54/E11 presented stochastic bowhead population models that examine impacts of climate change and habitat degradation in the context of natural variability, such as decadal climate oscillations. Models predicted major bowhead population declines despite a rising trend in the near term. The author argued that such scenarios, while uncertain, are supported by evidence, and were suggested for incorporation into AWMP trials. In discussion, many members questioned the methods and interpretations given in the paper and stressed that the bowhead whale robustness trials investigated changes in productivity, carrying capacity and mortality, as well as random episodic mortality events (see Annex E, item 2.2 and Annex F, item 6.1.1).

9.1.1.2 CATCH INFORMATION

Catch information was summarised in SC/54/BRG20; 75 bowhead whales were struck during the 2001 Alaskan hunt, resulting in 49 animals (30 males, 19 females) landed. The efficiency (the ratio of the number landed to the number struck) of the hunt was 65.3%, which is less than the average efficiency over the past 10 years (76.5%). In 2001, ice conditions made hunting difficult, leading to a lower efficiency. Of the 19 females, two were presumably mature ($> 14.2\text{m}$ in length) but neither was closely examined to determine if they were pregnant. Since 1980, 27% of the landed females $> 14.2\text{m}$ in length were pregnant, although this is probably an underestimate because not all females were examined closely for small fetuses.

Ohsumi asked whether reproductive tissues could be collected from harvested animals for future laboratory analysis. Thorough examinations of bowheads and tissue collection occur primarily at Barrow, where most of the

whales are harvested. Examinations and tissue collections occur opportunistically in other villages. The Committee **encouraged** continued collection and examination of reproductive organs.

One female bowhead whale (15.2m; estimated 46.8 tons) was harvested off of Chukotka, Russia in 2001 (SC/54/BRG21).

9.1.1.3 MANAGEMENT ADVICE

The Committee noted that although the current catch limit ends in 2002, an in-depth assessment of this stock of bowhead whales is not scheduled until 2004. However, preliminary results from the successful new census conducted near Barrow indicate that the stock is larger than it has been in the last century and is still increasing. The Committee in addition noted that it has **agreed** the *Bowhead SLA* at this meeting (see Item 8.2.1.2.2) which it believes is its best tool for providing management advice for this stock (see Item 8.6.2). On the basis of the information discussed under Item 9.1.1 alone, the Committee **agreed** that there is no reason to change the management advice it had given last year, namely, that it is very likely that a catch limit of 102 whales or less annually would be consistent with the requirements of the *Schedule*.

The Committee reviewed data requirements for the proposed bowhead assessment in 2004. In particular, there was an interest in resolving the conflict between existing age data and the catch and abundance data. It was noted that photo-identification data, such as those collected near Point Barrow, which provide an estimate of adult survival rate, can help to resolve this. In addition, further genetic data would assist with stock assessment. However, it was noted that the SWG on the AWMP has carried out a thorough review of the sub-stock question and the Committee believes that the single-stock hypothesis is most consistent with existing data.

9.1.2 In-depth assessment of eastern North Pacific gray whales

The Committee welcomed new data on gray whale abundance, distribution in the lagoons, migration, strandings and catch. Two papers (SC/54/BRG7 and SC/54/BRG10) presented assessments for this stock.

9.1.2.1 CATCH AND STRANDING INFORMATION

SC/54/BRG21 provided details on the 2001 aboriginal catch of gray whales in the waters adjacent to Chukotka, Russia. The harvest was carried out in the Gulf of Anadyr, the Senyavin Straits and in the open waters of the Bering Sea. A total of 112 gray whales was harvested, including 62 males and 50 females.

There was some discussion of strandings in the Chukotka region. Borodin noted that while it is difficult to accumulate stranding information over such a large coastline, he believes that most have been entrapments in ice. Melnikov added that he has been collecting information over a ten-year period and believes that many gray whales are killed by killer whales. When asked whether these were mainly attacks on calves, Melnikov replied that 2-3 year olds were more frequent targets. It was also noted that the presence of killer whale scars is routinely documented when animals are harvested.

SC/54/BRG27 summarised basic biological data collected from harvested gray whales in Chukotka primarily since 1980. Most of the discussion focused on two discrete periods: 1980-1992 and 1994-2000, the latter period marking a shift to a more traditional type of hunting in

coastal areas. The data obtained from harvested animals included sex, size (length), age, physiological condition and a thickness of blubber indicator (blubber thickness in millimetres divided by whale length in centimetres). Following the change in the harvest method, there was a decrease in the number of whales taken, the ratio of females in the catch and the length and corresponding age of harvested whales. A total of 542 whales were caught between 1994 and 2000, compared to the 2,137 taken between 1980 and 1992. Females dominated the catch in the earlier period, probably due to a hunting preference for larger animals. However, the sex ratio of catches has not differed from parity since 1998. In subsequent years, the whales harvested were predominately juveniles with an average age of less than two years. The percentage of pregnant whales among mature harvested females prior to 1992 was 13.4%. However, caution should be exercised regarding the use of such data as an indicator of the true pregnancy rate in this population. The Committee **recommends** that reproductive organs be collected and archived for detailed determination of pregnancy rates, as these are some of the few animals for which this will be possible. Borodin noted that Russia would welcome such a request.

SC/54/BRG23 summarised available information on the unusual mortality of eastern North Pacific gray whales in 1999 and 2000. The number of strandings documented along the west coast of North America increased to approximately eight times the annual mean calculated between 1995 and 1998. The unusually high number of strandings in 1999 ($n=283$) continued in 2000, with 368 animals recovered from Mexico to Alaska. Several factors may have contributed to the large number of strandings reported in those years. Since most of the whales were not examined thoroughly, the actual cause of death is unknown. There was also a change in the demographics of stranded animals during this period relative to 1995-1998, with an increase in the proportion of females and adult whales. However, the total number of strandings recorded in 2001 was only 21. This number is within the range of annual strandings in the period 1995-1998. It was also noted that very few strandings have been recorded in 2002 (as of 1 May).

9.1.2.2 NEW SCIENTIFIC INFORMATION

SC/54/BRG24 presented a study of the distribution and abundance of gray whales in the Magdalena Bay complex at Baja California Sur, Mexico. This work compared cow-calf pairs to other whales in three well-defined zones: Santo Domingo Channel (north), Magdalena Bay (central) and Almejas Bay (south). The authors proposed that Magdalena and Almejas bays were mainly used for courtship and mating, or as congregation areas for young and immature whales that do not take part in active breeding. By contrast, Santo Domingo Channel was an important nursery ground.

SC/54/BRG26 described the movement patterns of mothers and single whales in Laguna San Ignacio based on satellite telemetry. Twelve gray whales (six mothers and six singles) were instrumented with Argos satellite-monitored radio tags in February 1996. Mothers stayed in the lagoon longer, made repeated excursions to and from the lagoon, and had a significantly higher percentage of locations inside the lagoon than single whales.

SC/54/BRG11 examined trends in relative abundance of adults and calves in Laguna Ojo de Liebre and Laguna López Mateos (in the Magdalena Bay complex) based on a series of air and vessel surveys between 1980 and 1998. Temporal and seasonal patterns of abundance were estimated by fitting

generalised linear models to weekly counts with a Poisson regression. The authors concluded that lagoon use and calf production were severely disrupted around 1990, at least in the two areas studied.

SC/54/BRG16 reviewed existing information on gray whales in their wintering grounds in Mexican waters. This review included the history of exploitation in Baja California, the formal protection of gray whales in Mexico, research in Mexican waters, abundance within the lagoons, distribution, calf production and mortality, duration of stay within the lagoons, birth rate, mortality, movements from telemetry studies, site fidelity from genetic studies, environmental and anthropogenic threats, and future research and monitoring needs.

For the winter seasons 1997-2002 estimates of annual calf production suggest a decrease in calf production from the 1997 high (910 calves estimated) to a low in 1999 (286 calves), followed by a gradual increase to 670 calves during the period 2000-2002. Photographic identification of 975 single whales and 519 mothers with calf obtained during the winter seasons of 1996-2000 in Laguna San Ignacio revealed that the cow-calf pairs remain within the area approximately three times longer than single whales. Based on the photo-identification of 34 females seen in more than one year, and 18 with calves in different winter seasons, calving intervals were estimated to range from 2-4 years. The mean length of the calving interval was estimated as 2.50 ± 0.29 years (95% CI = 2.21-2.8; $n=19$). This interval is significantly higher than 2.11 (SD = 0.403) years estimated for the period 1977-1982.

SC/54/BRG25 described the northern migration route and speed of one gray whale tracked with an Argos satellite-monitored radio tag. During migration, the whale maintained an average speed of 134 km/d (5.6 km/h), suggesting a total coastal migration period of 49 days from Laguna San Ignacio to the Bering Sea.

Perryman *et al.* (2002) summarised results of seven shore-based sightings surveys for gray whale calves during their northbound migration. Calf estimates and a calf production index for the survey years (1994-2000) were given. In addition, the relationship between the duration of seasonal ice coverage over primary gray whale feeding grounds and the fluctuations in calf estimates was examined. The authors then examined the correlation between the length of the feeding season (the period free of ice at a point along the selected meridian near the centre of the Chirikov Basin feeding grounds) and the calf estimates in the spring season immediately following the feeding season. A significant positive correlation resulted between the duration of the feeding season and the calf estimates.

SC/54/BRG4 examined the relationship between sea-ice and calf production more closely. A log-linear model was developed to examine the relationship between this ice-free index and calf production, as measured by the estimates of the number of calves passing central California during the northbound migration. A potential relationship was examined at three different lags. The best fitting model indicated that calf production was correlated with both sea-ice cover in the first half of the feeding season and with year. The sea-ice effect accounted for the most inter-annual variability in calf production, but there was also a slow decline in average calf production. The authors interpreted this as potentially representing a compensatory decline in fecundity as the population approaches carrying capacity. Sea-ice cover in 2001 was also measured, and the authors predicted calf production in the spring of 2002 would be from 349-703.

SC/54/BRG3 provided an estimate for 2001 northbound calf production. A total of 87 calves were counted in 714 hours of watch, and the resulting estimate of 256 is the lowest estimate in the entire time-series which started in 1980. Photogrammetric data has also been collected on the width and length of whales for several years in the same area. The whales measured during the 2001 count appear to have been in better condition than in the two previous surveys. Urbán noted that the same pattern was seen in the lagoons, where fewer skinny whales have been seen since 2001, and a higher calf production has been documented.

SC/54/BRG6 documented the shore-based counts of southbound migrating eastern North Pacific gray whales carried out by the National Marine Fisheries Service (NMFS) in the winters 2000/01 and 2001/02. Research protocol was essentially identical to that used in previous surveys. The provisional abundance estimate from the 2000/01 census was 18,761 whales (CV = 0.10; 95% CI = 15,429-22,812), and the 2001/02 provisional estimate was 17,414 whales (CV = 0.10; 95% CI = 14,322-21,174). Both of these estimates are well below the previous (1997/98) estimate of 26,635 whales (CV = 0.10; 95% CI = 21,878-32,427).

9.1.2.3 ASSESSMENT MODEL RESULTS

A revised assessment of the eastern Pacific gray whale population was presented in SC/54/BRG7. Previous gray whale assessments were presented to the Committee in 1997, with papers SC/49/AS3 and SC/49/AS24 (based on methods subsequently published as Punt and Butterworth (2002) and Wade (2002), respectively). Since those assessments were completed, new abundance estimates are available for three years (1997/98, 2000/01 and 2001/02). Additionally, there is now an eight-year time series of annual estimates of the number of calves passing central California during the northbound migration, data which had been used in only a preliminary way in Wade (1997). SC/54/BRG7 presented four analyses, one using only the population estimates, and three variants using both the population estimates and the calf production estimates. The model and statistical techniques were essentially the same as used in Wade (1997). Over the four scenarios run, current carrying capacity (K) was estimated to be about 22,000, with 90% probability intervals between 19,000 and 35,000.

The maximum population growth rate was estimated to be about 7% to 8%, with 90% probability intervals from about 4% to 11%. The population was estimated to be at K , although lower bounds of the intervals were as low as 71%. There was essentially zero probability that the population was currently below $MSYL$. It was noted that the use of the calf estimates did not substantially change the results, but made the results more precise, particularly the estimates of K .

The quantities Q_0 and Q_1 have previously been recognised as the most appropriate for management advice on gray whales (IWC, 1998c, p.94). These quantities are identical for populations above $MSYL$ (as estimated here), so that it was **agreed** to express results in terms of Q_1 . The point estimates for Q_1 ranged from 605-669, with the lower 5th percentile of the posterior distributions ranging from 455-490.

The model estimates that a density-dependent decline in fecundity occurred throughout the 1980s and 1990s, that the population had nearly levelled off by around 1990, and that average calf production should have levelled off by 2000. It was noted that the abundance estimates have been roughly stable since 1984. In the single analysis in which the model was not fitted to the calf production data, the model still

estimates that a compensatory decline in fecundity occurred throughout the 1990s. This is consistent with the independent results of an analysis of the calf estimates themselves, which indicated a slow decline. Higher mortality of gray whales in 1999 and 2000 (suggested by higher stranding rates) along with lower calf production from 1999-2001 could have led to a decline of gray whales in those years. Population estimates in 2000/01 and 2001/02 that were lower than estimates in most recent years are consistent with this idea, although it is impossible to determine how much of the drop in the estimates is due to a real decline in the population and how much to sampling error in the estimate.

In SC/54/BRG10, assessments of this stock were performed using the standard BALEEN II model (Punt, 1999) and the inertia model developed by Witting (2000; 2001). The inertia model is a density-regulated model that uses between-generation changes in the heritable component of fecundity to induce additional density-dependence that is delayed one generation. The advantage of this model is that it reconciles abundance estimates with historical catches, which traditional assessment models cannot do without assumptions such as an increase in carrying capacity. The results of the analyses based on the BALEEN II model are qualitatively and quantitatively very similar to those of SC/54/BRG7, although the results are not identical owing to slight differences in the model formulation, the choice of the model parameters and the data included in the likelihood function. Analyses based on the standard BALEEN II model fit the calf count data better than the inertia model and indicate a population at its (current) equilibrium level and that the current catches are sustainable.

The Committee **agreed** to seek management advice in quantities such as Q_0 and Q_1 , and to compare that advice for model uncertainty against the inertia model that uses exponential functions and a catch history starting in 1600. Without commenting further on the plausibility of the inertia model governing gray whale population dynamics, the Committee noted that the model results did not give cause to modify management advice from the BALEEN II or similar models.

The Committee **recommends** additional research to investigate the observed changes and differences in the counts of gray whales, particularly gray whale calves observed in the breeding lagoons and along their migration routes, and to better understand the factors that are influencing the productivity of this population. It further **recommends** that the Commission co-sponsors¹¹ an intersessional workshop to bring together the most recent and historical data with which to examine process error in gray whale abundance, including: mother/calf counts; pregnancy rates in catch data; and seasonal distribution at the end of the southbound census. This workshop should also review relative habitat information (e.g. prey base) for examination and analysis relevant to the dynamics of the population. If the workshop is held, the report should be available for the 2003 Committee meeting.

9.1.2.4 MANAGEMENT ADVICE

The Committee noted that the assessments in SC/54/BRG7 and SC/54/BRG10 (using the BALEEN II model) used similar methods and yielded similar results, although they differed in some details, such as the behaviour of each model close to its unexploited equilibrium level. The Committee **agreed** that management advice can be formulated on the

¹¹ There was insufficient time to develop a funding proposal at the meeting.

basis of the results from the approaches in SC/54/BRG7 and SC/54/BRG10. Both assessments indicated that the population was above MSYL, and may be close to or above its unexploited equilibrium level.

In the previous assessment, the Committee agreed that management quantities such as Q_0 and Q_1 were more appropriate for management advice than RY for populations possibly above MSYL. In this case, the point estimates of population size are well above MSYL, and Q_0 and Q_1 are identical for such population sizes; the Committee **agreed** that Q_1 is the appropriate quantity for providing management advice for the eastern Pacific gray whale. The lower 5th percentiles for estimates of Q_1 in SC/54/BRG7 and SC/54/BRG10 were 482 and 475, respectively, using the methods of the last assessment. When the estimates of calf production were additionally used, the lower 5th percentiles for estimates of Q_1 were 463 and 466, respectively.

The last full assessment of this stock was in 1997 (IWC, 1998c, pp.92-94), and substantial new information has become available since then. The estimates of Q_1 are very similar to the estimates from the previous assessment (e.g. the lower 5th percentile from Wade (1997) was 472 compared to 482 from the new assessment). Based on data and analyses examined this year, the Committee **agreed** that a take of up to 463 whales per year (the lower of the 5th percentiles of Q_1) is sustainable for at least the medium term (~30 years), and is likely to allow the population to remain above MSYL.

The Committee noted that it hopes to be able to recommend a gray whale SLA at its next meeting (see Item 8.7).

9.1.3 Minke and fin whales off West Greenland

The Greenland catch for 2001 included 137 landed minke whales from West Greenland (32 males, 91 females, and 14 unknown sex, plus 2 struck and lost), 14 landed minke whales from East Greenland (14 females, 0 males, with 3 struck and lost) and 7 fin whales (3 males and 4 females, and 1 struck and lost).

The Committee has never been able to provide satisfactory management advice for either the fin or minke whales off Greenland. This reflects the lack of data on stock structure and abundance and is the reason for the Committee to first call for the Greenland Research Programme in 1998 (IWC, 1999c).

This **inability to provide any advice on safe catch limits is a matter of great concern**, particularly in the case of fin whales where the best available abundance estimate dates from 1987/88 and is only 1,096 (95% CI 520-2,106). The Committee notes that there is to be an abundance survey (see Item 8.4.2) this year. The Committee stresses that obtaining adequate information for management should be seen as of very high priority by both the national authorities and the Commission. Other recommendations related to the Greenland Research Programme are discussed under Item 8.4.

Without this information, the Committee will not be able to provide safe management advice in accord with the Commission's management objectives, or develop a reliable SLA for many years, with potentially serious consequences for the status of the stocks involved.

9.1.4 Humpback whales off St Vincent and The Grenadines

Hester reported the catch of a 55ft non-lactating female and a 28ft male (no milk present in stomach) at Bequia on 27 March 2002. He stated that photos and skin samples had

been taken. However, he noted that the animal's ventral side may not have been photographed due to problems turning it over. More information on these catches is given in SC/54/ProgRep St Vincent and The Grenadines. Hester confirmed that a straight-line measurement was used to determine length. However, the whale was measured in water, which would have been logistically more difficult and may have introduced measurement error. Brownell and Clapham noted that a length of 55ft for a North Atlantic humpback whale was highly improbable (Clapham and Mead, 1999) and suggested that this reflected a measurement error.

Based on the available data, the Committee believed it is most plausible that eastern Caribbean humpbacks are part of the West Indies breeding population (Item 10.5.3.1). However, the Committee reiterated its view of last year that the question of abundance and population identity of humpback whales in the eastern Caribbean remains unresolved.

The Committee **recommends** that collection and analysis of photographic, genetic and abundance data be undertaken as a matter of urgency and referred to its discussions under Item 10.5.3.1. It noted that information on stock identity and abundance would be required in any future AWMP for humpback whales in the North Atlantic.

In response to a specific request to the Chair of the Scientific Committee from the Commissioner for St Vincent and The Grenadines, the Committee considered the likely impact on the stock of an annual take of four whales. Assuming that the humpback whales found in the eastern Caribbean are part of the West Indies breeding population, the Committee **agreed** that a catch of up to four whales taken annually will be unlikely to harm this stock.

9.2 Catches by non-member nations

No catches by non-member nations have been reported.

9.3 Contaminated gray whales from the eastern North Pacific stock

SC/54/BRG21 reported that two whales were 'stinky' (smelled of medicine) during the 2001 season, and samples from those animals are currently being analysed by Russian and North American scientists.

Rowles commented that samples from these whales had been shipped to Fairbanks, Alaska and would be analysed for ketones and anthropogenic contaminants sometime after this meeting. Brownell noted that discussions are underway for Japanese scientists to undertake additional studies on these samples.

9.4 Work plan

The work plan agreed by the sub-committee on bowhead, right and gray whales is given in Annex F and considered further under Item 19.

10. WHALE STOCKS

10.1 Matters relevant to more than one stock (Annex G)

10.1.1 DESS: Progress with data entry and analysis options

Data from the 1999/2000 and 2000/01 SOWER surveys have been validated and included in DESS (Database Estimation Software System). It was noted that the variance calculation in DESS uses each segment of survey mode on a transect as an independent sampling unit. The Committee **agreed** that there should be an option in DESS to use other sampling

units. It also **agreed** that a feature to be considered in future modifications of DESS is to include the surfacing data from sightings tracked during IO mode. These data would need to be entered into the database and an extraction query written. The Committee also **agreed** that the default option for school size estimates be changed so that the size bias regression method is used, even if the regression was not significant (for more details see IWC, 2002g, pp.196-7).

10.1.2 SOWER circumpolar cruises

10.1.2.1 SOWER 2001/02

Following last year's recommendation (IWC, 2002d, p.30), the cruise started approximately three weeks earlier than the six most recent previous surveys. This strategy was adopted to facilitate the temporal compatibility with earlier cruises (those prior to 1994/95), with the aim of ensuring that the survey took place during the peak migration period of minke whales. The planned survey area was the western half of Area V. However, extremely poor weather was encountered, and so longitudinal coverage was restricted to the area between 130°E and 150°E, in which good coverage was obtained in both the northern and southern strata. As a consequence of the poor weather, it was not possible to carry out the biopsy sampling feasibility study of minke whales, although the Estimated Angle and Distance Experiment (and training) was conducted.

Minke whales were the most commonly sighted species in the research area, with 123 groups comprising 358 animals seen. A surprisingly high number of blue whales were encountered (14 groups; 35 animals). The acoustic element of the blue whale research resulted in an unprecedented number of good quality recordings of sounds attributed to true blue whales.

Notwithstanding the numerous changes that have occurred during the course of the circumpolar cruises (e.g. reduced working hours, increased latitudinal coverage), a concern was raised regarding the relative lack of longitudinal coverage compared to earlier cruises (20° on this cruise compared to 60° on earlier surveys, both with two vessels). It was emphasised that the weather on this survey was *exceptionally* poor, and that this was the main reason for the particularly low coverage attained. On this survey, the vast majority of blue whale research was conducted in such conditions, barely impinging on potential minke whale research time.

The Committee expressed its gratitude to the Government of Japan for providing the vessels to conduct the survey. The Committee also thanked the officers and crews of both vessels, the Cruise Leader (Ensor) and the researchers for their efforts during a difficult cruise due to the exceptionally bad weather conditions encountered.

10.1.2.2 PLANS FOR FUTURE CRUISES

Given the poor coverage in 2001/02, SC/54/IA20 proposed a revised plan for the completion of the third circumpolar set of cruises, comprising coverage of the eastern area of Area V in 2002/03 and the western area in 2003/04.

Noting the importance of the SOWER surveys to its work, and of completing the third set of circumpolar surveys, the Committee expressed its gratitude to the Government of Japan for the offer to make the survey vessels available for this purpose in 2002/03 and 2003/04, for a time period longer than usual.

Some members were concerned about the simultaneous operation of SOWER and JARPA surveys in Area V and the possible effect that this could have on results. It was suggested that the two sets of survey tracks be planned such

that: (a) a comparison of the resulting estimates of minke whale density from JARPA and SOWER is possible; and (b) disturbance effects are reduced by the SOWER vessels always preceding the whaling vessels in time and space. The Committee **agreed** that this is feasible and details will be finalised at the planning meeting (and see Item 16.4.1).

The remaining areas to be covered are disproportionate in size, with Area V East (which encompasses the Ross Sea) being much larger than Area V West (and especially the remaining unsurveyed area of Area V West). The plans outlined in SC/54/IA20 accommodate this concern to some degree by increasing the number of days allocated for research to 60, compared to the normal 40+ days. Noting the difficulty in surveying Area V East because of its wide latitudinal range, the Committee **agreed** that emphasis should be placed on surveying the southern (and mid-) strata in this Area. It was **agreed** that the survey should be designed to ensure full longitudinal coverage in these strata, but in order to accommodate this priority, the northern strata should be restricted to 20° longitudinal coverage in 2002/03, leaving the remaining 5° northern sector to be added to the area covered in the 2003/04 survey, although it should be attempted if the schedule of the cruise allowed.

10.1.3 NASS cruises

The coordinated international North Atlantic Cetacean Sighting Surveys (NASS) started in 1987 and have since been conducted in 1989 and 1995. In these surveys, large areas of the northern North Atlantic have been covered simultaneously by up to 15 vessels and two aircraft with participation of up to five countries (NAMMCO, 1998). The fourth international sightings survey (NASS-2001) was coordinated by the NAMMCO Scientific Committee and was carried out during the 2001 summer by the Faroes, Norway and Iceland. On two of the Icelandic vessels acoustic surveys for redfish were conducted simultaneously without any particular conflicts. The aerial survey component of NASS 2001 (SC/54/O12) covered the inshore areas of Iceland. This was the third NASS aerial survey carried out since 1987, using essentially the same survey design and procedures.

The Committee welcomed the report of these surveys, however, due to the lack of time, it was not possible to fully explore the methods and results. The Committee noted that sharing the survey platforms with the redfish survey on the Icelandic vessels had apparently been successful. It was noted that the international redfish surveys included a large area to the south and west of the NASS survey areas; had participation from Germany, Iceland, Norway and Russia; and will be carried out on a three-year rotation schedule. The Committee **recommends** that the nations participating in the next redfish survey incorporate a cetacean survey, if feasible. This would extend the geographical range of the NASS surveys to cover a larger area of the North Atlantic.

10.2 Antarctic minke whales – abundance estimates (Annex G)

10.2.1 Review of new data

Using standard IWC methods, estimates of Antarctic minke whale abundance from the 1999/2000 IWC-SOWER cruise in Area I, which surveyed the area south of 60°S to the

ice-edge, between 60° and 80°W was 5,910 whales (CV = 0.339). Using standard IWC methods, estimates of minke whale abundance from the 2000/01 IWC-SOWER cruise in Areas I and VI, which surveyed the area south of 60°S to the ice-edge, between 110° and 140°W, was 35,150 (CV = 0.309).

Comparing these estimates to other years in which parts of these areas were surveyed was difficult due to different longitudinal coverage. The Committee **agreed** that it is important to assess the longitudinal consistency of density estimates between surveys, and to gauge the scale at which different densities could be expected to be found, i.e. would a high density area seen one year on a longitudinal scale of 30° (say) be expected to be detected in another year, on the same scale, or it is more appropriate to compare densities on a smaller or larger longitudinal scale?

It was noted that there appeared to be a difference in the estimated detection functions in IO mode between the *Shonan Maru* (SM1) and the *Shonan Maru No. 2* (SM2). In principle, there should be little difference between these vessels since they have the same design and engine. It was not possible to determine the cause of this difference, nor indeed whether the difference should be of concern at all, given the fairly low sample sizes, different observers and different conditions encountered during the survey imparting a composite effect on the fitted detection function. Some members suggested it would be useful to look at the noise profiles of the two vessels from acoustic tests at different operational speeds to investigate whether the differences might be due to more vibration on the SM2 at typical survey speed (11.5 knots). This is of particular importance as it could provide evidence of responsive movement being the cause of the differences between vessels seen in the analyses.

10.2.2 Updated estimates by area

Using the estimates reported under 10.2.1, the third circumpolar series of surveys now encircles the Antarctic, although the surveys in Area V do not extend completely from the ice-edge northwards to 60°S. The percentage of ice-free area between 60°S and the ice-edge covered by CPI, CPII and CPIII is 63.1%, 79.5% and 91.1% respectively. The updated estimate of abundance for CPIII is 312,000 (CV = 0.086). Abundance estimates for comparable areas indicates the CPIII estimate is now 46% of that in CPII. This is statistically significant at the 5% level.

10.2.3 Inter-year comparisons and trend

10.2.3.1 METHODOLOGICAL ISSUES THAT MAY INFLUENCE ABUNDANCE ESTIMATES AND THEIR TRENDS

10.2.3.1.1 EFFECTIVE SEARCH HALF-WIDTH AND SCHOOL SIZE ESTIMATION

The effects of different pooling strategies on the estimation of abundance of Antarctic minke whales, using data from the CPII and CPIII were explored in several papers, and details can be found in Annex G. SC/54/IA13 found that whilst stratum had a significant effect on both perpendicular sighting distance and school size, there were no significant differences between the two primary survey vessels. SC/54/IA15 reported revised minke whale abundance estimates for the 1998/99 circumpolar cruise in Area IV, by adopting the pooling strategy suggested in SC/54/IA13. The revised estimate increased by 47% to 10,470 (CV = 0.35). SC/54/IA5 also examined the effect on the abundance estimate for the 1998/99 survey of different pooling strategies. The changes in the abundance estimates from the

estimates of a standard analysis, which was presented in Burt and Stahl (2001), ranged from 0% to 23% in closing mode and from -3% to 18% in IO mode. Although SC/54/IA5 and SC/54/IA15 analysed the same data, the abundance estimates were substantially different because of the different ways in which mean school size was estimated. SC/54/IA32 presented Akaike Information Criterion (AIC) estimates for different pooling options for the IDCR/SOWER surveys. Using the authors' preferred north vs south strategy only increased the ratio of abundances from CPIII/CPII by a factor of 1.04 compared to the estimates using the standard method.

The purpose of estimating the Closing:IO mode density ratio (*R*) is to correct for bias caused by surveying in Closing mode. SC/54/IA26 investigated possible changes in *R* for minke whales on the IDCR/SOWER surveys with: (1) time; (2) the inclusion of like-minke sightings; and (3) whale density. It was shown that estimates of (average) *R* for minke whales (which ignore any whale density effect) were generally identical for CPII and CPIII, but lower (though not significantly so) for CPIII when like-minke sightings were also taken into account. For pragmatic reasons, the authors suggested that adopting different *R* estimates for specific time periods (e.g. CPII and CPIII) avoids the problem of continual updating of the historic abundance estimates as more data by which to calculate this ratio become available. The Committee **concurred**.

The above papers came to the conclusion that pooling by stratum fits the data better than pooling by vessel. Pooling by stratum may be preferred *a priori* on biological grounds, especially if the two survey vessels are operationally similar.

The Committee concluded that whilst different analysis options may produce different point estimates, it would be unlikely that these differences would generally be substantial, even if they happened to be so for a particular dataset. It **endorsed** the view that decisions regarding general methodology should be based upon data from more than one survey, and pooling should not solely be based upon statistical criteria, but also on biological or environmental evidence, when available. Where appropriate, this strategy should be adopted even if it leads to higher variance estimates.

10.2.3.1.2 POTENTIAL COVARIATES

SC/54/IA17 investigated the effects of sighting conditions (school size, sighting cue, latitude and sea state) on Antarctic minke whale abundance estimation parameters (effective search half-width, sighting forward distance and mean school size). As school size decreased, the effective search half-width and the sighting forward distance decreased. Cues from schools of size 1 or 2 were usually 'body', which is generally considered more difficult to find in high sea states as compared to 'blow' cues. The proportion of schools of size 1 or 2 increased with decreasing latitude. Small school sizes and bad weather conditions prevailed in the northern part of the survey area. Because the survey area was extended northwards in the third circumpolar survey, the effects of small school size and bad weather conditions were substantial.

It was suggested that a 'synthetic sightability' variable that is some, perhaps non-linear, combination of other variables might be a better covariate than any single covariate. It was agreed that the IDCR/SOWER data should be used to determine which covariate or group of covariates provides the best estimate of optimal sighting conditions and

should be included in any method to estimate abundance. The Committee **recommends** that a synthetic sightability variable be investigated.

SC/54/IA16 explored the effect of different factors on the probability of a duplicate sighting of several species, and investigated any change in these probabilities between CPII and CPIII. The effect of school size on the probability of duplicate sightings was statistically significant for minke, humpback and southern bottlenose whales. For minke whales, the probability of a duplicate sighting for schools of size 2 was 1.56 times larger than for solitary animals (95% CI = 1.21-1.78), and for schools of 3 or more animals, it was 1.84 times larger (95% CI = 1.68-1.93). This provides strong evidence that $g(0)$ depends on school size. For minke whales, the duplicate sighting probability was about 20% smaller in CPIII than CPII, with this effect being more appreciable for the northern strata. This may be because solitary whales constitute a greater proportion of the schools in the northern regions, and survey effort was extended northwards in CPIII. A similar reduction was found for humpback whales; this suggests the possibility that humpback and minke whales have similar habitat preferences. In addition, it was shown that as visibility improves, the probability of a duplicate sighting tends to increase significantly. There is also a similar decreasing non-significant trend with sea state and a weaker trend with sightability, for which variation may not change in a systematic manner. In addition, when inexperienced observers (those with experience of less than five surveys) were observing from the IO platform, the duplicate sighting probability was 20% less than when observers with at least five years experience were there. This effect was not statistically significant, but sample sizes were quite small.

Whilst recognising that differential observer experience is a plausible explanation for changes in the duplicate sighting probabilities, the Committee noted that the effect is difficult to tease out from the data. The Committee concluded that the hypothesised observer experience effect contributes less to differences in $g(0)$ than does school size, but should be considered further.

The Committee cautioned that prior to the completion of CPIII, it is difficult to interpret some of these results because they may be strongly influenced by a particular survey area. For example, Area V East, which has not yet been surveyed, contributes a large proportion of the sightings.

The Committee **agreed** that these papers provide evidence supporting the assertion that $g(0)$ could be less than 1, at least in some of the circumstances investigated, and covariates that should be considered in future analyses include sighting cue, observer experience, survey mode, sightability (synthetic or that recorded in the field), Beaufort sea state, school size, distance from ice and stratum (North or South).

10.2.3.1.3 METHODS TO INCORPORATE COVARIATES AND ESTIMATE $g(0)$

SC/54/IA29 explored the use of the covariate estimation framework available in the program Distance 4 (Thomas *et al.*, 2001) for improving detection function estimation in the computation of minke whale abundance estimates for the IDCR/SOWER surveys. Estimation from pooled data including environmental and other covariates was attempted for the CPII. Annex G, Appendix 4 examined data from CPII, and showed that including covariates when estimating the search half-width improved the fit in all cases except when weather was included. In all cases, the AIC value was

lower for the hazard-rate model than for the half-normal. A correlation matrix was obtained between all the covariates; although most factors were significant, correlations > 0.2 were only obtained for sightability with weather and wind speed, and confirmed sightings with closing mode.

SC/54/IA23 investigated generalisations of size bias regression methods for estimating school size from line transect data.

The methods were illustrated using data from the 1999/2000 and 2000/01 circumpolar surveys. There appeared to be little gained from applying GLMs (generalised linear models) or GAMs (generalised additive models) in the perpendicular distance based model. However, the inclusion of a regional effect in the detection function did provide improvement over the perpendicular distance only approach, yielding increased precision, and possibly more reliable estimates. Including unconfirmed sightings was not successful and possible reasons for this were suggested.

The Committee **agreed** that this method is a promising way to extend the standard method that could produce less biased abundance estimates and could be relatively easily incorporated into DESS. However, it requires evaluation with respect to its robustness and accuracy.

The 'Big Beautiful Model' estimates abundance by accounting for variations in $g(0)$ caused by size bias, changes in school size distribution and changes in sighting conditions (SC/54/IA21). The method provides estimates of $g(0)$ independent of double-platform data and so avoids some of the complexities and sensitivities associated with double platform estimation. The Committee welcomed this new approach and **recommends** its further development (see Item 21).

Spatial modelling potentially provides a better insight into true uncertainty than stratified estimation, since the latter tends to yield fluctuating estimates of variance. However, in practice, developing well-behaved spatial estimators can be difficult. Five linked issues requiring further work were raised:

- (1) estimating variance (dealing with clustered sightings, and incorporating uncertainty from earlier steps in the analysis, e.g. in effective search half-width);
- (2) choosing the scale of smoothing, when sightings are clustered on small spatial scales;
- (3) allowing for spatial variation in the scale of smoothing, perhaps linked to localised environmental factors;
- (4) changing the form of the underlying smoother, e.g. to accommodate non-smooth changes in density;
- (5) restricting the fitted density surfaces to realistic values in regions of rectangular strata that are far from the zigzag track.

The Committee **encourages** further intersessional work on these issues.

SC/54/IA10 introduced a relatively simple hazard probability model using perpendicular and forward distance data for double-platform line transect surveys in which the independent observers have the same visual searching area. This model can provide an abundance estimate of diving animals without the assumption of $g(0) = 1$, and takes account of unmodelled heterogeneity derived from the whales' surfacing behaviour. The proposed model may be viewed as an integration of the Skaug and Schweder (1999) and Cooke (2001) approaches, but is more general and tractable. It may be easily extended to a model with only perpendicular distance data or to include data from 'incompletely independent' observers.

A simulation study and an application to actual IDCR/SOWER sightings data suggested that the proposed method performed well and could be useful for the future analyses. In particular, simulation tests indicated that using other available data, such as incompletely independent observer sightings data and mean surfacing rate estimated from external data, can improve the performance of the model. The ability to utilise the former is important because such data can easily and economically be collected. The provisional results from applying the model to actual sightings data when $g(0)$ is assumed to be 1 and when it is not, yielded considerably different abundance and trend estimates.

In discussion of SC/54/IA10, it was noted that the results presented were considered preliminary by the authors, the main aim of the paper being to introduce the methods. Key points raised were: (1) the improvement in precision obtained when the IO platform data were added to the model was likely to be an artefact of increasing sample size (since a common detection function was assumed across all platforms); (2) school size was not included in the current simulation (although this is planned – with simultaneous surfacing of all animals in a school); it is however presently incorporated as a covariate in the model; (3) the reversal of the trend in abundance estimates seen when comparing those from the proposed methods and those from Branch and Butterworth (2001b) was not fully understood – in particular, neither the difference in the methods used to estimate school size, nor $g(0)$ estimation were thought to be responsible – it seemed most likely that the reversal was a result of different stratification options used in the analyses; and (4) the apparent gain in precision using the proposed methods compared to the standard methods was due to assuming independence between sightings, which is invalid in the presence of clustering.

SC/54/IA30 examined the discrepancy in whale density between the true value and an estimate assuming that $g(0) = 1$, using a simple mathematical equation. Whale density was defined as the product of the school density estimate and mean school size. Estimates of $g(0)$ from the 1989/90 and 1993/94 IDCR/SOWER surveys (SC/54/IA10), stratified by school size class (1, 2, 3+), were assumed to apply for all years in the 2nd and 3rd circumpolar surveys respectively. This approach was taken for illustrative purposes only; clearly it is preferable to estimate $g(0)$ separately for each survey. The discrepancy between density estimates which assumed that $g(0) = 1$, and those which used $g(0)$ stratified by school size class, ranged from –18% to –39%.

SC/54/IA1 reported progress on (1) estimating strip width without the assumption $g(0) = 1$; and (2) estimation of additional variance. Estimation of strip width was based on the method described and tested in Cooke (2001), which the Committee had recommended last year (IWC, 2002g, p.199). The two tasks were addressed together using the integrated modelling framework outlined in Cooke and Leaper, 1998. The method for treating the three platforms on IDCR/SOWER cruises was similar to that used in SC/54/IA10. The data collected in IO mode are necessary for the estimation of $g(0)$, but school sizes estimated in this mode appear to be biased low, hence a method was developed for allowing for school size bias in the estimation.

The Committee noted that this method was promising because it would probably be able to be used to extrapolate to unsurveyed areas, simultaneously accounting for all the potential covariates that have been discussed. Technical

questions included: how was the changing ice-edge in the non-symmetrical Antarctic study area incorporated into the Fourier series; was there a conflict between estimating the overdispersion term and automatically selecting the terms for the smoothing function; what should the most appropriate scale for smoothing be; and should that scale vary depending on the amount of variability in a region? After discussion, it was concluded that further work should resolve these technical issues.

The Committee **welcomed** all the new methods, **encourages** further development and simulation testing of these (and other) methods and **looks forward** to seeing the results from applying them to the IDCR/SOWER data.

The Committee **agreed** that $g(0)$ differs by school size, but the difficulty remains as to how to address this in analyses. It is complicated by the fact that in IO mode (which has traditionally been the mode used to estimate $g(0)$), there is negative bias in the size of recorded schools – a large proportion of which are unconfirmed. It was noted that data from Closing mode, for which the recorded school sizes are thought to be unbiased, could be used to calibrate the recorded IO mode school sizes.

The Committee **agreed** that the performance and robustness of any new method should be evaluated. Some new simulation datasets will have to be created for this purpose, since the original datasets were primarily designed for testing North Atlantic minke whale analysis methods. Some of these changes will be minor: a detection function to simulate upper or front bridge observers' sightings, for example. Other changes will require more thought e.g. determining an appropriate way to generate Antarctic minke whale school size distributions and surfacing patterns (as well as detectability based on school sizes and other covariates). To further complicate matters, the fact that recorded school sizes in IO mode tend to be negatively biased estimates of true school size was raised, and its effects should be considered and if possible, accounted for. A more complete description of factors to be included in the simulated datasets was developed, and a timetable was established to ensure results from the simulations could be presented next year.

The Committee **recommends** that simulated datasets be used to evaluate any method that might be used to analyse the IDCR/SOWER data, including the standard method. In addition, the Committee **recommends** that further development of the standard method is, at this time, lower priority than evaluating the performance of the new methods. The Committee also **agreed** that when all the circumpolar data are available, these data are analysed by the standard method, and by any new methods found to be robust to the heterogeneities introduced into the simulated data. The Committee also **recommends** that results of methods when applied to both simulated and actual IDCR/SOWER data be presented at next year's meeting.

10.2.3.2 TIMING OF THE SURVEYS

The JSV, JARPA and IDCR/SOWER sightings data in Areas III, IV and V were used to examine the migration pattern of Antarctic minke whales (SC/54/IA12). The analysis included JSV data from 1971/72 to 2000/01 and JARPA and IDCR/SOWER data from 1987/88 to 2000/01. Five factors were considered as covariates in a GLM: latitude, longitude, time, season and Beaufort wind force. AIC was used to select the final model. It was concluded that in the 1970s, the peak migration was in late January; in the 1980s, it was bimodal, in mid-January and mid-February; and in the 1990s, it was also bimodal, in late December and

mid-February. CPUE data from the 1970s showed a consistent peak of migration in January (Shimadzu, 1980), which is somewhat different than the results of this analysis.

A potential problem with the analysis is the differing nature of the three data sources. It was suggested that including a covariate for JSV vs IDCR vs JARPA might make the analysis more robust. Nevertheless, because of these data source problems, any results would necessarily be rough.

A GLM analysis of daily minke whale density estimates from IDCR/SOWER surveys from 1978/79 to 1997/98 was used to determine migration patterns. The effects of survey mode, latitude, year and Management Area were included. A 20% drop in abundance was seen only after mid-February, although a larger real drop may be masked by a possibly confounding year effect. Inclusion of a year-date interaction term might help with this.

SC/54/IA7 noted that this shift in timing of migration was in the December to January period when the annual decrease in sea ice extent is most rapid and divergent. The author indicated that inter-annual climatological oscillations that affect variability in ice coverage may have indirectly affected the timing of the minke whale migration through changes due to, for example, prey availability or changes in the relative amounts of open water, ice edge and pack ice habitats. A more complete discussion of climatological indices and their relationship to pack ice and minke whale abundance and distribution is given under Item 10.2.3.5 and in SC/54/IA7.

The reason for the investigation into the timing of the minke whale migration was to determine if the recent change in timing of the IDCR/SOWER surveys affects the estimated abundance (IWC, 2002g, p.199). Given the new results presented, the Committee **agreed** that changes in survey timing probably had only a small impact on abundance estimates.

10.2.3.3 USING JSV DATA TO EXTRAPOLATE TO UNSURVEYED REGIONS

SC/54/IA12 extrapolated densities from the IDCR/SOWER (south of 60°S) area to northern areas covered by the JSV cruises (30°S-60°S). The IDCR/SOWER data were from CPII, 1985/86 to 1990/91; the JSV data were collected from 1971/72 to 2001/02. Assuming no difference in conditions, the extrapolation rate was calculated as the ratio of the index abundance between the northern area and the area south of 60°S. This ranged from 5% to 18%. Using estimates from CPII, the population in the northern area is estimated to be about 320,000 in Areas III, IV and V. This may be slightly positively biased, because the sightings in the northern area may include some dwarf minke whales.

10.2.3.4 COMPARING JARPA DATA TO IDCR/SOWER DATA

SC/54/IA14 compared trends in Antarctic minke whale abundance between JARPA and IDCR/SOWER surveys in Areas IV and V. It reported that the trends in abundance estimates from the JARPA surveys (Hakamada *et al.*, 2001) in both Area IV (six surveys examined for the period 1989/90 to 1999/2000) and Area V (six surveys examined for the period 1990/91 to 2000/01) were not significantly different from zero. In contrast, abundance estimates from IDCR/SOWER surveys showed a negative trend in these Areas. The IDCR/SOWER surveys started several years earlier (1978/79 for Area IV; 1980/81 for Area V) but were conducted less frequently. It was suggested that JARPA surveys may better reflect the trend in abundance for minke

whales for the following reasons: (1) the estimates of abundance from the IDCR/SOWER surveys in CPIII are negatively biased estimates of true minke whale abundance and thus the downward trend is exaggerated; (2) there have been more JARPA surveys in these Areas than IDCR/SOWER surveys; and (3) there is more consistency among JARPA surveys than among IDCR/SOWER surveys in terms of the survey method, and geographical and temporal coverage of the surveys.

Childerhouse commented that the first five JARPA surveys in Area IV indicated a downward trend similar to the IDCR/SOWER surveys, and that the non-significant result quoted above was a reflection of a particularly high value for the sixth survey within the series. In response, it was pointed out that the low results for the fifth survey (1997/98) were particularly influential in suggesting an initial negative trend. There were reasons related to different ice conditions and a smaller proportion of mature females in the survey region in 1997/98 which strongly suggested that the 1997/98 survey had covered a smaller than usual proportion of the overall population.

The Committee considered that the temporal incomparability and survey design differences between the IDCR/SOWER and JARPA surveys rendered direct comparisons between their trend estimates inappropriate. However, the greater consistency of the JARPA surveys suggests that they may provide information on additional variance.

10.2.3.5 ANIMALS WITHIN THE PACK ICE

The survey ships used to collect IDCR/SOWER data cannot survey within the pack ice at normal survey speed (11.5 knots), so the ice-edge defines the southern border of the survey area. Although it is known that minke whales are within the pack ice during the surveys, it is not known what the order of magnitude nor inter-annual variability of the abundance in the pack ice is. Attempts were made to quantify these unknowns as detailed in Annex G.

One attempt to directly quantify the density of minke whales in the pack ice involved the analysis of data collected on the annual Southern Ocean Cetacean Ecosystem Program (SOCEP) and Australian APIS cetacean survey. This shipboard survey was conducted from 3-28 December 1999 within the pack ice starting at (64°23'S 150°50'E) and travelling westwards through the pack ice to Davis Base (68°34'S 77°50'E). The target species were seals, not cetaceans. In addition to the usual line transect data, they collected an extensive description of patterns of ice distribution. The potential to make inferences about densities in the pack ice is limited due to timing of the surveys and potential violations of line transect assumptions. The Committee **recommends** that methods to obtain unbiased, precise abundance estimates using data collected in the pack ice be developed. Progress on this issue was being developed in the Standing Working Group on Environmental Concerns (Annex J, Appendix 3).

In the absence of Antarctic minke whale abundance estimates within the pack ice for the same times and Areas as the IDCR/SOWER or JARPA surveys, other more indirect ways were explored (see Annex G). Two sources of data were used: JARPA data and previously published estimates of animals in the pack ice.

10.2.3.5.1 JARPA DATA

Based on the observation that mature female minke whales tend to be found further south, near the ice-edge, the sexual maturity rates and ice coverage from years with low

abundance estimates in open water were compared to those from years with high open water abundance estimates. A coarse estimate of the number of whales in the pack ice was calculated by multiplying the observed proportions of mature females from the JARPA samples by the abundance in open water as estimated from the JARPA data.

On the 2001/02 JARPA cruise, a substantial number of minke whales were sighted in the SE stratum and in Prydz Bay, and the sexual maturity rate of sampled females was 74%. In contrast, in the SE stratum in the 1997/98 JARPA survey there were few minke whale sightings, and the sexual maturity rate of sampled females was only 5%. According to the NIC satellite information, there were many ice-free areas south of the ice-edge in 1997/98, where research vessels could not enter. In fact, in Area IV in 1997/98, the ice coverage was higher than in other years in the JARPA series (Annex G, Appendix 6). Using these data, it was estimated that the number of mature females south of Area IV in the pack ice in 1997/98 was 2,876 (Annex G, Appendix 7). It was noted that this figure was probably an underestimate of the total number of minke whales in the pack ice, as the estimate does not include males or immature females.

The Committee spent some time discussing the possible whereabouts of minke whales during years when the open water abundance estimates were low and the various hypotheses included: into the pack ice; north of 60°S; and east or west.

SC/54/IA18 presented the same pattern between ice coverage and abundance from the 1988/89 (CPII) and 1998/99 (CPIII) IDCR/SOWER surveys in Area IV. The 1998/99 season was colder and the estimated abundance of minke whales was very low; it is not clear where they were. On either side of the study area, the Ross Sea and Prydz Bay were both closed in January 1998/99, although they are well known to be high-density areas of Antarctic minke whales. It is possible that the whales scattered widely in the northern stratum, although the abundance in the northern stratum was lower than the southern stratum (Burt and Stahl, 2001). Therefore, the authors concluded that many minke whales could have gone into the pack ice region in 1998/99.

It was further noted that the proportion of mature males in Area IV (greater than *ca* 0.6) always exceeds that observed in Area V (*ca* 0.5) (Annex G, Appendix 8). This is consistent with the differences in ice conditions in Area IV and V. There was also substantial variability in the proportion of mature males by year (i.e. a difference of about 0.25 between the maximum and minimum proportions). In Area IV this appears to be inversely proportional to the JARPA abundance estimates, while in Area V there is little or no relationship. The latter, despite similar levels of variation in the sex ratios in Area IV and V, suggests that either the change in ice cover is not the sole explanation for the observed data in Area IV or that different factors are the source of the variation in Area V. The estimates of the number of mature and immature animals in Areas IV and V, by sex and year, lead to the conclusion that the pattern of abundance estimates cannot be explained simply by increasing proportions of females within the ice, and that if increase in ice is the explanation for the declines, then both males and females must be entering into the ice zone.

During further discussion, it was noted that the analyses in Annex G, Appendix 8 estimated abundance by using Area-specific proportions of mature females. It was agreed that using estimates of abundance by stratum within an Area would provide further information for the Committee to consider, should such data be available.

10.2.3.5.1 PREVIOUSLY PUBLISHED DATA

SC/54/IA19 presented estimates of the abundance of minke whales in unsurveyed regions within the pack ice for three scenarios of the proportion of whales in the pack ice. The closing mode density of Antarctic minke whales in open water was obtained from the southern stratum of each sector in the IDCR/SOWER data from 1978/79 to 1997/98 (Branch and Butterworth, 2001b). This density was applied to areas of open waters inside the pack ice using data from Kasamatsu *et al.* (2000). Scenario 1 was based on 1979 data from Naito (1982); scenario 2 combined the 1979 and 1981 data in Naito (1982); and scenario 3 used data from Ainley (1985). The estimated abundance (for each scenario) within the pack ice in CPII was 18%, 102% and 51% of that in the ice-free area; in CPIII the percentages were 28%, 159% and 72% respectively. The area within the pack ice region in CPII was 123% of that in CPIII. Estimated total abundances in CPII were 100%, 99% and 110% of that in CPIII. This suggests that there could be a substantial difference between CPII and CPIII.

The Committee noted that there are very few surveys on densities of minke whales within the pack ice, and that this paper was useful in presenting calculations of the possible proportion of minke whales in the pack ice. However, certain incompatibilities (the density estimates in the pack ice were not from the same Areas as the open water density estimates; the timing of surveys within the pack ice did not overlap the entire time period of the IDCR/SOWER open water surveys) made interpretation of the results difficult.

SC/54/IA7 noted that the distribution of minke whales may be affected by inter-annual climatological variability that affects the extent and coverage of the sea ice. To try to examine the mechanism behind the inverse correlation between open water abundances and ice coverage, the Committee attempted to link the patterns of proportions of mature females with patterns of pack ice. A list of environmental covariates that might be useful in quantitatively investigating this correlation include: (a) Southern Oscillation Index (Kwok and Comiso, 2002); (b) SAO (Reuter, 1936; Van Loon, 1967); (c) Antarctic Oscillation Index (AOI) (Gong and Wang, 1999); (d) El Niño-Southern Oscillation (ENSO); (e) sea ice-edge e.g. monthly mean sea ice-edge, equator-most position of the 30% isopleth of ice concentration in each degree of longitude (Yuan and Martinson, 2000); (f) sea ice edge anomaly – monthly, removes seasonal cycle, contains inter-annual and longer-term variability as well as linear trends (Yuan and Martinson, 2000); (g) ice concentration – 25 km × 25 km grids; (h) ice area; (i) sea ice motion; and (j) ice thickness.

This information introduces some hypotheses for changes in open water abundance of minke whales; however, more research and data from the pack ice is needed to test the hypotheses. In the meantime, the Committee **agreed** that correlation analyses between open water abundance estimates and environmental factors may help to develop functional/biological connections between climate, ice, productivity (e.g. chlorophyll) and Antarctic minke whale abundance.

One attempt to develop such a functional link between the patterns of proportions of mature females with patterns of ice conditions is given below. In Area IV, the pattern of ice melt is characterised by the southward recession of the ice edge and (based on satellite predicted estimates) the development of ice-free areas inside the pack ice, near the Antarctic coast. In a 'normal' year, the main ice-edge recedes southward, and especially at longitudes corresponding to the ice-free areas inside the pack ice. During the survey period, some, but not

all, of the ice-free areas inside the pack ice become contiguous with the open sea to the north, and characteristically they form bays in the main ice-edge. The pattern of ice melt was considered 'normal' in the following seasons: 1989/90, 1991/92, 1993/94 and 1999/2000. The proportions of mature females in the catch data from the southern stratum for these years were 31.1%, 39.1%, 27.6% and 42.8%, respectively. The pattern of ice melt was 'abnormal' in 1997/98 when the ice-edge was farther north than usual. Based on satellite predicted estimates, extensive ice-free areas were present inside the pack ice this year. The percentage of mature females in the catch was substantially lower (7.1%).

These analyses and observations support the hypothesis that the 'missing' mature females are possibly distributed in the pack ice, but do not preclude other hypotheses, such as longitudinal movement out of the Areas. More work is needed to fully explore these ideas. Despite the difficulties in interpreting the variety of information, the Committee **agreed** that there could be large numbers of minke whales within the pack ice, quite possible some tens of percent of the open water IDCR/SOWER abundance estimates, at least for certain areas. However, potential biases and paucity of surveys in the pack ice make it difficult to be more definitive. The Committee **recommends** the ice-edge information in the analyses of SC/53/IA15 be used to give a simple annual index of the week or month of greatest ice cover and the percent ice coverage for the times and areas of the IDCR/SOWER and JARPA surveys. In addition, it **recommends** that the IDCR/SOWER and JARPA data (which covered a longer time series) be used to investigate if there is a correlation between open water abundance and ice coverage.

10.2.3.6 WORK PLAN

In the light of current uncertainty about the density and distribution of minke whales in the pack ice, and to what extent this might affect interpretations about trend from the IDCR/SOWER and JARPA surveys, the Committee **agreed** that little further progress can be made on this issue without new data and analyses. It therefore sought to identify potential existing sources of data, and to make recommendations on what data would be useful to collect from vessels that operate in the pack ice.

It was noted that the most useful data were those from dedicated cetacean observer platforms, particularly those platforms on which the observations were made both in open water and in the pack ice, such as the 1995/96 BROKE survey (Nicol *et al.*, 2000) and SO-GLOBEC cruises with cetacean observers onboard (SC/54/E12). Other potential data sources include: APIS data; data collected during transits to and from Antarctic bases; surveys in Area III conducted by Australian SOCEP; and data collected during ice navigation modes during the IDCR/SOWER and JARPA surveys. Concerns were expressed regarding the APIS aerial survey data, given that these surveys were primarily aimed at surveying seals (hauled out on to the ice) and hence would not have consistent search effort for whales. Some of these aerial surveys also had dedicated cetacean observers onboard so cross-validation with corresponding dedicated shipboard cetacean observations data would be useful.

Different views were expressed regarding the applicability of conventional line transect estimation methods to data from within the pack ice. However, it was agreed that sighting distance and angle data may have a role to play in any future analyses, and that these data should be

collected where possible. The Committee also **recommends** that consistent and regular descriptions of the ice characteristics (see Annex J, Appendix 2) and other factors affecting the detectability of minke whales be collected. Furthermore, the Committee **recommends** that data corresponding to where the IDCR/SOWER 'ice edge' would have been located should be recorded where possible. It was also suggested that satellite telemetry should be used to provide information on the movement of minke whales between pack ice and open water (the IDCR/SOWER survey area).

The Committee also **recommends** the following items to facilitate progress on identifying available data sources and to encourage the collection of new data within the pack-ice region:

- (1) the Secretariat should make an official request to the APIS coordinators inquiring about availability and access to any cetacean data that their member countries may have collected within and outside the pack ice;
- (2) relevant members of the Scientific Committee should approach individuals whom they know to have been involved with the APIS surveys with the same enquiry as in (1) above (Thiele and Gales will coordinate this effort);
- (3) requests should be made to countries that use ice breakers in the Antarctic to conduct dedicated cetacean observations from their vessels (e.g. Australia, France, Germany, Japan, South Africa, the UK and the USA). Thiele will coordinate this effort, and ensure that data are collected in a standardised format.

10.2.3.7 TRENDS IN ABUNDANCE USING POPULATION DYNAMICS MODELS

In SC/54/IA25, the ADAPT VPA methodology of Butterworth *et al.* (1999) was refined and/or extended with catch-at-age and abundance information (from both the IDCR/SOWER and JARPA programmes) in Areas IV and V. The results suggest statistically significant increases in recruitment until a peak in the late 1960s, followed by a drop and then stabilisation for more recent years. Total (1+) population trends over the past two decades show slight non-significant declines of about 1% per annum. The Area IV population is, however, estimated to have declined over the 1970s. Estimates of M for the two Areas range from 0.046-0.070 per year, and are statistically compatible. These results are consistent with supercompensation (with the population having expanded beyond its current carrying capacity) and subsequent reductions in that carrying capacity (the population first having rapidly increased towards an increased carrying capacity earlier in the last century).

The authors noted that the suggestion of only a slight decline in abundance (about 1% per year, or 20% over the timeframe of the IDCR/SOWER surveys) initially appears to contradict the results from the IDCR/SOWER surveys that show an appreciable decrease in abundance estimates between CPII and CPIII. Further examination of the abundance estimates showed that estimates from Areas IV and V in CPIII were 58% of the estimates from CPII. This supports the results from this model. However, the estimates from the remaining Areas I, II, III and VI in CPIII were 36% of that in CPII, a much greater reduction. The difference in circumpolar estimates between CPII and CPIII is therefore not completely addressed by the ADAPT VPA model. However, the IDCR/SOWER survey estimates have wide confidence limits, and are not statistically incompatible with the VPA results.

In discussion, several members argued that other plausible scenarios existed to explain these results. In particular, the analyses presented implicitly require some subjective decisions to be made, fixing some parameters to enable estimation of others. For example, some concerns were expressed about the plausibility of the extent of the increase in population until the 1970s; such an increase would not follow if the natural mortality rate (M) was as high as 0.1. Opinions differed on how realistic a rate of 0.1 for M was, but Butterworth pointed out that it exceeded the confidence limits of the estimates of M provided by the VPA.

Concerns were raised about the selectivity constraints in the VPA model and lack of fit to the age distribution in the 'plus' group. Although some concerns about the selectivity constraints had been addressed in Butterworth *et al.* (1999), further consideration of fit to the age data for older animals was needed in Area IV. Another concern raised was the need to consider the implication of uncertainty about stock structure on the VPA results.

Possible reasons for the estimated decrease in abundance in the late 1960s were discussed. It was noted that the large harvests in Area IV probably contributed. However, it is unlikely that these trends could be explained by supercompensation alone; the postulated decrease in carrying capacity was also essential to explain the observed patterns (unless the current estimates of abundance from the IDCR/SOWER surveys were very negatively biased). Other suggested explanations for the observed changes in population size include an inertial dynamics model, and changes in carrying capacity that were climatologically driven.

It was pointed out that the stock recruitment relationships estimated by the VPA for minke whales in Areas IV and V (particularly the recent large drops in *per capita* recruitment) do not appear to be supported by some of the biological evidence available from commercial catch and JARPA data. If recruitment estimates from the VPA are truly representative, and pregnancy rate and age at first parturition are without trend, then some other mechanism(s) must be postulated to account for a variable stock/recruitment relation. One possible explanation is a decrease in juvenile survival rate (lactation having higher demands on females than pregnancy). It was **noted** that an estimate of body condition, perhaps derived from data on whale length, weight and blubber thickness, as well as apparent pregnancy rate and age at first ovulation, might be a useful diagnostic for future results from VPA or other integrated models. The historical catch records also include data (e.g. oil yield, blubber thickness) that might be useful in determining an appropriate condition factor.

Ohsumi noted that the 1997 JARPA Review meeting had confirmed that blubber thickness had decreased since the JARPA programme began in 1987 (IWC, 1998b). He also expressed the view that blue whales and humpback whales were increasing in the Antarctic, and that consequent competition effects might be restricting the carrying capacity of minke whales.

The Committee noted that whilst the combined three-year-three-age catch-at-age data from these Areas is published, the sensitivity and robustness of the VPA model could only be independently investigated if the corresponding data on a one-year-one-age basis were also available. Kato reminded the Committee that the Institute of Cetacean Research, which owns the JARPA data, established data policies during the JARPA Review Meeting that are applicable in this case. Furthermore, it was noted that details on how the catch-at-age matrices are constructed

were also necessary, of which some were provided in Butterworth *et al.* (1999). To address some of the concerns about this VPA analysis, Polacheck agreed to convene an interessional e-mail group to: (1) request the required summary data following the established data policies; (2) make a list of the concepts that need to be addressed in further analyses (i.e. alter the model structure, incorporate other biological data and stock structure alternatives, and investigate model robustness); and (3) coordinate individuals to pursue analyses to address these concerns.

The Committee **recommends** that the power of different approaches to detecting a trend be investigated, including a simple regression on abundance estimates, the integrated approach suggested in SC/54/IA1 and the VPA approach of Butterworth *et al.* (1999).

10.2.4 Other

10.2.4.1 UPDATE ON mtDNA ANALYSES

An update of the mitochondrial DNA (mtDNA) RFLP analysis in Antarctic minke whales from Areas V and VIW was presented (SC/54/IA9). The analysis used all the available samples from these Areas (1988/89-2000/01 JARPA surveys). Samples were divided arbitrarily as follows: Area V Western (130°-165°E); Area V Eastern (165°E-170°W); and Area VI Western (145°W-170°W), with two temporal periods (Early and Late). A total of 2,228 samples was examined in six longitudinal/temporal groups. Following an examination of yearly variation, a hierarchical analysis by AMOVA was conducted for the total samples. Overall, no significant mtDNA heterogeneity was found in Areas V and VIW. Each of the longitudinal/temporal groups in Areas V and VIW differed significantly from an out-group sample from Area IVWE in both F_{ST} and PHI_{ST} statistics.

It was suggested that information on any geographical and temporal differences in stock structure in the Antarctic Areas could be incorporated into integrated models such as the VPA. Pastene informed the Committee that a new study covering Areas III-VI is underway using nuclear DNA in addition to mtDNA. The Committee **recommends** that attempts be made to collect samples from lower latitudes, recognising that the exact locations of the putative breeding grounds are at present unknown. In this regard, it **recommends** that the use of satellite telemetry to track whales between the Antarctic and lower latitudes should also be investigated.

10.2.4.2 RESPONSE TO RESOLUTION 2001-7

Resolution 2001-7 'requests the Scientific Committee to provide to the Commission at IWC 54 (IWC, 2002c):

- (i) a list of plausible hypotheses that may explain this apparent population decline;
- (ii) the possible implications that such a decline in abundance may have for the management of minke whales in the Southern Hemisphere, and for ecologically-related species, in particular other cetaceans, and the state of the Antarctic marine ecosystem.

The Committee noted the estimates of abundance using the 'standard methods' of Branch and Butterworth (2001b) for the third circumpolar set of surveys are appreciably lower than estimates for the second circumpolar set of surveys. Last year, after coarsely quantifying many of the factors affecting abundance estimates, there remained evidence of a decline in abundance estimates from CPII to CPIII, although it was not clear how this reflected any actual changes in minke abundance. This year, many contributions were

submitted suggesting refinements to these coarse quantifications (Annex G, Appendix 10), but it is premature to attempt an update of last year's computations, at least until the results of further work scheduled for the 2003 meeting could be reviewed.

Given the wide range of plausible hypotheses identified above, the Committee respectfully informs the Commission that it believes it is premature to comment on the equally wide range of potential management implications. The Committee **agreed** that the most appropriate time to fully address this issue will be after completing its work on reviewing the IDCR/SOWER abundance estimates.

10.2.5 Plans for completion of the Antarctic minke whale review

Annex G, Appendix 9 details the tasks identified by the Committee to further the review of Antarctic minke whale abundance estimates, together with an indication of priorities for the next year. Noting the need to explain why the estimates of abundance using the standard methods for CPIII are appreciably lower than for CPII, the Committee **strongly recommends** that substantial progress be made on all high priority tasks by next year's Scientific Committee meeting.

To successfully complete its review of the IDCR/SOWER abundance estimates and trends, and to address Resolution 2001-7, resources are required to complete the last two years of the IDCR/SOWER survey and to develop and test new analytical methods that result in less biased abundance estimates and trends. Financial details of the IDCR/SOWER cruises are discussed in Annex G, Appendix 2; and financial details of the method development and testing are discussed under Item 21.

10.3 Southern Hemisphere blue whales – plans for assessment (Annex G)

10.3.1 Abundance estimation

An attempt had been made to improve the precision of detection functions for blue whale abundance estimates by using data for all circumpolar sets of cruises combined, instead of separately as at present (SC/54/IA27). The attempt was not successful, probably because small sample sizes do not contain sufficient information to distinguish the numerous factors affecting the shape of the fitted distributions. It was estimated that $g(0)$ is likely to be much closer to 1 for blue whales than for minke whales (SC/54/IA16), probably because of their large body size and blow.

The updated abundance estimates for blue whales from the IDCR/SOWER surveys from 1978/79 to 2000/01 using the methods of Branch and Butterworth (2001a) are given in

Table 7. When comparable areas are considered, the point estimate of abundance in CPIII is appreciably higher than that in CPI and CPII; this difference is more marked when 'like-blue' sightings are also included in the comparable-area estimates. However, because of the high CVs associated with these abundance estimates, the CPII and CPIII estimates for comparable areas are not significantly different at the 5% level. These estimates refer to animals sighted south of 60°S, and are therefore likely to refer largely to 'true' blue whales. Given the results in SC/54/IA8 (see below) no more than 7% of such animals are likely to be pygmy blue whales.

Due to time constraints, the Committee did not complete its review of the abundance and trends of blue whales in the Antarctic.

10.3.2 Progress on sub-species differentiation

10.3.2.1 BEHAVIOUR AND MORPHOLOGY

A total of 362 video sequences of 28 hours 36 minutes and 146 photographs of 52 animals obtained mainly on SOWER circumpolar cruises in the period 1995/96-2000/01 had been examined to provide distinctive external morphological keys for sub-species discrimination of blue whales during shipboard surveys (SC/54/IA8). For comparison of morphological keys and surfacing behaviour between sub-species, in the absence of an appropriate genetic marker, the sampling location of blue whales in mid-summer was used, with animals north of 55°S identified provisionally as pygmy blue whales, and those south of 55°S as true blue whales. A statistically significant trend that putative pygmy blue whales submerge without showing the dorsal fin and keel was confirmed. A 'tadpole' shape typifies putative pygmy blue whales and a 'torpedo' shape putative true blue whales, while in putative pygmy blue whales the anterior tip of the central blowhole groove extends beyond the anterior tip of the nostrils. Furthermore, there were statistically significant differences in dorsal hump type between the two sub-species. Bayesian analyses indicated the reliability of the keys in combination for discriminating between the sub-species. The morphological analyses indicated that some animals identified as pygmy blue whales using the keys are found among true blue whales (south of 55°S). The proportion of such animals was calculated as 2.3% or 6.9%, depending on morphological key used. These values could be a measure of the mixing rate of pygmy blue whales south of 60°S.

Preliminary mtDNA analyses using biopsy samples collected earlier indicated statistically significant differences in haplotype frequency between the provisional sub-species,

Table 7

Point estimates of abundance, CV and 95% confidence interval (CI) for blue whales in the Antarctic, from the baseline analysis ('baseline'), when estimates from comparable areas are considered ('comparable areas') and when like-blue sightings are additionally included ('comparable + like blue').

Circum Set	Baseline			Comparable areas			Comparable + like blue		
	Abundance	CV	95% CI	Abundance	CV	95% CI	Abundance	CV	95% CI
I	400	0.41	200-940	500	0.41	250-1,200	500	0.41	250-1,200
II	500	0.48	230-1,300	700	0.51	270-1,700	700	0.51	260-1,700
III	1,700	0.42	760-3,700	1,900	0.42	860-4,200	2,300	0.38	1,100-4,600

although no specific haplotype peculiar to either sub-species was detected. Dizon and Brownell reported that new blue whale samples from the Southern Hemisphere had been received, thus significantly increasing the sample size. They will use these samples to expand their exploration of likelihood-based approaches using microsatellites to assign individuals to sub-species and report this to the Committee next year.

The Committee **recommends** the following:

- (1) take still or video-photographs of the blowhole region in blue whales at every opportunity;
- (2) conduct genetic (including microsatellite) analyses on the sample materials available from the IDCR/SOWER and JARPA cruises, taking account of information for each sampled whale on the three morphological criteria developed in SC/54/IA8 for sub-species differentiation.

10.3.2.2 ACOUSTICS

Clark reported that analysis of calls recorded so far on SOWER cruises indicated that all recordings made in high latitudes (from three areas over four years) were identical to themselves but differed from those made in mid-latitudes, i.e. from Madagascar, Chile and Western Australia, which were themselves different from each other. Calls recorded on the most recent (2001/02) cruise were identical to those recorded earlier in high latitudes, and are presumed to be made by males as part of a reproductive display. The results so far do not contradict the hypothesis that high latitude animals are different from those for which calls have been recorded in mid-latitudes. He noted however that so far only 75% of the tapes from earlier SOWER cruises have been made available.

Since 2000, the Committee has recommended that the acoustic data from the cruises be archived and examined. Clark reported that the archiving was almost complete.

For the past two years, the Committee has also recommended convening a workshop specifically on blue whale acoustics to: (1) review the sounds recorded on SOWER cruises in the context of known blue whale sounds; (2) reappraise the value of acoustics for distinguishing between the two sub-species; and (3) make recommendations for future acoustic work to address the sub-species issue. Participants invited will be people with experience in blue whale acoustics, including Clark (USA), Doherty (USA), Ljungblad (USA), McDonald (USA), McCauley (Australia), Shimada (Japan), Rankin (USA), Stafford (USA). Clark reported plans were underway to hold it during the 2002 summer, prior to the SOWER Planning Meeting.

Acoustic detections of baleen whales near the Antarctic Peninsula were recorded using passive acoustic recording packages (ARPs) (SC/54/O3). The aim was to provide information on seasonal occurrence, distribution and minimum population size for, *inter alia*, 'true' blue and fin whales. Preliminary analysis of data retrieved from seven out of eight ARPs deployed revealed numerous 'Antarctic-type' blue whale calls, detected year-round. Calls on the shelf-break were apparently louder than those detected on the shelf.

10.3.3 Other

Mikhalev presented information on a catch of pygmy blue whales obtained in a limited area south of Australia in late January 1965. The Soviet fleet *Sovietskaya Ukraina* took

177 animals in a small area centred on *ca* 39°S, 125°E, south of the Great Australian Bight, between 24 January and 1 February. Because animals were taken indiscriminately as encountered, their biological characteristics represent a random sample of stock structure prior to commercial whaling. Ninety-nine animals (55.9%) were male. Males ranged in length from 14.2-22.1m (mean length 19.7m). Forty-one of the 78 females were examined, ranging in length from 15.5-22.8m (mean 19.9m); 12 (29.3%) were immature, including one calf. Sexually mature females measured from 18.6m.

The Committee welcomed this important new information. In response to a request from the Committee, Mikhalev stated that he would attempt to obtain additional information on catches by the same fleet earlier in the season, for example east of Amsterdam/St Paul Islands in the Indian Ocean, for presentation at next year's meeting.

The Committee **recommends** that the Chilean and Japanese governments be urged to make available any data from the blue whale catches from the 1960s. An effort is needed to resolve the question of whether both sub-species were taken from Chilean land stations.

10.3.4 Work plan

The Committee noted that it was impossible to conduct the review on the IDCR/SOWER analysis methods and complete an in-depth assessment of blue whales. Therefore, the Committee **recommends** that the assessment of blue whales start in 2005, the year after the completion of the IDCR/SOWER review. To ensure the necessary materials are available by the time of the review, the sub-committee identified a number of important tasks. These are given in Annex G.

The Committee suggested that satellite-tagging be discussed next year. To ensure the success of this discussion it **recommends** that the appropriate tagging experts be invited to next year's meeting. The Committee requests the Secretariat to complete the coding of the historic catch data.

The Committee's final work plan is discussed under Item 19.

10.4 Southern Hemisphere humpback whales (Annex H)

10.4.1 New information on distribution, stock structure, abundance and trends

Surveys for humpback whales off the coast of Oman were conducted between 2000-2002 (SC/54/H3). This population appears to be resident in the Arabian Sea year-round and observations of song and of mother/calf pairs in February supports the suggestion by Mikhalev (1997) that this population is on a Northern Hemisphere breeding cycle. Photo-identification and genetic data were collected. There was a statistically significant difference between Omani samples and those collected from sites in the southwestern Indian Ocean. However, given the observations of year-round feeding off Oman, it is possible that animals that breed in the southwestern Indian Ocean cross the equator to feed in the Arabian Sea in the austral summer (boreal winter).

Humpback whale occurrence and distribution around Mayotte in the Mozambique Channel were investigated during the austral winters of 1995-2001 (SC/54/H18). There were sightings of 152 groups of humpback whales, of which 64% were mother/calf pairs. This is a much higher

percentage than has been reported for other breeding areas and suggests that Mayotte may represent an important nursing/calving area or resting point along the migration route.

Rosenbaum described the formation and activities of the Indo-South Atlantic Humpback Whale Network which exists to promote collaboration and to coordinate research among scientists working in the Indian and South Atlantic Oceans (primarily around Africa). The Network aims to make large-scale data comparisons to investigate migration links, population structure, trends in abundance and identification of critical habitats for humpback whales over a large proportion of their range around Africa and in the northern Indian Ocean. The Government of South Africa has contributed ship time for a whale research and training cruise which will be conducted in collaboration with dedicated shore-based surveys off Cape Vidal. The Committee expressed its appreciation to the Network and to the Government of South Africa for this important collaborative effort, and looked forward to seeing the results next year.

Research on humpback whales in the coastal waters of eastern Madagascar and off Gabon was summarised (SC/54/H20). The estimated abundance of humpback whales in Antongil Bay was 1,746 (CV = 0.19). This estimate is conservative, since 47.0% of the individuals are identified from dorsal fin photographs and were excluded from the analysis.

Carlson noted that surveys for humpback whales and other marine mammals off Kenya were being conducted (Weru, 2001), and would be coordinated with other members of the Indo-South Atlantic Humpback Whale Network. The Committee welcomed this work, and strongly supported research in this important and previously unstudied area.

A shore-based survey for humpback whales on the west coast of South Africa (Saldanha Bay) was conducted from July to December 2001 (SC/54/H21). Observations were made of 95 sightings of 233 humpback whales and 217 sightings of 354 right whales. Results seem to confirm the presence of a suspended migration in spring, as proposed by Best *et al.* (1995). Biopsies and fluke photographs were also collected. In addition to survey work, there was further investigation of whaling data. Catch per unit effort data from the Donkergat and Salamander whaling stations showed two peaks in humpback whale availability, one in July and the other in November/December. The size composition of the catch suggests that these peaks coincided with an influx of mature animals, representing peaks of migration.

Data from field notebooks kept by the late Dr William Dawbin including information on land-based sighting surveys for humpback whales in Fiji during the austral winters of 1956, 1957 and 1958 were presented. A preliminary analysis of these data (SC/54/H7) indicated that humpbacks were quite abundant in the area during this period although recent anecdotal reports indicate that humpbacks are much rarer in Fijian waters today. Clapham noted that, if details of Dawbin's field effort could be obtained from his notebooks, there would be an attempt to conduct replicate surveys in the area to better assess the present status of this population, which is presumably part of the depleted Area VI stock.

Activities of the South Pacific Whale Research Consortium (SPWRC) were summarised in SC/54/O14. This group includes researchers from areas of Oceania and the South Pacific as well as from adjacent regions of South America and the Antarctic. Matching within the regional catalogue of fluke photographs has revealed some degree of migratory interchange between adjacent areas of Oceania,

South Pacific, but no interchange with South America or the Antarctic Peninsula. Non-systematic surveys and published capture-recapture estimates based on photo-identification indicate that the density of whales remains low throughout the wintering grounds of Oceania and the New Zealand migratory corridor.

The issue of animal ethics and experimental guidelines had arisen in the sub-committee on the Comprehensive Assessment of humpback whales (Annex H, item 6.1). A range of views was expressed during discussions but no agreement was reached on how this issue should be addressed. The Committee agreed that this was a complex issue that had some relevance to potential collaboration among scientists but did not pursue it further.

The abundance of humpback whales in New Caledonia was estimated from a catalogue of individuals identified by microsatellite genotyping ($n=214$), by fluke photographs ($n=217$) and by combined records of both (SC/54/H9). The estimate obtained from the genotype data (95% CI = 366-674) was larger and less precise than the photo-identification estimate (95% CI = 279-432). Overall, it is apparent that the population of humpback whales in New Caledonia is small. Although there were unresolved methodological issues with combined photo-identification and genotyping estimates of abundance, the Committee noted that this was a promising approach and encouraged further investigation into this issue. In this context, a collaborative discussion between the Indo-South Atlantic Humpback Whale Network, the South Pacific Whale Research Consortium, and researchers in the North Atlantic was recommended.

Occurrence of humpback whales in French Polynesia over the period 1988-2001 was summarised (SC/54/H14). From 1988-2001, more than a thousand observations of humpback whales were made near 25 islands in four of French Polynesia's five archipelagos. Analysis of skin samples showed few mtDNA haplotypes shared with other areas of the South Pacific. Given the high haplotype diversity within this region, this latter finding is not surprising.

SC/54/H5 reported on aerial surveys carried out off the coast of Brazil, between 12° and 20°S, with the objective of investigating distribution and abundance of humpback whales. Standard line transect sampling was used, and the resulting estimates were corrected for availability bias. The corrected estimated abundance was 2,291 individuals (CV = 0.45). Population estimates for humpback whales from Abrolhos Bank, Brazil over the period 1996 to 2000 ranged from 1,389-3,977 with an average CV of 0.27 (SC/54/H11). A maximum-likelihood estimate for the year 2000 was 3,871 individuals (95% CI = 2,795-5,542), with an estimated growth rate at 31%. In discussion, it was noted that this growth rate was clearly unreasonable (see Clapham *et al.*, 2001), and suggested the existence of some unknown methodological problems in sampling or in the estimation process. As a result, the estimate of abundance should be treated with considerable caution.

SC/54/H12 described research on humpbacks conducted off the western side of the Antarctic Peninsula. Photo-identification, biopsy sampling and vessel surveys were used to investigate the biology, distribution and density of cetaceans in the Antarctic Peninsula area. The authors encouraged the development of multidisciplinary habitat studies in the region to improve understanding of humpback whale ecology in the Antarctic.

The Committee regretted that a lack of funding had prevented the authors of the papers SC/54/H5, H11 and H12 from attending the meeting, and highlighted the need for the

IWC to support the attendance of researchers from developing countries.

A comparison of duplicate sighting rate for Southern Hemisphere humpback whales between the IDCR/SOWER CPII and CPIII was presented in SC/54/IA16. The duplicate sighting probability for school sizes greater than two was 1.6 times larger than for a single school. This confirms that duplicate sighting probability (and hence $g(0)$) is dependent on school size. The probability of duplicate sightings did not significantly differ between the second and third set of circumpolar surveys.

Sightings of humpback whales from the 2001/2002 JARPA survey were summarised in SC/54/O18. Total primary sightings of humpback whales were 1,219 schools/2,387 animals. This was the highest number recorded on any JARPA survey. Humpback whales and minke whales showed clear separation in most areas except for some areas near the ice-edge where both species were concentrated. The authors suggested that the increase in abundance of humpback whales may be leading to interspecific competition with minke whales because both species prefer the same prey and are generally distributed in similar areas while locally segregating from each other. In response, Clapham noted that simple overlaps in distribution were not sufficient to support claims of interspecific competition, which was a complex issue (Clapham and Brownell, 1996). Weinrich also noted that experience in the Gulf of Maine over 25 years has shown that patterns of prey abundance and distribution can cause medium-scale annual shifts in humpback distribution. Hence, dramatic local increases cannot be interpreted without similar effort throughout the stock's feeding range. In response, Ishikawa noted that JARPA surveys covered a large part of the Antarctic and had been conducted repeatedly over the last 15 years, and that therefore the results were reliable and showed that there had been an increase in humpback whales.

Results of aerial surveys of humpback whales migrating northward along the coast of Western Australia between 1976 and 1994 (Bannister and Hedley, 2001) were presented. These surveys demonstrated a rate of increase of approximately 10% per annum, at least between 1982 and 1991. The 1994 survey confirmed the rate of increase and provided an abundance estimate of 4-5,000. The most recent survey in 1999 was considerably affected by poor weather but applying a correction factor for animals missed yielded an estimate of absolute population size of 8,207-13,640.

Overall, in reviewing current studies in the Southern Hemisphere, the Committee commended all of the researchers working on humpback whales in Oman, Kenya, Madagascar, the Comoros, Mayotte, Gabon, Brazil, South Africa, Australia, Oceania and the Antarctic. The Committee was particularly pleased to see multi-area collaborations such as the Indo-South Atlantic Humpback Whale Network and the South Pacific Whale Research Consortium, and strongly encouraged the development of additional collaborative work of this nature.

10.4.2 Further population dynamics modelling

An assessment of the West and East Australian stocks of humpback whales was conducted using an age-aggregated production model that allows for mixing in the feeding grounds of Areas IV and V (SC/54/H17). These stocks were projected to reach pristine levels (assuming zero catches) in 10-15 years for the western stock and 15-20 years for the more depleted eastern breeding stock. The authors noted that their results were dependent upon absolute abundance estimates available for the two breeding stocks. A

subsequent reanalysis using new estimates suggested that current abundance of the Western stock could be as high as 65% of the pristine level.

Baker commented that the total known catch over certain periods was greater than the total population estimated by the model for that period. Butterworth responded that the numbers caught reflected a combination of catches on the feeding and breeding grounds taken from both stocks. However, further concerns were raised about the assignment of previously unreported Soviet catches to Antarctic Areas, and it was agreed that this requires further discussion. Baker commented that genetic analysis in progress may allow the assignment of animals from the feeding grounds to the breeding grounds, and that this would assist future modelling efforts.

In response to a question, the authors responded that the growth rate estimated in the model approaches 12.6% when abundance was at its lowest, and that this rate declines as the population grows. Clapham noted that 12.6% was the maximum plausible rate of increase derived from knowledge of humpback whale biological parameters.

10.4.3 Antarctic humpback whale catalogue

Carlson reported on the status of IWC Research Contract 16, the Antarctic Humpback Whale Catalogue (SC/54/H13). The catalogue has received 448 images from 17 contributors during the contract period, bringing the total number of catalogued individuals to 1,405. Of particular note were thirteen matches, including between Southern Ocean Area V and Eastern Australia (one match), and the Antarctic Peninsula and Costa Rica (three matches). There was considerable discussion about the protocols for accessing these data. A Working Group was set up to discuss this issue; its report is given as Annex H, Appendix 4. The Committee was pleased to receive this information and **recommends** that this work continues to be supported with the new conditions laid out in Appendix 4 of Annex H.

10.4.4 Work required to complete assessment

Substantial progress has been made in recent years in improving the understanding of humpback whales in certain areas of the Southern Hemisphere. However, many major gaps in data remain. Time constraints meant that a comprehensive review of the current state of knowledge about Southern Hemisphere humpback whales was impossible to achieve during the meeting. To address this, an intersessional group under Bannister was established (see Annex S). The terms of reference of this group are to: (1) summarise current knowledge regarding Southern Hemisphere humpback whales, by population or management area; (2) identify major gaps in knowledge; and (3) establish priorities for research to fill these gaps. Current information under (1) would include abundance and trends, catches and incidental takes, population structure and stock identity, biological parameters, environmental concerns and assessment models. The intersessional group will use the North Atlantic humpback whale Comprehensive Assessment as a model in summarising information. After reviewing the group's report at next year's meeting, further consideration will be given to whether it is feasible to set a deadline for the completion of the Comprehensive Assessment.

The Committee **agreed** that the results of the most recent East Australia humpback whale survey (in 2000) were important to the assessment, and **strongly recommends** that they be made available soon.

10.4.5 Work plan

Considerable progress had been made in some areas of the work plan from last year; however many items still require further work. The proposed work plan of the sub-committee is given in Annex H. The Committee's work plan is discussed under Item 19.

10.5 North Atlantic humpback whales – completion of Comprehensive Assessment (Annex H)

10.5.1 Review of assessment model developments

Last year, the Committee had recommended further development to the assessment model (IWC, 2002h, p.239). The Commission had supported this work and an improved framework for the assessment of North Atlantic Humpback Whales was outlined in SC/54/H1. The population dynamics model underlying the assessment is density-dependent, age- and sex-structured, and allows for multiple feeding and breeding grounds, 'stock'- or feeding ground-specific values for the resilience parameter and survival rates, as well as depensation. The model is fitted to data on absolute abundance, trends in relative abundance, estimated rates of increase, and information about the proportion of animals from each breeding ground on the feeding grounds.

10.5.2 Review of catch data

Intersessional work attempting to improve estimates of historical removals of humpback whales had been completed. Searches of historical archives in Maine and in Provincetown, Massachusetts yielded a modest amount of new information (SC/54/H16). To refine estimates of catches from the West Indies and the Cape Verde Islands, whaling logbooks from an additional stratified sample were read and information analysed. The resulting figures generally corroborate previous work, but improve the accuracy of removal estimates and provide measures of precision that were lacking in earlier studies.

A struck and lost rate of 1.85 was applied to West Indies and Cape Verde non-mechanised shore fisheries up to 1957; this was derived from information given in Mitchell and Reeves (1983). A rate of 1.23 was used for catches after 1957; this was derived from data given in Price (1985), and reflects the fact that use of power boats to tow dead whales resulted in a decrease in the struck and lost rate.

The new data were added to existing records of removals; these are listed by year in Annex H, Appendix 2. These figures represent plausible best estimates, not minimum estimates, with the possible exception of a shore-based fishery in the Cape Verde Islands (searches for information on which have not been conducted). Current knowledge suggests that there are no substantial gaps in the catch history as presented. Additional discussion is given in Annex H (item 5.1.2).

10.5.3 Additional analysis and data collection

10.5.3.1 POPULATION STRUCTURE AND STOCK IDENTITY

Incidental observations of humpback whales given in the logbooks of 19th century American whalers showed humpback whales in locations where little or no survey effort has occurred in recent times (SC/54/H22). Sightings in summer (June and July) on, or to the west of, the Mid-Atlantic Ridge may represent animals in previously unknown mid-ocean feeding habitats. The Committee noted that singing is common on the Mid-Atlantic Ridge from November to March; no acoustic sampling had occurred there during June, July and August.

The Committee noted that one of three biopsy samples taken on a US research cruise in the eastern Caribbean had recently been matched (by microsatellite genotyping) to an individual sampled in the Barents Sea. This represents the first match (either photographic or genetic) between the eastern Caribbean and the northeastern North Atlantic.

The Committee was informed that photographs and tissue samples had been collected from animals taken in the St Vincent hunt, and that tissue samples would be analysed in collaboration with Japanese colleagues.

The Committee **strongly encourages** that photographs be submitted to the College of the Atlantic to allow comparisons with the North Atlantic humpback whale catalogue, including the YoNAH collection. It also strongly encouraged that tissue samples or results from their analysis be forwarded to Palsbøll at the University of California Berkeley for comparison with the YoNAH genetic database.

Pastene reported that tissue samples would be analysed using mtDNA control region sequencing and micro-satellite profiling at the ICR genetics laboratory, and that he would contact Palsbøll so that results could be compared with those for the entire North Atlantic.

Hester reported that a collaborative project among eastern Caribbean countries had been initiated to collect photo-identification data. The photographs will be submitted to the North Atlantic humpback catalogue at the College of the Atlantic.

The Committee welcomed these initiatives and looked forward to the early resolution of the question of population identity of humpbacks in the eastern Caribbean.

10.5.3.2 ABUNDANCE AND TRENDS

Information on humpback whales was presented for the Icelandic component of the NASS-95 survey (SC/54/H10), with a revised estimate of abundance of 13,900 (95% CI = 3,900-29,000). SC/54/H10 also presented estimates for each of the two survey vessels separately. One of these, 7,900 (CV = 0.22) for the vessel AFR was considered to be the most appropriate estimate for inclusion as input into the assessment model (see Item 10.5.4). Abundance for Icelandic nearshore waters from the NASS-2001 aerial survey (SC/54/H2) was estimated as 3,057 (95% CI = 1,727-5,410). However, this survey did not sample the entire area and the analysis did not account for availability bias; these are both sources of negative bias.

A trend of 11.4% (SE = 2.1%) annual increase was estimated from an analysis of sighting rates of humpback whales in four aerial surveys conducted in Icelandic coastal waters in the period 1986-2001 (SC/54/H6). The reported rate was similar to one of 11.6% reported from sightings of humpback whales recorded by whalers for the period 1970-1988. In discussion, it was noted that these figures should not necessarily be taken as population growth rates; they are close to the maximum plausible rates for humpback whales calculated from demographic parameters (Clapham *et al.*, 2001). Some members believed that this may reflect a combination of population growth and immigration into the survey area from other regions.

10.5.3.3 BIOLOGICAL PARAMETERS

An update to previously published data on reproductive parameters of Gulf of Maine humpback whales was presented in SC/54/H23. Details are given in Annex H (item 5.1.4). Mature females observed in five consecutive years produced an average of 0.43 calves per year during that time period. Mothers and calves were much more likely to occur

in a particular area in the Gulf of Maine, suggesting that studies of humpback whale reproductive rates in other populations may be subject to bias (notably negative bias) if sampling is not undertaken in all parts of the feeding range. This may have important implications for assessments of humpback whales in other feeding areas.

10.5.4 Assessment

The Committee **agreed** a series of assessment model runs to provide information on humpback whale populations in the North Atlantic. Results from the model runs are given in Annex H, Appendix 3. The main general features of all the results are: (1) poor fit; and (2) populations in all areas are predicted to have recovered to carrying capacity. This is not consistent with observed continuing increases in a number of areas. In addition, the observed fecundity rate (0.43, reported in SC/54/H23) is not consistent with the model's prediction of a lower rate.

Results of a simple exponential model, which assumed that catches and abundance data for each feeding ground were independent, to approximate the trend in each feeding ground, were reviewed. Details are given in Annex H (item 5.2.2). The results suggested that population sizes for the Gulf of Maine and Iceland were still very low during the period 1940 to the 1960s. This is not consistent with known catch data in at least Iceland, which were believed to be fairly accurate. Any additional (unrecorded) catches would therefore have to have been taken elsewhere. Gunnlaugsson noted that sightings by whalers of humpback whales off the western coast of Iceland were very rare in the 1950s.

The Committee **agreed** that possible explanations for the failure of the assessment model to fit the data include the five listed below.

- (1) The model structure is wrong. It is possible that other structures, such as an inertia model (Witting, 2001), might provide a better approach to the assessment.
- (2) The catch data contain major gaps. This is unlikely to be the case for the 20th century, for which the catch record is reasonably well documented, but it is possible that removals from earlier periods have been significantly underestimated.
- (3) The recent estimates of abundance are wrong. These would have to be overestimates to explain the problems with model fitting; this was not considered likely.
- (4) Carrying capacity may have fluctuated and increased in recent years, thus affecting the abundance of whales. It was acknowledged that the marine ecosystem has changed in many respects over the last century as a result of human exploitation and climatic variations.
- (5) The existence of a largely unexploited population of humpback whales in some unknown area of the North Atlantic which has expanded and is now recolonising other habitats.

With regard to the last possibility, the Committee noted the incidental historical sightings around the Mid-Atlantic Ridge (see Item 10.5.3.1) as well as recent acoustic observations of humpback whales in the Norwegian Sea in winter (reported by Clark last year). It also noted that satellite tagging (in the North Pacific) has shown that humpback whales sometimes feed in remote offshore areas. Overall, the impression of the humpback whale as largely a coastal and shelf animal may well be erroneous.

In summary, as discussed above, the assessment model developed over the last two years did not provide good fits to the available data, nor were the results consistent with the observed data. In particular, all the best fits of the model

under the range of options explored predicted that the populations in all areas have recovered to carrying capacity. As a result of this inconsistency, the Committee is unable to provide advice on the population level of North Atlantic humpback whales in relation to carrying capacity. This statement applies to past carrying capacity and to present carrying capacity.

In conclusion, the Committee **agreed** that it has greatly increased its knowledge of North Atlantic humpback whales as a result of its Comprehensive Assessment. In particular, populations are increasing in a number of areas in the North Atlantic (Gulf of Maine, Iceland, West Indies) and the rate of increase of the West Indies breeding population is estimated at 3% per annum between 1979 and 1992 (IWC, 2002h, p.236). This breeding population has an estimated population size of 10,752 in 1992 (IWC, 2002i, p.258).

The Committee agreed that its Comprehensive Assessment of North Atlantic humpback whales was now complete.

10.5.5 Future work

At last year's meeting, the Committee discussed future work that would lead to a better understanding of North Atlantic humpback whales (IWC, 2002h, pp.239-41). This year, catch data had been updated (Item 10.5.2), new information on abundance around Iceland had been received (Item 10.5.3.2), analysis of data on calves per mature female in the Gulf of Maine had been completed (Item 10.5.3.3), and work recommended on development of the assessment model, and supported by the Commission, had been completed (Item 10.5.1).

However, most of the areas of future work identified last year had not yet been progressed. The Committee identified a number of additional areas of future work arising from discussions this year; the following list includes previously and newly identified areas of future work that the Committee believes would increase knowledge of North Atlantic humpback whales.

Catches

- (1) Review of historical data sources for land station catches in the Cape Verde Islands.
- (2) Examination of eastern North Atlantic catch data by season.
- (3) Review of additional historical data to allocate unidentified catches to species in the Faroe Islands and Iceland for the period approximately 1880-1930.
- (4) Further examination of Bermuda Blue Books and other colonial records on the Bermuda shore fishery.
- (5) Review of the Blue Books for Grenada, St Lucia and other West Indies Islands not previously covered.
- (6) Examination of whaling station diaries from West Greenland.

Analysis and data collection

- (1) Obtaining photographic and genetic samples from the Cape Verde Islands. The Commission has provided partial support for sample collection being undertaken in the Cape Verde Islands this year by Jann and colleagues. The Committee looked forward to the results of this work being presented at a future meeting and noted that further recommendations for additional work may be warranted in light of those results.
- (2) Estimation of survival rates in areas other than the Gulf of Maine.

- (3) Examination of the effect of heterogeneity of capture probabilities on abundance estimates.
- (4) Further examination of patterns of migration and distribution using photo-identification data and historical records.
- (5) Matching the YoNAH dataset to the North Atlantic Humpback Whale Catalogue. This work would greatly facilitate (3) and (4), above.
- (6) Further elucidation of the relationship between animals in the Lesser Antilles (eastern Caribbean) and the rest of the West Indies; additional photographic and genetic samples are required. The Committee referred to its discussion under Item 10.5.3.1 with respect to this issue.
- (7) Calculation of abundance estimates from NASS and NILS data that have not yet been analysed.
- (8) Investigation of oceanic distribution through satellite tagging, offshore surveys or other means. In particular, the collection of acoustic data at the mid-Atlantic ridge during the summer months would be valuable.
- (9) Additional photo-identification and biopsy-based surveys off the eastern coast of Iceland.
- (10) Genetic approaches to determine the number and identity of animals using 'missing' breeding and/or feeding grounds, based on an analysis of microsatellites and/or haplotype frequencies.
- (11) Continuation of assessment model development, including incorporation of the ability for carrying capacity to change, and exploring other types of models.

The Committee **agreed** that all of these areas of future work are valuable and **recommends** that they should be pursued if possible. It looked forward to receiving new information resulting from these studies at future meetings.

10.6 Other small stocks – bowhead, right and gray whales (Annex F)

10.6.1 Small stocks of bowhead whales

10.6.1.1 DAVIS STRAIT/BAFFIN BAY AND HUDSON BAY/FOX E BASIN STOCKS OF BOWHEAD WHALES

Fisheries and Oceans Canada provided an update on these stocks. One aerial survey was performed, four satellite tags were deployed, and 48 biopsy samples were collected. The Committee appreciated the offer by Canada to provide information on the results of these studies at the next meeting.

The Committee was not advised of any bycatch or intentional removals from either bowhead whale stock.

Greenland Institute of Natural Resources reported to the Committee that about 10 bowhead whales out of a pod of about 30 were killed by a large, uncounted pod of killer whales near Qeqertarsuaq in Disko Bay during four days in late April 2002. The Committee was grateful for this information and **requests** that the relevant authorities in Greenland provide more details on this incident to next year's Committee meeting.

10.6.1.2 OTHER STOCKS

The Committee received a report of a sightings survey performed by the All Russian Scientific Institute of Fisheries and Oceanography, in the Sea of Okhotsk in September and October 2001. A total of 48 bowhead whales were reported out of 1,065 cetaceans. Unfortunately, it was noted that poor weather conditions precluded an adequate survey of the Shelikhova Gulf and coastal areas near western Kamchatka.

10.6.2 North Atlantic right whales

Clapham reported on progress regarding recommendations from past IWC meetings and workshops concerning North Atlantic right whales (Annex F, Appendix 6).

Rosenbaum described ongoing work to compare historic specimens from the eastern North Atlantic (from the Bay of Biscay to Iceland) with genetic variation (historical and extant) in the western North Atlantic population. It is hoped that this work can be expanded to include eastern North Atlantic right whale specimens that are currently housed at European institutions. The Committee **recommends** that European institutions holding North Atlantic right whale specimens grant access to these samples for genetic analysis.

Biopsy sampling continues in the modern population, with some samples obtained from the calving grounds in the southeastern USA in 2002.

Two seasons of aerial photogrammetry work in the Bay of Fundy have been conducted by the US National Marine Fisheries Service, and have yielded a large sample of data on length of identified individual right whales; these data will be tied to information on sex, age and reproductive condition as obtained from sighting histories. An extensive study of the reproductive biology of this population has also been conducted in the last year.

Studies of previously satellite-tagged right whales have shown no apparent impact of the tags on these animals; observations of these individuals will continue over the next few years.

Right whales continue to die or become seriously injured by entanglements in fishing gear or ship collisions, and, in accord with the Committee's recommendations, this remains the highest priority in the US government's management of this species. Areas which are characterised by predictable concentrations of feeding right whales have been subject to seasonal area closures to fishing gear; other areas, in which right whales occur less predictably, are closed if sightings exceed a trigger density. Aerial surveys continue to be flown regularly in major shipping areas to warn mariners of the presence of right whales.

In recent years, (e.g. IWC, 2001c, p.34) the Committee has expressed grave concern over the status of this population. In particular it has noted that it is **a matter of absolute urgency** that every effort be made to reduce anthropogenic mortality in the population to zero. The Committee **reiterates** this recommendation.

10.6.3 Southern Hemisphere right whales

SC/54/BRG8 presented evidence of a summer right whale feeding ground on the west coast of South Africa. The current understanding of right whale seasonality on the South African coast is that it is normally distributed with a peak in September/October, and very low numbers over the period January-April. Most of the data in support of this come from the south coast of South Africa, between Cape Town and Port Elizabeth. However, when pelagic whalers from the USA and France first arrived on the South African coast in the late 18th century, they operated mainly between the months of November and May i.e. completely outside the currently 'understood' season. These vessels operated on the west coast, however, north of Cape Town, centred round St Helena Bay. Recent incidental observations in the St Helena Bay region resulted in 26 sightings of 54 right whales between February and April i.e. in summer. Four cow-calf pairs seen had been photo-identified about four months earlier on the south coast, and so had moved onto the west coast in summer. A total of 21 right whales were

satellite-tagged on the South African coast in September 2001. The results from this experiment will be reported fully next year. Such a summer feeding ground in coastal waters has not been recorded previously in the Southern Hemisphere, and provides unique opportunities for a study of southern right whale feeding behaviour.

SC/54/O18 described sightings of 22 southern right whales in Antarctic waters. Rosenbaum *et al.* (2001) described two sightings of right whales off the east coast of Madagascar. The Committee recognised the potential importance of these areas off Madagascar for the small population of southern right whales, and **strongly encourages** that these investigations continue.

10.6.4 Other small stocks of right whales

The Committee received only two reports of North Pacific right whale sightings over the past year: five animals seen in the southeastern Bering Sea from US aerial surveys; and three animals in the western North Pacific during JARPN II surveys.

The Committee recognises that these are among the world's most little known and critically endangered populations of whales. It **strongly recommends** that every effort be made to gather information about their status, and to take whatever measures are necessary to assist their recovery.

10.6.5 Western North Pacific stock of gray whales

The western gray whale population exists in small (<100) numbers and is considered to be one of the world's most endangered populations of large whales (Weller *et al.*, 2002). Since 1995, joint USA-Russian ongoing studies of western gray whales off northeastern Sakhalin Island, Russia (the 'Piltun Feeding Ground') have resulted in a photographic dataset that can be used for mark-recapture survival estimation. In SC/54/BRG9, non-calf and calf survival were estimated as 0.941 (SE = 0.0194, 95% CI = 0.890-0.970) and 0.389 (SE = 0.1255, 95% CI = 0.185-0.642), respectively. Such estimates are essential for assessing the status of this population and determining appropriate protection and management measures.

A skeleton of a young gray whale was discovered on the eastern coast of Kyushu (Miyazaki Prefecture) in March 2002. This could be one of the 'missing' yearlings reported in SC/54/BRG9. The Committee **strongly recommends** that efforts be made to extract DNA from this skeleton and that microsatellites be compared to all 'missing' yearlings from the Piltun feeding ground. It also **recommends** that details of the stranding of the Miyazaki specimen be presented to the Committee next year.

Recent photo-identification data collected on the Piltun Feeding Ground indicate that most reproductive females follow a three-year inter-birth interval (SC/54/BRG12) rather than the normal two-year interval for some other whales. This longer interval may reflect nutritional stress and might be compounded by ongoing anthropogenic disturbance while on the feeding ground (see below).

SC/54/BRG14 presented evidence of behavioural disturbance from seismic surveys on the Piltun Feeding Ground. During summer 2001, high-intensity seismic surveys were carried out over a six-week period. The whales appear to have moved away from the region where seismic surveys were conducted, reoccupying the region from which they had been displaced once the surveys ceased. This endangered population depends on the Piltun Feeding Ground for most of its annual food intake. Such disruption of

feeding could have major negative effects on individual whales and the population as a whole, especially those observed to be 'skinny'. Half of the adult females with calves have been recorded as 'skinny' over the past three years. Borodin referred the Committee to the results of a Russian sighting survey in the Sea of Okhotsk that corresponded with the post-seismic period of the SC/54/BRG14 study. Forty-one gray whales were observed off the northeast coast of Sakhalin Island.

Last year, the Committee had strongly recommended that no seismic work be conducted while whales are present on their feeding ground (IWC, 2002d, p.47). As a result of this and Resolution 2001-3 (IWC, 2002c), the Russian government was able to get the seismic work stopped last summer, and the Committee commends this action. SC/54/BRG14 provides strong empirical evidence in support of the Committee's concerns last year that seismic activities can have a major impact on gray whales (IWC, 2002f, p.182). Last year, the Committee also recommended acoustic monitoring and behavioural observations be conducted to examine noise-related disturbance of these whales; it **reiterates** that this recommendation should be implemented.

The Committee is concerned to hear that additional seismic work is planned for 2002, 2003 and the future. It again **strongly recommends** that no seismic work be conducted on or near the Piltun Feeding Ground while whales are present because: (1) gray whales in this area have shown strong avoidance responses to seismic survey activities during which they were displaced from important feeding habitat; (2) this region is the only known feeding ground for the population and is therefore critical to its continued survival; (3) 'skinny' whales, including many reproductive females with calves, have been observed in the area between 1999 and 2001 and require maximum food intake during the summer feeding season; (4) the cumulative impacts of seismic operations on the health and survival of these whales, especially 'skinny' animals, are unknown and of great concern.

During summer 2001, the oil and gas industry conducted a number of research activities related to these whales and the Committee **strongly urges** that these studies and associated findings be presented to the Scientific Committee for review at the earliest possible date. Furthermore, the Committee **recommends** that all future monitoring and mitigation plans for seismic surveys and other activities (e.g. planned construction of piers and pipelines bisecting the feeding ground and migratory corridor) related to Sakhalin oil and gas development be reviewed by an independent panel of outside experts that are not directly funded by the operators working in the area.

Two sightings surveys are scheduled within the range of the western gray whale during 2002, one along the eastern side of the Korean Peninsula in May (SC/54/RMP21) and one along the eastern coast of Sakhalin Island in August-September 2002 (SC/54/RMP9). The Committee **strongly recommends** that every effort be made to photograph any gray whales sighted during the aforementioned surveys in 2002, following protocols outlined in SC/54/BRG13.

As in previous years, the Committee **strongly recommends** that the ongoing (1995-2001) USA-Russian western gray whale research and monitoring programme, and national programmes, be continued and expanded into the future; this research is currently the only means for assessing the status of this critically endangered population. The research methods used in this programme to monitor the

population (vessel-based photo-identification work, shore-based distribution and behavioural observations, and biopsy sampling) must be continued annually. Photo-identification is an excellent way to monitor the status of this population. Genetic sampling needs to be continued in order to validate long-term individual identifications, determine sex and examine the relatedness of individuals, whilst a portion of skin from biopsy samples might be used to analyse for CYP1A induction as a biomarker to assess oil-related contamination. Additional actions are needed to ensure: (1) adequate and stable funding for the continuation of the current research and monitoring programme; (2) establishment of more effective range-wide monitoring and protection measures; (3) increased cooperation between science, industry and government.

The Committee also **recommends** the following additional research items: (1) benthic sampling and prey resource assessment (i.e. prey base evaluation) in known foraging locations and in areas outside of the feeding ground; (2) simultaneous theodolite-based behavioural observations and acoustic monitoring of industry-related noise to examine possible disturbance; (3) satellite and radio telemetry work to determine movements on the feeding ground, migration pathway(s) and location of the wintering grounds (tag design and attachment protocols, however, should first be assessed on eastern gray whales to evaluate safety and effectiveness); and (4) obtain DNA and photos to match to existing catalogues of such materials of any stranded or living animals.

As in previous years, the Committee **strongly recommends** that the Commission facilitates a workshop comprising interested scientists, including those from range states. The purpose of the workshop should be to:

- (1) assess the current status of the population;
- (2) develop the foundation for range-wide research;
- (3) update the 10-year research and monitoring programme presented to the Committee in 1999.

The Committee **strongly endorses** the proposal for such a workshop given in Annex F. Unfortunately, there was insufficient time to develop the funding requirements and include them in discussion under Item 21. The Committee therefore **strongly recommends** that at a minimum, the Commission endorses the proposed workshop and cooperates in its organisation. A Steering Group was established comprising Brownell (Chair), Borodin, Kim and Ohsumi.

Research in Chinese coastal waters is of particular importance, as this is suspected to be the location of the calving and breeding grounds. Such knowledge is critical to the survival and recovery of the population. The Committee **recommends** that ground searches in combination with local knowledge interviews be used to determine gray whale locations within the wintering grounds and that photo-identification and biopsy sampling be implemented where possible. Research protocols and methods should follow those developed during the USA-Russian programme. Comparisons of photographs and DNA collected from China and elsewhere to similar materials already catalogued from Sakhalin Island will provide important new information on the population. Ohsumi suggested the possibility of holding an international meeting to plan research on the wintering grounds.

The Committee also **recommends** continuation and further development of comparative studies between the

western and eastern gray whales to better understand the health of individual whales in both populations.

In conclusion, the Committee **strongly reiterates** (IWC, 2002d, pp.46-47) that it is a matter of **absolute urgency** that every effort be made to reduce anthropogenic mortality (including direct catches) and disturbance to zero to save western North Pacific gray whales from extinction.

10.6.6 Work plan

The work plan agreed by the sub-committee is given in Annex F. The Committee's discussion of its overall work plan is given under Item 19.

10.7 Other

10.7.1 Fin whales in the North Atlantic

The Committee received a standard line transect analysis of the Icelandic and Faroese vessel data from the NASS-2001 survey (SC/54/O9). An estimate of 25,352 (CV = 0.13) fin whales was calculated for the survey area. The CV is considered to be under-representative due to possible movement of animals over the survey period and irregularities in the realised effort. The sightings rate was generally higher than in earlier NASS surveys (1995, 1989 and 1987) and sightings were more evenly distributed, particularly in the Iceland-Greenland area. The 2001 estimate does not include areas farther to the south, as was covered in 1989. The estimates for comparable areas have been steadily increasing at a rate that is by an order of magnitude higher than expected due to the cessation of whaling in the area. Methodological improvements are considered unlikely to explain the whole difference. Immigration from stocks recovering elsewhere in the North Atlantic is suggested among other things that need further consideration.

The Committee did not have time to discuss this paper in detail.

10.7.2 Sperm whales

10.7.2.1 NORTH ATLANTIC

A novel protocol used to estimate sperm whale abundance from the NASS 2001 survey was presented (SC/54/O8). Sperm whales were tracked to determine the point of deep dive (fluking). Deep dives recorded before the animal was expected to come abeam of the vessel were used for a cue count estimate, while the animals on the surface abeam gave a traditional line transect estimate of the number of animals on the surface at any one moment and thus needs to be scaled up by dividing by the average proportion of time on the surface. The total weighted average estimate for the whole area was 9,477 (CV = 0.34). The corrected line transect surface estimate was significantly higher than the cue count estimate and is 1.41 times higher than a conventional uncorrected line transect estimate.

The Committee commended the authors of this paper for attempting to estimate $g(0)$ for sperm whales but regretted there was insufficient time to explore this method in detail.

10.7.2.2 WORLDWIDE

A global review of sperm whale estimates and a historical abundance trajectory for sperm whales worldwide was presented (SC/54/O6). Published population estimates were obtained from the literature, and a correction factor of $g(0) = 0.87$ was applied for animals missed on the trackline.

Scaling to habitat areas was used to produce a global estimate and a population model was used to estimate pre-whaling numbers and the status of the population in 1880 and 1999.

The Committee discussed several assumptions used by the author that may not be globally valid. These included: $g(0) = 0.87$; maximum rate of increase = 1.1% (range 0.7% to 1.5%); habitat definitions for extrapolating density estimates to unsurveyed areas; inadequately addressing uncertainties about 20th century catches by the Soviet Union. Since catches usually preferentially targeted males, a sex-specific model was suggested.

Given the uncertainties identified for this analysis, the Committee **agreed** that substantial further development is required before estimates using such an approach can be considered reliable.

Given that commercial sperm whaling ceased 14 years ago, the Committee **endorses** the idea of planning for an in-depth assessment of sperm whales. It **agreed** that it would be possible to get the available information organised and reviewed in the next few years and so conduct the assessment some time after that. A Steering Group, convened by Smith, was established and will include Best, Childerhouse, Gunnlaugsson, Leaper, Reeves, Rogan and Tynan. Scientists who do not normally attend Committee meetings will also be needed, including Barlow, Dawson and Whitehead. Subject to discussions under Item 19, the Committee **agreed** that planning for an assessment should start in 2003.

10.7.3 Status of abundance estimates

To help clarify the different statuses of the many and various estimates of abundance considered by the Committee (e.g. acceptable for RMP, acceptable for use in RMP trials, acceptable for inclusion on the IWC website, noted without any detailed review, etc.), the Committee requests that Donovan prepares a proposal for consideration at next year's meeting, suggesting categories that could be used to classify abundance estimates submitted to the Committee.

11. STOCK DEFINITION (ANNEX I)

11.1 Further review of terminology

Unit-to-serve

This year, the Committee has had extensive general discussions about RMP *Implementations* and *Implementation Reviews* (see Item 6.2). These discussions were prompted by the unanticipated and prodigious duration of the North Pacific common minke whale *Implementation* process, but have general relevance. One of the conclusions was that a lack of clarity over the unit-to-serve has been partly responsible for the difficulties and delays. This is particularly significant for the North Pacific case because of the operational objective of maintaining a coastal fishery on a more-widespread population, but unit-to-serve is an extremely important issue elsewhere too: not just for RMP, but also for AWMP, and for management of mortalities of other cetaceans and other species whether inside or outside the IWC. This year, the Stock Definition Working Group was asked to develop a list of potential definitions of 'unit-to-serve', and to clarify the implications that different choices would have for management.

The Commission has agreed management objectives for commercial whaling: avoidance of risk of undue depletion of

stocks, and making possible stable high yields¹². However, there is no consensus within or outside the Committee on the meaning of the word 'stock'¹³, and the Committee **agreed** that further attempts at 'stock definition' are not likely to be very useful.

Defining 'unit-to-serve' is a different task than defining 'stock'. It is also, perhaps, more useful, since it is more directly linked to management. Of course, many of the detailed issues are the same, but the change of emphasis is significant because it clarifies the need to think not just about biology, but also about explicit operational issues in the context of management. There is more room for case-by-case flexibility than with definitions of stock, and there is no need to try to develop a single all-embracing formulation. When considering possible options for unit-to-serve and what the implications of each option would be for management, it is not the remit of the Committee to propose a single option; instead, the Committee can develop a list of possible options and associated comments, for consideration by the Commission. These shifts in emphasis may help the Committee to provide something of greater value to management. It was agreed that the Stock Definition Working Group should henceforth direct its attention towards 'unit-to-serve' rather than 'stock', but that the Group should nevertheless retain its old name for pragmatic reasons.

There was no opportunity to have a full discussion of unit-to-serve during this meeting, although preliminary discussions ranged over a number of points (see Annex I). As a way of making progress on this issue, the Committee encourages the submission of papers for next year's meeting on unit-to-serve in the context of RMP-based management. Specifically, any paper proposing definitions of unit-to-serve, should discuss (1) how and whether it is possible to implement the RMP in such a way as to get both satisfactory yields and satisfactory protection at the level of that unit-to-serve; and (2) under what harvesting scenarios (i.e. the general aspects of when and where whaling is proposed) this would be possible. Discussion should be in terms of the two main 'adjustable' components of RMP-based management. The first of these is how the overall catch is to be spread out in space and time (*Small Areas* etc., and also the harvesting scenario). The second concerns what data are available or required on abundance, distribution, stock structure and movement¹⁴. Papers proposing definitions should include examples to demonstrate relevance to some plausible whale population structure and harvesting scenario. More detailed notes and suggestions for authors are given in Annex I.

¹² The exact words, as given in IWC (1988, p.36), are:

(a) stability of catch limits, which would be desirable for the orderly development of the whaling industry; acceptable risk that a stock not be depleted (at a certain level of probability) below some chosen level (e.g. some fraction of its carrying capacity), so that the risk of extinction of the stock is not seriously increased by exploitation; making possible the highest continuing yield from the stock.

¹³ At least when 'stock' is used on its own; there is more consensus over combined terms such as 'breeding stock'.

¹⁴ The *Catch Limit Algorithm* only uses information on total abundance (and catch history). However, each specific Implementation of the RMP requires information on population structure. Further, the allocation of catches in space and time may make use of other information besides total abundance.

The Committee noted that the choice of unit-to-serve, the harvesting scenario, and the quality of available information can all affect how easy it is to arrive at an RMP Implementation that delivers effective conservation and stable high yields.

Of course, this should not be interpreted as implying that ease of implementation and compatibility with harvesting should be the sole, or even the primary, factors that determine any future Commission decisions about the appropriate unit-to-serve in particular cases. Ultimately, though, choices about conservation and harvesting do need to take account of practicality, and the task of the Committee is to spell out as clearly as possible what the implications of different choices would be.

Archetypes

This year, the sub-committee on the RMP also recommended drawing up a list of archetypes for consideration in Implementations (see item 6.2.2 of Annex D). The point of this is to provide a checklist of conceptual models of what whales do, so that when considering a new population, the Committee will be obliged to give some (possibly very brief) consideration of the plausibility of the various different stock structures that are known to exist for other species and populations. It is important to include real examples (preferably cetacean) in discussions about unit-to-serve, both to ensure that any list of options for unit-to-serve is somehow related to the real world, and also to start the task of drawing up a list of archetypes.

Summary

The Committee emphasised that time for discussion on all aspects of 'stock definition' had been very limited this year, that the issues involved were complex, and that discussions so far were inevitably of a preliminary nature. These issues will need to be revisited in depth next year.

11.2 Review of historical responses of cetacean sub-stocks to severe depletion

In 2000, the Committee reviewed instances of (sub)stocks of large baleen whales that had been severely depleted, and had either been extirpated or had failed to recover after intense harvesting stopped (Clapham and Hatch, 2000). That review highlighted several important factors: (1) abundances had been reduced to no more than a few hundred animals; (2) in most cases, neighbouring (sub)stocks had also undergone heavy harvesting; and (3) in some cases, low-level human-induced mortality had continued after the end of the main harvest. The Committee had noted that it would also be useful to review instances where heavily depleted (sub)stocks *had* subsequently recovered.

As a starting point for identifying cases that might be informative, Smith summarised the information on 44 baleen whale stocks given in Best (1993). Many of those stocks were thought to have been reduced to below 10% of their original abundance. Of those 44 stocks, significant rates of increase had been demonstrated for 10, and at least 10 others were believed to be increasing. It was noted, though, that if the 1993 study was repeated today, the stocks chosen might be different, because of new information on stock structure.

The Committee recognised that it is by no means straightforward to interpret, or in some cases even to identify, instances of recovery from severe depletion, especially in the context of population structure. Lack of abundance data, and complications over the depletion of and immigration from neighbouring aggregations, were singled

out as particular difficulties. It was also pointed out that, in some cases where recoveries are observed, the local recovery rate may be a positively biased indicator of population recovery rates if increases in local abundance are driven more by social attraction/migration from other areas, than by intrinsic population growth.

The Committee noted that recovery and genetic analysis of bones and other material from historic whaling areas and prospective studies of slowly recovering stocks, might provide improved information on historical distribution, population structure and range. It **strongly encourages** the continuation of this work. A prospective approach could also be informative in areas with extreme variation in recovery; samples collected now could be useful for comparisons to future samples on decadal or generational time periods. Initial proposals for species and areas are presented in Annex I, Appendix 2.

11.3 Statistical and genetic issues pertaining to stock definition

SC/54/SD3 noted wide variations in life history and population structure between baleen whales, and cautioned against drawing general conclusions about the stock structure of all baleen whales based on the structure of one particular species in one region. The authors suggested that evidence of slight genetic heterogeneity based on very limited data does not provide a sound basis for concluding that more than one stock must exist in a region, for instance in the case of the putative O-W stocks of North Pacific minke whales. Differences between humpback whales and North Pacific minke whales were highlighted. For example, humpback whale calves appear to learn their migration patterns from their mother during the long lactation periods, whereas minke whales have a much shorter lactation period and in the North Pacific, the young-of-the-year are weaned before reaching the feeding grounds. The Committee **agreed** that data from both feeding and breeding grounds are needed to understand stock structure, migratory behaviour and site fidelity in North Pacific minke whales. It is important to consider how best to collect data to answer basic questions, such as how juveniles learn their adult feeding grounds. It was noted that various types of information (genetic data, biological markers and tagging) could shed light on this, and that genetic data could feasibly be obtained from breeding grounds in the near future.

SC/54/SD4 proposed methods for estimating dispersion or mixing rates from genetic data on kinship between pairs of animals. The author suggested ways to compensate for family fidelity, uncertainties arising from the nature of genetic data, uneven spatial sampling and differing dispersion rates by sex. Unlike some other genetic analyses, no assumptions about long-term history are required. The approach might be applicable to the determination of appropriate scales for management units. The Committee **encouraged** further development of this promising approach. Simulation testing will be required, particularly to investigate its applicability to more complex population structures. The advent of new genetic methods to obtain many loci from few individuals might prove useful for pedigree-based analyses such as in SC/54/SD4. Population genetics modelling for multi-locus genotyping is a rapidly developing area of current research, and the Committee **agreed** to seek participation of additional experts in this field to progress its work.

Cui *et al.* (2002) outlines a Bayesian approach for comparing single with multiple stock hypotheses. Bayesian methods should be preferable to classical methods for

hypothesis testing. One variant of the approach performs well in simulations where two stocks differ substantially in haplotype frequency, and/or when sample sizes are large. Answers inevitably depend on the priors chosen, and with the current version it is difficult to assess whether a given prior is biologically reasonable. The Committee **encourages** the authors in their ongoing work to address this.

The method in Cui *et al.* (2002) requires an *a priori* choice of postulated boundary between stocks; if there is real stock structure but the *a priori* choice is inappropriate, the power of the method, and of classical hypothesis tests, will be reduced. By contrast, the Boundary Rank (BR) method (see Martien and Taylor, 2001; Cui *et al.*, 2002; SC/54/SD5 and discussion in SC/54/Rep1) uses the data to propose a number of possible stock boundaries. A permutation test has now been developed to allow the use of BR for a general hypothesis test of one versus two or more stocks (although not of the particular boundary selected), without relying on a particular *a priori* boundary. The boundaries suggested by BR, and the power of the statistical test, will still depend on the basic population structure assumptions (i.e. what is the maximum number of stocks and what patterns of movement are realistic), and to a lesser extent on how samples are initially grouped; some grouping is necessary in order to keep sample sizes high enough to adequately characterise gene frequencies. Tests for North Pacific minke whale data resulted in the rejection of a single stock hypothesis at a 5% significance level for two out of six different population structure assumptions. However, the power of the tests was shown to be low, because of limited information content.

Based on the new work presented and on discussions held during this year's meeting, the Committee **endorses** the value of BR for use in *RMP Implementations* and *Implementation Reviews*, and **encourages** further development of the method. Some members noted, though, that there had been limited time available for in-depth consideration, and that the discussion had proceeded very rapidly, particularly given the language difficulties.

The Committee noted that it is of considerable importance to make a determination on the applicability of BR in a timely fashion, because of issues arising in the North Pacific minke whale Implementation. If, after further consideration, any specific concerns do arise, then the Committee **urges** that they be promptly communicated to the BR developers so that they can be addressed intersessionally.

Hypothesis tests are another tool often used to investigate issues of stock structure. The Committee **reiterates** its concerns about the value of conclusions based solely on the results of hypothesis tests, expressed in IWC (2001f, p.236). In brief: it is often not clear *a priori* what hypotheses should be tested; multiple hypothesis tests are a poor way of doing exploratory data analysis; stock definition analyses should begin with exploratory data analysis and proceed, where possible, to estimation (e.g. of dispersal rates between areas) rather than to hypothesis testing.

In summary, the Committee noted that it is important, in any application of stock structure methods, to examine the sensitivity of conclusions to different *a priori* decisions about the definition of initial units, and about which population structure hypotheses to examine.

on how well the management units defined by a technique would meet specific objectives if they were to be managed under (for example) the RMP or AWMP. The paper also discussed the use of formal decision analyses in which specific costs are assigned to different stock structure scenarios and different types of stock definition errors. For instance, the errors of defining too few or too many stocks can be assigned equal cost or, if a precautionary approach is taken, a higher cost can be assigned to the definition of too few stocks. These different cost structures can have a substantial impact on the relative performances of different methods.

The Committee noted the useful points identified in SC/54/SD6. The process of spatial structure simulation (i.e. testing different techniques for identifying spatial stock structure, and for translating results into management units), is a crucial step in validating the applicability of current and future methods for analysing population structure. An intersessional Working Group on the Testing of Spatial Structure Models (TOSSM) had been established last year to progress this issue, but pressure of work had prevented any substantive progress in the intervening period.

The Committee reaffirmed the importance of the simulation work, and decided to continue TOSSM under the Terms of Reference agreed last year (IWC, 2002k, p.412). Further consideration in TOSSM will be required to devise appropriate performance criteria. Substantial efforts will also be required to develop the operating model that governs the 'real' population structure and the 'real' management rule; it is important to strike an appropriate balance between 'too much realism' (excessive complexity, and problems in extrapolating conclusions to other situations) and 'too much simplicity' (conclusions irrelevant to practical management situations in the IWC).

Setting up extensive simulation trials is complex, and the Committee **agreed** that an intersessional workshop is essential in order to make reasonable progress on spatial structure simulation. Apart from those interested in actually developing methods, this meeting would ideally require two other types of participant: first, one or more Scientific Committee members with extensive experience in setting up large simulation trials, particularly in an RMP or AWMP context; and second, experts from outside the usual IWC circles who can provide input on appropriate genetic, statistical and ecological considerations to be used in developing the simulations. Further details on the proposed workshop can be found in Annex I, Appendix 3.

There is significant divergence between the terminology of the IWC and of other scientific arenas, e.g. conservation biology. To avoid confusion among workshop participants and authors of papers, especially those outside IWC circles, a glossary of terms relevant to the management framework of the RMP and AWMP should be developed for distribution, along the lines of the glossary that already exists for the AWMP. The new glossary should include some indication of what harvesting scenarios are likely to be contemplated. Donovan agreed to do this in conjunction with Hammond.

11.4 Simulation testing

SC/54/SD6 discussed some issues to address when designing performance tests of methods for analysing population structure. Performance criteria should be based

11.5 Work plan

The Committee has already given attention to the issue of archetypes of population structure (IWC, 2001f, p.236), and expects to be able to develop at least a preliminary list during next year's meeting.

The Working Group's proposed work plan is given in Annex I and the Committee's discussion of its overall work plan is given under Item 19.

12. ENVIRONMENTAL CONCERNS (ANNEX J)

12.1 Cooperative research in the Antarctic

12.1.1 Results from SOWER 2000 cruise (cooperation with CCAMLR)

There were no specific papers that pertained to results from SOWER 2000. However, SC/54/IA7 was discussed since it highlighted the importance of management information being tailored to the regional specificity of the Antarctic climate (e.g. the observed trends of warming and loss of ice are greatest in the Bellingshausen Sea, Amundsen Sea and part of the Ross Sea).

The Committee **agreed** that the Ecosystem Working Group of CCAMLR should be approached concerning further collaborative support of the GLOBEC cruises and data previously collected by CCAMLR in the parts of the GLOBEC study region held in the CCAMLR database. DeMaster **agreed** to coordinate this.

12.1.2 Progress on development of joint research programme with SO-GLOBEC

In 2001, a multi-year series of collaborative research cruises began with Southern Ocean GLOBEC (SO-GLOBEC). The US SO-GLOBEC cruises are multidisciplinary and comprise standard mooring cruises, line transect surveys over a constant grid, and process studies at selected locations, all within the Western Antarctic Peninsula study region around Marguerite Bay. A preliminary report on the first three cruises in this series was provided last year (Thiele *et al.*, 2001). SC/54/E12 presented preliminary results from the IWC collaborative studies conducted on the 2001 winter survey and the 2002 late summer mooring cruise with the US SO-GLOBEC programme. It provided a summary of research and preliminary results for the cetacean visual, biopsy and sonobuoy studies conducted on the two cruises since the last report (Thiele *et al.*, 2001). Results from the ARP (acoustic recording package) year-long deployments were reported in SC/54/O3. The full colour version of SC/54/E12 and reports of all the IWC SO-GLOBEC collaborative cruises can be found at: http://www.ccpo.odu.edu:80/Research/globec/iwc_collab/menu.html

The *Nathaniel B Palmer* (NBP) (US SO-GLOBEC) survey cruise was conducted 23 July to 1 September 2001 and the *Laurence M Gould* (LMG) mooring cruise was repeated in February 2002. Sea-ice cover was significantly more extensive earlier in the season in 2002. Only minke whales were observed in the study region in winter 2001, although humpback whale concentrations were seen as late as the end of May. Concentrations of humpback whales were seen in Marguerite Bay and east of Adelaide Island up until late May in 2001, and at the ice edge in southern Marguerite Bay and the passages to the north in February 2002. Although geographic locations of humpback concentrations are different between years, habitat remained consistent. Baleen whale calls detected on sonobuoys included blue, minke and possible fin whales. Autumn and winter multidisciplinary research cruises conducted last year under this programme will be repeated this year, and will include both passive acoustic and IWC visual/biopsy teams. Currently, there are IWC visual, biopsy and collaborating sonobuoy teams on the US SO-GLOBEC LMG and NBP cruises (April-May 2002).

In September/October 2002 a small workshop will take place in the USA to assist with data integration analyses prior to the second International GLOBEC Open Science Meeting in China in October. Final submissions for a special issue of *Deep Sea Research* are due in November. Proposals from the group will be submitted to the NSF for funding under the synthesis and analysis phase of US SO-GLOBEC (2002/2004).

Regarding future plans for collaborative work between SO-GLOBEC, CCAMLR and the IWC, the following activity was endorsed by the SWG on Environmental Concerns (Annex J): one dedicated multidisciplinary survey per season for at least the next five years consisting of visual survey, biopsy sampling and fine scale ecological studies, including passive acoustics work. It was noted that a contribution of £25,000 per year would be a minimum amount of support to continue the partnership of the IWC with SO-GLOBEC and CCAMLR. This request for support is considered under Item 21.

Committee members from Japan expressed their reservation regarding the competence of the IWC in a programme such as SO-GLOBEC.

Finally, the SWG on Environmental Concerns recognised the need for the development of a standardised data collection protocol for sea-ice observations. An *ad hoc* Working Group chaired by Thiele was established which will report back to the Committee next year concerning progress related to the process described in Annex J, Appendix 3.

12.2 Steering Group report on POLLUTION 2000+

Details of POLLUTION 2000+ research completed in the last 12 months are summarised in Annex J, Appendix 4. Activities conducted under the bottlenose dolphin sub-project of POLLUTION 2000+, which seeks to evaluate potential biomarkers of exposure to organochlorine contaminants, included: (1) analyses of samples collected in Sarasota Bay, Florida; and (2) comparison of PCB-concentrations in blubber samples from the three study sites (the Bahamas Islands and Charlotte Harbor, Florida, representing sites with 'low' pollution, and Sarasota Bay, a site with 'moderate' pollution). The sub-project also included a feasibility study to collect biopsy samples from the Mediterranean, where dolphins are likely to carry high levels of polychlorinated biphenyls (PCBs).

The second sub-project involves the calibration of post-mortem time effect on changes of biomarkers and pollutants in harbour porpoises. This analysis will enable the utilisation of bycaught animals throughout the North Atlantic. In the summer of 2001, samples were collected in the Bay of Fundy for this purpose. Most of the samples were collected using the detailed field protocol previously designed, and the successful collection of these critical samples was very much due to the work of Read and colleagues.

In addition to completion of analyses currently in progress, the 2002-2003 work plan for POLLUTION 2000+ will include an intersessional meeting to synthesise results among the laboratories involved, and an intersessional meeting of the Steering Group to finalise Phase 1 of this programme and to determine activities to be conducted under Phase 2. Within this work plan, the highest priority projects are the collection of samples and PCB analyses under the bottlenose dolphin sub-project, and completion of the harbour porpoise post-mortem calibration project. The budget to complete the entire 2002-2003 work plan will require £140,500, of which the majority will be sought

through external direct or 'inkind' funding. To complete the highest priority projects mentioned above, a request for £54,410 from the IWC was proposed. The Committee agreed to consider this request for support under Item 21.

Phase 1 of POLLUTION 2000+ is approximately 80% complete. Finalising the harbour porpoise post-mortem calibration sub-project and the bottlenose dolphin sub-project was considered to be of high importance to many Committee members. The value of the results from the completion of the post-mortem calibration sub-project include: (1) ability to improve the utilisation of existing stranding data; and (2) enhanced value of information from stranded and bycaught animals to the field of ecotoxicology. The value of the results from the bottlenose dolphin sub-project include: (1) reporting on the health consequences of a wide range of pollution levels on bottlenose dolphin; and (2) contributing to the establishment of cause and effect relationships between levels of pollutants and physiological responses in cetaceans. Finally, many members believed that the completion of POLLUTION 2000+ will lead to the development of a valuable model concept for ecotoxicological research on cetaceans and other animal species.

Committee members from Japan expressed concern that this project is not consistent with the objectives of the IWC since the species dealt with by the current POLLUTION 2000+ are limited to small cetaceans. It was noted that since its inception, it was **agreed** to initially concentrate on these species and areas for which it was most likely to obtain successful results. The ultimate aim is to provide a predictive model that, with caution, can be applied to all cetacean species (Reijnders *et al.*, 1999).

12.3 Habitat related issues

12.3.1 State of Cetacean Environment Report (SOCER)

During the intersessional period, a Steering Group from the SWG on Environmental Concerns was charged with making recommendations for the development of a mechanism for the compilation, review process, style, structure and frequency of this type of report. The Steering Group had considered a wide range of proposals for the future style and content of SOCER, and these were presented and discussed within the SWG. The proposal recommended by the Steering Group and endorsed by the SWG involved taking a regional approach for each annual report (i.e. the six regions used in the original form of SOCER (Mediterranean and Black Seas, Indian, Pacific, Arctic, Southern and Atlantic Oceans) along with a seventh 'global' category). Each region would be covered on a rolling basis every 3-5 years, with scope for the inclusion of significant events on a global scale, or repeat events from particular regions to be updated on an annual basis. This would ensure the timely receipt of recent significant 'events' from any region, and those occurring on a global scale, for the consideration of the Commission.

A clear set of criteria identifying an appropriate scale and scope for material for SOCER and a submission procedure that is easy to follow were developed by the SWG (Annex J, Appendix 5). The aim of implementing such a process is to encourage submissions to SOCER from a wide range of sources, including member governments, individual scientists and a range of agencies and organisations. The Committee recognised that invitations to make submissions to the SOCER need to cover a broad scale of sources and it extended its appreciation to the SWG for agreeing to develop a covering letter to facilitate this.

Finally, it was noted that a Working Group within the SWG would aim to produce a draft SOCER for next year's meeting. This report would be distributed as a Committee document in the spring of 2003. It is intended to be a preliminary attempt at a form of the report that will be developed over the years into an objective product and an easily followed submission process. Productive comments and suggestions on the draft SOCER will be welcomed and incorporated wherever possible.

Some members of the Scientific Committee recommended that the SOCER should be: (1) consistent with the competence of the IWC; (2) conducted in an objective manner; (3) cost-effective; and (4) reviewed by the SWG before sending to the Committee for finalisation. It was further recommended that the usefulness of the SOCER and the efficiency of how it is prepared should be evaluated by the SWG and the Committee. After some discussion, the Committee accepted all of these recommendations.

12.3.2 Review results from workshop on habitat degradation

At the first meeting of the parties to ACCOBAMS (The Agreement for the Conservation of Cetaceans of the Black and Mediterranean Seas), the importance of developing work on habitat degradation in the region was recognised. The Meeting of Parties had established a list of priorities for the next three years and this included the Habitat Degradation Workshop proposed by the IWC. The issue of funding for the IWC workshop has yet to be resolved, but there is still considerable interest, and it is hoped that funding from outside sources might be found to at least contribute towards the meeting.

Some Committee members noted that this workshop had been proposed and given priority in the budget for some years now (e.g. IWC, 2002d, p.73). It was agreed that the workshop was still a priority for the Committee, and although it appears unlikely that funds can be allocated this year, it is hoped that this proposal would receive high priority for funding next year.

12.3.3 Review information regarding whalewatching activities and noise impacts

A summary of this discussion is reported in Annex L and under Item 14.2.

12.3.4 Interactions between cetaceans and fisheries

IWC Resolution 2001-9 encouraged the Scientific Committee to plan and convene a methodological/scientific workshop to examine interactions between whales and fish stocks. To this end, a Steering Group (Northridge, Walløe, Tamura, Friday and Donovan) was established to organise such a workshop to be held intersessionally. The Government of St Lucia generously offered to host the Workshop (IWC, 2002d, pp.55-6).

As noted in a circular to the Committee in November, it was not possible for a sufficient number of the experts identified by the Steering Group to attend in February and the new dates were narrowed to the period mid-late June. The precise new dates were agreed by the Steering Group in December. In April, the Government of St Lucia informed the Secretariat that it was unable to host the meeting. A request was then sent out to Contracting Governments to find an alternative venue at this late stage. The only reply received was the offer from the USA to host the meeting in La Jolla, which was thus gratefully accepted for the dates agreed by the Steering Group.

The agenda for the meeting is provided in Annex J, Appendix 6. The meeting has been planned to include an introductory overview on the modelling approaches currently being used to address related issues, followed by a discussion on aspects of data availability and reliability. Specialists have been invited to present their modelling work covering a range of approaches (e.g. food web models, mass balance models and minimum realistic models). The workshop will determine how best these approaches can be taken forward by the Committee. The report of the workshop will be available at next year's meeting. The £10,000 funding allocated last year is still available and thus the Steering Group has not requested additional funding to support the workshop. However, several members noted that one of the advantages of a venue in St Lucia was to encourage the participation of scientists from developing countries. The Committee **draws this to the attention** of the Commission this year so that it can consider providing additional funding to support travel of scientists from developing countries to the specialist workshop in La Jolla.

During the plenary session discussion of this item, Komatsu noted that the proposed changes in venue and timing for the workshop were problematic. He expressed the view that the workshop should be held in either Japan or Norway since these countries have large amounts of relevant data. Further, he noted that the proposed dates conflict with other obligations for Japanese scientists. He concluded that these matters should be decided by the Commission since the original decision was made by the Commission.

The Chair responded that this was a short specialist workshop, primarily intended to address methodological modelling concerns. Therefore, hosting the workshop where there are considerable data holdings is not important to the success of the workshop. She also noted that the change in dates had been approved by the workshop's Steering Group in December. The IWC Secretariat had been forced to request an alternative venue as late as 22 April and the only response received was from La Jolla (California, USA).

During review of the report, Smith, who had been absent during plenary discussions of this item, queried if Komatsu's comments above meant that Japanese scientists would not be allowed to participate in the meeting.

He expressed his disappointment at Komatsu's response that they would not participate. He also expressed his disappointment that one reason given was that the dates were not acceptable, even though Tamura had represented Japan in the Steering Group that agreed those dates as long ago as November 2002. Smith noted his appreciation of Walløe's statement that even though these dates were not ideal for Norwegian scientists, they planned to participate nonetheless. He then expressed his regret that Japanese scientists would not be allowed to participate, because in his view the workshop had been set up to address issues arising out of discussion of JARPN research whaling. Japan's withdrawal will negatively affect the work of the Committee.

12.3.5 Mitigation of incidental capture of large cetaceans in fishing gear

IWC Resolution 2001-4 requested that the Committee provide the Commission with a summary of recent work on the most feasible methods to mitigate the incidental capture

of large cetaceans in fishing gear and ways in which entangled large cetaceans may be removed from fishing gear with minimal risk to rescuers.

In response to the Resolution, an intersessional Working Group was formed. Its report is given as SC/54/BC2 and is summarised in Annex J, Appendix 7. The Committee expressed its appreciation to the Working Group, and its Chair (Clapham) for their efforts.

The report provides advice on the handling of large whale entanglements, developed from the experience of personnel involved in long-term disentanglement programmes, particularly from the east coast of the USA. Examples of entanglement rates for some species of large whale have been calculated for this region e.g. 71% of humpbacks and 62% of North Atlantic right whales had been entangled at some stage in their lives, with an annual rate of entanglement of 10-31% for humpbacks and 10-28% for right whales.

There have been few studies to quantitatively measure the survival of disentangled large whales. However, it appears that such releases may be successful in many instances. The likelihood of a successful release of an animal that has been entangled and stranded for a significant period of time is low (as it is for otherwise healthy animals that have been beachcast for long periods). Disentangling procedures for entangled southern right whale calves in South Africa appear to have been successful. In these cases the calves had been entangled for less than 24 hours, and their mothers appeared to wait offshore. The Committee **recommends** that photographs of the scarring patterns on entangled animals be recorded as a matter of course, to assist with the assessment of survival. It was also noted that small whales, such as minke whales, are more likely to die quickly if entangled in nets, while larger whales can carry off even heavy gear, which may eventually cause immobilisation, infection and/or death.

Disentanglement programmes exist in a number of regions, including Oman, South Africa, eastern Canada, Gulf of Maine and the western Mediterranean. Based on the information reported in Annex J, Appendix 7, it is clear that disentanglement is a dangerous task, with great potential for serious injury or death of persons involved. The Committee **strongly recommends** that disentanglement should only be attempted by experienced personnel. It was noted that the Center for Coastal Studies has extensive experience in disentangling large whales and has held training/advisory workshops in the past (contact David Mattila, dmattila@coastalstudies.org).

During the intersessional period, a number of Scientific Committee members with expertise in cetacean bycatch issues attended a meeting (convened by World Wildlife Fund) in Annapolis, Maryland (USA), January 2002. The objective of the meeting was to produce a strategy to eliminate unsustainable bycatches of cetaceans and, over the long term, ensure that cetacean populations are restored to, or maintained as, functional components of their ecosystems. The strategy was developed in recognition of bycatch as a major threat to whales, dolphins and porpoises and is summarised in SC/54/BC6. It was noted that a final report would be available in the near future.

Finally, the Committee recognised that many countries are currently making particular effort towards developing effective marine mammal conservation measures and many member countries and individual scientists are likely to benefit from the information contained in SC/54/BC2 and BC6. The Committee **agreed** that the authors of these reports should ensure widespread distribution of the recommendations to appropriate government agencies.

12.4 Other

The following issues are briefly discussed in Annex J (Item 8): (1) current status of the ozone layer; (2) distribution of Vitamin A (retinoids) in tissues of common dolphin; (3) effects of acoustic harassment devices on killer whales; (4) results of JARPN II feasibility study on pollutants in the western North Pacific Ocean; (5) categorisation of South African cetaceans according to the 2001 IUCN Red List; (6) effects of a major tourist development (called Nautical Steps) in Baja California, Mexico, on cetaceans; and (7) effects of seismic noise on the western North Pacific population of gray whale.

After some discussion, the Committee **recommends** that: (1) the Commission requests information from the Government of Mexico on the specific locations and types of construction that comprise the development, referred to as Nautical Steps; (2) the Commission requests that the Government of Mexico take steps to ensure the maintenance of habitat important to cetaceans; and (3) scientific experts on the western gray whale and oil and gas industry experts hold one or more workshops to identify specific potential risks to gray whales from oil and gas exploration off Sakhalin Island, and identify alternative methodologies to mitigate any potentially harmful effects.

Finally, IWC Resolution 1999-4 expressed concern over human health effects related to the consumption of cetacean products. Considerable uncertainty exists as to how the World Health Organisation (WHO) would like concentrations of contaminants in cetaceans reported. A new manual exists that provides details of the requirements for data to be submitted to the Global Environment Monitoring System (GEMS). This is summarised in SC/54/E2. Although data could be formatted manually, it would be more efficient for laboratories to automate the procedures if large quantities of data need to be submitted. Thus, if the IWC would like to have cetacean contaminant data submitted on a large scale or regular basis to the WHO/GEMS database, it should provide funds for creation of a spreadsheet or database to automatically convert chemical contaminant data for cetaceans into a format that would be acceptable for WHO.

12.5 Work plan

The work plan agreed by the SWG on Environmental Concerns is given in Annex J. The Committee's discussion of its overall work plan is given under Item 19. Funding implications are discussed under Item 21.

13. SMALL CETACEANS (ANNEX K)

13.1 Status of humpback dolphins

13.1.1 Review of information

In the past, the Committee has expressed concern regarding the status of humpback dolphins (genus *Sousa*). This concern has arisen from the existence of potentially unsustainable bycatches in fisheries, shark control nets, high levels of contaminants, and extensive habitat degradation in many areas of its range (e.g. IWC, 1999b, pp.213-214). This year the Committee examined the status of this genus throughout its range.

Humpback dolphins occur in coastal waters of the eastern Atlantic, Indian and western Pacific Oceans (see Annex K). Current knowledge regarding the distribution of this genus is

derived from sightings or stranding records. Gaps in the known distribution should be interpreted with caution, as they may represent real distribution gaps or gaps in current knowledge due to a lack of research effort.

The taxonomy of humpback dolphins is confused. Recent reports have suggested the existence of from one to five species within the genus. The classification proposed by Rice (1998) identifies three species: *S. teuszii*, *S. plumbea* and *S. chinensis* in the Atlantic, Indian and Indo-Pacific Oceans, respectively. In contrast, the IWC currently recognises only two species: *S. teuszii*, the Atlantic humpback dolphin and *S. chinensis*, the Indo-Pacific humpback dolphin (IWC, 2001k).

The Committee reviewed the results of new research on the taxonomy of *Sousa* using cranial morphometric (SC/54/SM8) and molecular (SC/54/SM34) analysis. In the analysis of skull characters, a Principal Components Analysis of skull characters revealed that specimens from west Africa were distinct from those from the western Indian Ocean, but showed strong overlap with those from the eastern Indian and western Pacific Oceans. This finding is in contrast to geographical variation in gross external morphology and colouration. Humpback dolphins from west Africa and the western Indian Ocean exhibit a prominent dorsal hump and are uniformly grey in colour, while those from the eastern Indian Ocean and western Pacific lack the dorsal hump and are light grey to white as adults, often with prominent darker spots.

A molecular analysis of geographical variation in sequences from the mitochondrial (mt) DNA control region and cytochrome *b* gene showed significant variance among groups from southeast Asia, northern Indian Ocean and the southern Indian Ocean. Preliminary phylogenetic analysis suggested three principal clades among the sampled populations of humpback dolphins: a monophyletic clade containing all humpback dolphins from the Pacific (southeast Asia); a clade containing only humpback dolphins from Oman; and a clade containing humpback dolphins from Madagascar, South Africa and a single lineage with two individuals from Oman. The results from population genetic analyses suggest that strong population structuring occurs in this genus, both within and across ocean basins.

The Committee **agreed** that it is premature to draw any firm conclusions concerning the systematics of humpback dolphins from these preliminary analyses. Therefore, it **recommends** that the current IWC classification of two species be maintained for the time being, but recognises that this classification may require future revision. The Committee also **recommends** the use of the common name 'humpback' instead of 'hump-backed' for dolphins of this genus.

There is little information on the life history of this genus and existing data come almost exclusively from South Africa and Hong Kong (SC/54/SM22; Jefferson, 2000). Gestation lasts for approximately 12 months and calves are born at lengths of between 90-115cm. In South Africa, age at sexual maturation was estimated to be approximately 10 years in females and 13-14 years in males; limited observations suggest a similar range for humpback dolphins in Hong Kong. The oldest animals aged to date were 34 years of age in Hong Kong and 46 years in South Africa. The calving interval in South Africa was estimated to be three years. Reproduction is diffusely seasonal in both areas, with a peak of births occurring during spring and summer.

There are few estimates of the abundance of humpback dolphins in any parts of their range and trend data exist at only one site, Hong Kong. The few existing estimates

derived from line transect surveys or photographic capture-recapture methods are presented in table 1 of Annex K. The Committee noted, however, that in comparison with many other small cetaceans, humpback dolphins are not very abundant in any part of their range.

Humpback dolphins are essentially coastal animals, inhabiting estuaries, river mouths and nearshore waters where mangroves, sandbars, rocky outcroppings or reefs harbour prey (Jefferson and Karczmarski, 2001). Most sightings have been made in water depths less than 25m, although the existence of populations in adjacent areas separated by deep water suggests that individual dolphins may traverse deeper waters on occasion. Data on feeding ecology are also limited, but most prey items are small estuarine or reef fish and some prey species are also commercially important.

There are few areas within the known range of humpback dolphins where anthropogenic alteration to habitat has not occurred. Humpback dolphins in Hong Kong live in a highly altered habitat, in which a 1,200-hectare airport was constructed in 1998, most of which was built on reclaimed land. In this area, therefore, habitat of humpback dolphins was both degraded and lost entirely. Unfortunately, there is no baseline data on habitat use patterns of humpback dolphins prior to construction of this airport. The Committee reviewed an analysis of humpback dolphin habitat use in Hong Kong (SC/54/SM36). The sightings data have not yet been standardised for effort, but a preliminary analysis suggests that dolphins are found most frequently near Lantau Island, in an area influenced by freshwater input from the Pearl River. Although humpback dolphins appear able to survive in the face of heavy shipping traffic, dredging, land reclamation and coastal development, the Committee noted that the continued presence of humpback dolphins in highly degraded habitats, such as the waters around Hong Kong, does not rule out adverse effects of habitat degradation. There are no long-term time series of relative abundance for this genus in any area of its range with which the effect of such environmental degradation could be measured.

With the exception of Madagascar, there is little evidence for intensive direct exploitation of humpback dolphins. In some areas, however, it is difficult to differentiate direct from incidental takes and, in other areas, directed takes are illegal and estimation of their magnitude is difficult to quantify. The Committee was particularly concerned about the magnitude and effect of directed takes of humpback dolphins in Madagascar (SC/54/SM33). Interviews and surveys at fishing camps made in 1999 in southern Madagascar revealed that humpback dolphins are hunted by harpoons and taken directly in gillnets. The magnitude of this fishery is unknown and there is insufficient information to evaluate the impact of these directed takes on affected stocks. Small numbers of humpback dolphins are also hunted in the Arabian Sea and Red Sea (SC/54/SM6). There are also recent reports of live captures of humpback dolphins from the Gulf of Thailand for the oceanarium trade, although the effects of these removals have not been evaluated.

Incidental takes have been recorded from almost all areas of the range of this genus. With the exception of some shark control programmes, there have been no observer programmes from which bycatch estimates could be generated. Consequently, it is difficult to evaluate the magnitude of this threat in most areas. Most evidence for bycatch comes from observations of strandings, interviews with fishermen and personal observations. Humpback dolphins are taken as bycatch in shark control nets in South Africa (SC/54/SM37). Current mitigation measures in this

area include the use of acoustic alarms and reduced fishing effort. Humpback dolphins are also taken in fisheries in northern Mozambique (SC/54/SM28), Madagascar (SC/54/SM34), Kenya, Oman (SC/54/O4) and Hong Kong (Jefferson, 2000). In Australia, bycatches of humpback dolphins occur in inshore gillnets in the Gulf of Carpentaria and Queensland, and in shark control nets in Queensland (Gribble *et al.*, 1998), where the response of humpback dolphins to acoustic alarms is currently being evaluated.

Studies of humpback dolphins in the Pearl River estuary in Hong Kong (SC/54/SM5) have noted high levels of organochlorine concentrations in the tissues of these animals. Half of the stranded animals examined in Hong Kong had PCB levels above which toxic effects might be expected (Jefferson, 2000), and 44% had PCB levels above which increased levels of infectious disease were reported in UK cetaceans (Jepson *et al.*, 1998). An area of particular concern is the effect of organochlorines transferred to humpback dolphin calves from their mothers' milk. A high proportion of stranded cetaceans in Hong Kong are neonatal animals and it has been suggested that this may be linked to organochlorine contamination via lactation. The Committee concluded that elevated concentrations of pollutants observed in tissues of humpback dolphins from Hong Kong indicate that pollution may pose a risk to the health of dolphins in this area and, by virtue of similar contamination in other habitats, possibly to *Sousa* populations in other regions.

13.1.2 Conclusions

Humpback dolphins are listed as *Data Deficient* by the World Conservation Union (IUCN) and are listed in Appendix 1 of the Convention on International Trade of Endangered Species (CITES) (Anon., 1979; Baillie and Groombridge, 1996). The taxonomy of humpback dolphins remains unresolved and information on this genus is fragmentary throughout almost all of its range. Humpback dolphins are long-lived, but nowhere have research programmes on these animals been in place for longer than 10 years, a small fraction of their lifespan. Baseline data on abundance, population structure, rate of increase, recruitment and mortality levels are lacking.

The primary threats to humpback dolphins are incidental mortality in fisheries, including shark control nets, habitat degradation and, in a few areas (such as Madagascar), directed catches. Levels of contaminants in tissues of humpback dolphins are very high in some areas, raising concern over the effects of these pollutants. The Committee recognised the existence of these threats, but was not able to evaluate them with current information. Therefore, the Committee **concluded** that the status of humpback dolphins is unknown, but recognises that this genus is adversely impacted by anthropogenic changes throughout its known range.

With respect to humpback dolphins, the Committee **recommends** the following:

- (1) wide collaboration among researchers to allow resolution of systematics and population structure within the genus;
- (2) expanded morphological and molecular sampling throughout the range of the genus;
- (3) representative sampling of humpback dolphins from areas in which samples have not yet been included in molecular analyses, such as Australia, India, Malaysia, Mozambique, Tanzania, the Persian Gulf, Gulf of Aden, Red Sea and West Africa;

- (4) studies over long time scales to obtain estimates of abundance, and rates of fecundity and mortality;
- (5) surveys, and photo-identification and genetic sampling in areas where the distribution of humpback dolphins is patchy, to allow for more detailed information on distribution, ranging patterns, discontinuity or population fragmentation and stock structure;
- (6) studies of the life history, behaviour and ecology of this genus, to better understand its conservation status, ecological requirements and social structure;
- (7) further quantitative studies of habitat use, and of the degradation of habitat, especially where habitat modification has occurred;
- (8) independent observer monitoring programmes to estimate incidental mortality from bycatch and to monitor the effects of mitigation measures when they have been introduced;
- (9) evaluation of the magnitude and effects of the directed fishery for humpback dolphins in Madagascar.

13.2 Progress on previous recommendations

The Committee noted IWC Resolution 2001-13, which directs it to continue to review progress on recommendations and resolutions relating to critically endangered stocks of small cetaceans on a regular basis. This year, the Committee reviewed progress on several of these stocks.

13.2.1 Status of the baiji

The baiji is the most endangered cetacean. Its range is restricted to the Yangtze River and its population size is probably only a few tens of animals (IWC, 2001i, p.275). Recent sightings have confirmed the continued existence of this species in the Yangtze River. Given its critically endangered status, the Commission has (IWC, 2001b; 2002c) requested the Government of China to report progress on the conservation of this species to the Scientific Committee on an annual basis. Unfortunately, for the second consecutive year, no new information has been received from China. The Committee expressed its extreme concern for the survival of this species in the near future and stressed the immediate need to eliminate all sources of anthropogenic mortality, including bycatch. The Committee **reiterates** its request for updated information on the status of this critically endangered species and on management efforts intended to conserve it.

13.2.2 Status of the vaquita

The Committee has followed progress on conservation efforts directed towards the highly endangered vaquita with great interest and this year reviewed three papers on this topic. Acoustic surveys of the distribution of the vaquita in the northern Gulf of California indicated that porpoises continue to inhabit a core area between Rocas Consag and San Felipe Bay (SC/54/SM17), a region of intense fishing operations. The northern Gulf of California is a Biosphere Reserve, but also an important fishing ground for shrimp (*Penaeus* spp). A study on the distribution of vaquitas and shrimp trawlers obtained during 1997 (SC/54/SM19) revealed a positive relationship between the occurrence of trawlers and the level of aggregation of vaquita. Whether this result is a direct consequence of the presence of trawlers is as yet unknown, but these findings raise concerns that such spatial aggregations of vaquita might be vulnerable to a single large mortality event.

The Committee reviewed progress on the conservation of vaquita in Mexico (SC/54/SM18). The main recent event has been the establishment of a Working Group whose mandate

is to develop a general strategy for the recovery of the vaquita. This strategy consists of four elements: conservation, socio-economic considerations, education and establishment of a legal framework. The Scientific Committee **commends** the joint efforts of WWF, CIRVA, Conservation International and the Government of Mexico for their development of this strategy, and looks forward to receiving information regarding its implementation at its next meeting.

13.2.3 Harbour porpoise

The harbour porpoise has experienced major declines in parts of its range, perhaps most notably in the Baltic Sea. Previous surveys in the Baltic have not included Polish coastal waters, where porpoise bycatches are known to occur, and where it has been suggested that an unknown but significant part of the Baltic population might occur. To address this possibility, an acoustic and visual survey for porpoises was conducted in Polish waters during August and September 2001 and the results were reported in SC/54/SM3. Only two independent porpoise detections were made, both in the extreme western part of the survey area. This study confirms that harbour porpoises do occur in the Polish sector of the Baltic Sea but only in low numbers.

At the request of the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS), the Committee then considered a draft version of the ASCOBANS recovery plan for harbour porpoises in the Baltic Sea (the 'Jastarnia Plan'). The draft recovery plan contains the following elements: (1) reduction of fishing effort in fisheries known to have high bycatch rates of porpoises; (2) changes in fishing methods from those with high bycatches to alternative gear that is less harmful; (3) compilation of standardised data on fishing effort; and (4) implementation of a pinger programme on a short-term basis.

The Committee commended ASCOBANS for a valuable draft recovery plan that provides guidance for action to conserve harbour porpoises in the Baltic Sea. It **strongly endorses** the plan and concurs with its recommendations. With respect to the implementation of a pinger programme on a short-term basis (i.e. two to three years), the Committee **recommends** the following actions.

- (1) Before introducing pingers to the Baltic environment, a simple modelling exercise should be conducted to confirm that their acoustic properties there will be similar to those in other, less brackish environments. Sound propagation measurements from a series of selected sites and water depths in the Baltic would be needed for this.
- (2) Cost-effectiveness and efficiency will be best served if pinger implementation is targeted on those areas/times considered most likely to have overlap between 'high' porpoise densities and intensive driftnet and/or bottom-set gillnet fishing (hotspots). A few of these can be identified based on available information on bycatches and fishing effort, and short-term implementation in these areas should move ahead now.
- (3) To identify other hotspots will require that the recommended compilations of data on fishing effort, the timing and location of porpoise bycatches (both historical and recent) and porpoise distribution (sightings, strandings etc.) be undertaken immediately.
- (4) As noted in the draft recovery plan, it is essential that any pinger implementation must be accompanied by an

observer programme to verify that pingers are being used properly at sea.

- (5) Despite the associated difficulties with high fishing effort and low bycatch rates, bycatch monitoring should be made an integral part of any pinger implementation programme, especially in the hotspots identified above.
- (6) The concern expressed in the draft recovery plan that pingers might exclude porpoises from large areas of critical habitat should be addressed before pinger use becomes widespread in the Baltic.
- (7) The draft recovery plan recommended that implementation of pingers be short-term and therefore any such implementation should be reconsidered within three years, with the expectation that pinger use will be replaced by longer-term mitigation measures at that time.
- (8) The requirement in the draft recovery plan for rapid development of medium- and long-term approaches to mitigation (e.g. reduced fishing effort in 'high-risk' areas, conversion to fishing gear and practices that are much less likely to result in porpoise bycatch) is crucial and should not be compromised.

In view of the critical status of harbour porpoises in the Baltic, it is important to review the progress of the recovery plan at frequent intervals and to incorporate new information. The first review should occur within three years of the implementation of the plan. On behalf of ASCOBANS, Reijnders thanked the Committee for its careful and constructive review of this plan.

In some respects, for example their small population size, the conservation status of harbour porpoises in the Baltic Sea is similar to that of the vaquita in the Gulf of California, and the Committee recalled that it had recommended against the use of pingers to reduce bycatches of vaquitas at its meeting in Grenada (IWC, 2000e, pp.242-3). Nevertheless, the Committee concluded that the two situations were indeed different and, therefore, distinct conservation approaches were called for.

The Committee also received updated estimates of harbour porpoise bycatches in Danish North Sea bottom-set gillnet fisheries from 1987-2001 (SC/54/SM31). One estimation method resulted in an estimated annual bycatch of from 2,867-7,566 harbour porpoises. A second, newer method produced estimates that ranged from 3,887-7,366 porpoises per year. Both methods suggest that bycatches have been reduced in recent years due to decreases in both effort and landings, although the new method suggests a smaller reduction. Neither estimate accounted for the use of pingers in the wreck net fishery for cod, which may have reduced the bycatch in that fishery to near zero (SC/54/SM32).

13.2.4 Survey methodology for freshwater cetaceans

At its meeting in 2000, the Committee recommended that scientists with appropriate analytical skills be directly involved in the design and implementation of surveys for freshwater cetaceans, so that these surveys might result in statistically robust estimates of abundance. This year, the Committee reviewed the results of work that had been conducted in response to this recommendation. Line-transect, strip transect and photo-identification surveys of boto and tucuxi were conducted in the Colombian Amazon involving field collaboration among quantitative analysts and field researchers. The study was carried out in

March and April, 2002 and presentation of results is expected next year. The Committee **recommends** the continued development of these techniques.

13.2.5 Bycatch mitigation

The Committee reviewed the results of a study to test whether gillnets made from high density monofilament (impregnated with iron oxide) would catch fewer harbour porpoises (SC/54/SM30). These modified nets were designed to be more detectable to an echolocating odontocete. The trial was conducted in the Danish North Sea bottom-set gillnet fishery in 2000 and recorded a 20% reduction in cod catch relative to nets made from conventional materials. Eight porpoises were caught in control nets and none were taken in high-density nets, a significant reduction in bycatch. Surprisingly, acoustic testing indicated that there were no significant differences in the acoustic target strength of modified and control nets, suggesting that the reduction in bycatch was not caused by an increase in acoustic reflectivity. Instead it is more likely that the modified nets caught fewer porpoises (and cod) because they were stiffer than conventional nets. If this is true, modification of net stiffness offers the potential for an inexpensive means of reducing bycatch. The Committee welcomed the results of this research and encouraged further developing and testing of these modified nets.

Use of pingers became mandatory in Danish North Sea wreck cod gillnet fisheries in August 2000. SC/54/SM32 outlined the results of an independent observer programme monitoring harbour porpoise bycatch in this fishery before and after implementation of pingers (1993-2001). Before the introduction of pingers, porpoises were observed taken in 19 of 873 sets, while after their introduction, no porpoises were observed in 129 sets in nets equipped with pingers. Thus, the introduction of pingers significantly reduced the bycatch rate in this fishery. The Committee welcomed these encouraging results and **recommends** continued monitoring of this fishery, including pinger use and bycatch rates.

A growing number of studies have demonstrated the ability of pingers to reduce harbour porpoise bycatch in fishing nets, but concerns remain regarding their use. The research outlined in SC/54/SM2 was conducted to investigate two of these concerns: (1) that the devices might exclude porpoises from preferred habitat; and (2) that porpoises might attempt to swim through nets where malfunctioning pingers create an acoustic window. The presence and behaviour of porpoises were monitored around a simulated net, equipped with functioning and non-functioning pingers, off the coast of western Scotland. The results of this work suggest that pingers may exclude porpoises from a larger area than was previously believed and that it is possible that porpoises may occasionally become entangled in nets with malfunctioning or missing pingers.

13.2.6 Dall's porpoises

IWC Resolution 2001-12 directed the Committee to complete a full assessment of the status of exploited Dall's porpoise stocks as soon as sufficient information becomes available. In its review of the subject last year, the Committee was unable to complete this assessment, because information on takes in the Japanese hand harpoon fishery was not made available. The hand harpoon fishery for Dall's porpoises continues, but members of the Japanese delegation did not participate in the work of the standing sub-committee on small cetaceans this year and no new information was

made available to the Committee on this topic. Therefore, the Committee was unable to complete its assessment of the status of Dall's porpoise stocks.

Komatsu noted that new information on Dall's porpoises will be made available outside IWC meetings to those requesting such information. He explained the Government of Japan's position on this matter, that the management of small cetaceans is the sovereign right of states and outside the terms of reference of the IWC. Komatsu further noted that as long as the Scientific Committee continued to involve itself in issues related to these species, the Government of Japan will not participate in the work of the sub-committee on small cetaceans or provide data on these species.

In conclusion, the Committee referred to the great value of the information provided by the Government of Japan on the status of small cetaceans in previous years; it was disappointed that members of the Japanese delegation were unable to contribute to its work on small cetaceans again this year. The Committee respectfully **requests** that the Government of Japan reconsider its position on this matter and resume the valuable contribution of Japanese scientists to its work on small cetaceans.

Komatsu responded that the Government of Japan would not change its position on this matter.

The Committee thanks the Government of the Republic of Korea for including observations of incidental takes of Dall's porpoises in its progress report (SC/54/ProgRep Korea). The Committee **reiterates** its request that the Government of the Russian Federation report bycatches of Dall's porpoises (and other small cetaceans) in its National Progress Report, together with estimates of the magnitude of bycatches in other fisheries. Borodin noted that the Russian Federation believes that matters pertaining to small cetaceans are outside the competency of the IWC.

13.2.7 Other recommendations

The Committee reviewed a monitoring project and boat-based observer scheme to investigate the takes of small cetaceans in coastal fisheries in Peru (SC/54/SM10) Three Burmeister's porpoises were taken in 10 overnight sets in artisanal bottom gillnets. In addition, evidence for a minimum of 471 small cetacean captures was documented from 1999-2001. Most striking was a continuation in the reduction of the relative proportion of dusky dolphins taken in fisheries along the central coast (Van Waerebeek, 1994). The Committee **requests** that the Government of Peru submit catch statistics of small cetaceans in their next progress report to the Commission.

Brownell informed the Committee that a permit for catch quotas of white and killer whales had been issued recently by the Russian Central Committee of Fisheries. The quotas included 1,000 white whales (for aboriginal harvest) and 10 killer whales (for live capture). In its last review of the status of white whales in 1999 (IWC, 2000e, pp.243-250), the Committee noted that some of the stocks from which these harvests were planned, particularly those in the Okhotsk Sea, were depleted or of unknown status. The Committee also recalled IWC Resolution 1998-9 which expressed concern that some directed takes of white whales may not be sustainable. As in the past (IWC, 1992; IWC, 2001i, p.278) the Committee expressed concern over such takes of small cetaceans when there is insufficient information to adequately assess the impact on the target populations. The Committee **recommends** that these planned takes of white and killer whales be preceded by an assessment of the size of affected populations and of the impact of these removals.

13.3 Takes of small cetaceans

The Committee was not able to review its table of recent catches of small cetaceans (Annex K, Appendix 2) at this year's meeting. Nevertheless, the Committee **agreed** that it is highly likely that this table would be incomplete, as it has been in previous years. The Committee recalled Resolution 1997-8, which requested member governments to provide data on the directed and incidental takes of small cetaceans. The Committee noted that the following countries have not contributed these data over the past six years and asked that the Secretariat request data on directed and incidental takes of small cetaceans from these governments, preferably on a stock-by-stock basis: Antigua & Barbuda, Chile, People's Republic of China, Costa Rica, Denmark, Grenada, India, Kenya, Norway, Peru, the Russian Federation, St Vincent and the Grenadines, Senegal, Solomon Islands and Venezuela.

13.4 Work plan

The standing sub-committee's discussion of its future work is given in Annex K. The Committee's overall work plan is discussed under Item 19.

14. WHALEWATCHING (ANNEX L)

The Committee had identified three priority topics for discussion this year:

- (1) review the work of the Intersessional Correspondence Groups (Data Collection Correspondence Group and Whalewatching Management Correspondence Group);
- (2) review information on the significance of noise production from vessels and aircraft in a joint session with the Standing Working Group on Environmental Concerns; and
- (3) review the research on the effectiveness of and compliance with national whalewatching guidelines and regulations.

Additional work would be to review new information on: (1) dolphin feeding programmes; (2) 'swim-with' whale and dolphin programmes; and (3) national guidelines and regulations.

A representative of Japan drew attention to the following statement:

It is the Government of Japan's position that whalewatching is outside the competence of the IWC. Japan does not deny that studying the effects of whalewatching on whale stocks is beneficial in order to obtain better understanding of the stocks. However, the IWC has limited financial and human resources and should be focusing its efforts on important matters such as stock assessment.

In response, one member noted that, in many locations, whalewatching has provided a platform for data collection that has proved of importance to the assessment and understanding of local cetacean populations. Such studies have resulted in many publications in international journals. Consequently, to state that the IWC should ignore whalewatching and instead concentrate its scarce resources on 'assessments' ignores the considerable contribution to the latter that can be made by whalewatching data.

14.1 Reports of the intersessional working groups

14.1.1 Data Collection Correspondence Group

SC/54/WW2 reported on the further development of the 'Data Recording System' (DRS), including preliminary instructions and recommendations for its use in the field. A prototype computer program has been developed to assist would-be researchers in producing simple data-collection

forms based on the DRS. The Committee **agreed** to form an intersessional group to continue the work as described in Annex L, Appendix 2.

The Committee also **agreed** that Carlson should collate data forms from whalewatching operations and research groups around the world, as well as the scientific question(s) the forms attempt to address, and present a report to next year's meeting.

14.1.2 Whalewatching Management Intersessional Correspondence Group

Oosthuizen presented the report of the Whalewatching Management Intersessional Correspondence Group regarding a workshop on the development of scientifically-based whale- and dolphin-watching management. He noted that the rationale and need for such a workshop were discussed in detail at the Scientific Committee last year (IWC, 2002l, pp.345-346).

Noting the ongoing proliferation of whalewatching activities worldwide, and concerns about possible impacts of whalewatching activities on cetacean populations, the Committee **agreed** that an intersessional workshop will benefit future whalewatching management. Details of the workshop are given in Annex L (item 5.2). As this will not be an official IWC workshop, funds will not be sought from the IWC, but from member nations and other potential sponsors. The workshop will be scheduled before next year's meeting.

The Committee **recommends** that:

- (1) an Intersessional Advisory Group be established to advise Oosthuizen on the scientific parameters which would be discussed during the proposed workshop; and
- (2) that the Commission endorses the Workshop and encourages participation by members of the Scientific Committee and IWC member states.

14.2 Whalewatching activities and noise impacts

This was initially discussed in a joint session with the sub-committee on whalewatching and the standing working group on environmental concerns.

SC/54/E7 reviewed recent knowledge concerning noise pollution and its implications for cetaceans, with particular reference to vessel noise. The paper considered: developments in the theoretical framework (including recent recommendations that seismic surveys avoid areas where densities of marine mammals are known to be high, that initial surveys for marine mammals should be conducted in the vicinity of deployment, and the recent use of computer models to estimate noise impacts); technological mitigation; vessel design; and information on avoidance behaviour as well as changes in behaviour and habitat use by cetaceans as a result of vessel traffic.

M. Simmonds concluded that, despite increasing concerns about noise pollution, it still receives little attention from policy makers. The need for the regulation of boat traffic, when in the vicinity of cetaceans, including in particular (but not limited to) whalewatching vessels, is also indicated.

There was a brief discussion on the mass stranding of beaked whales in the Bahamas in March 2000 (IWC, 2001g, p.255). Few to no *Ziphius* were sighted in the summer of 2000, but some *Ziphius* were sighted the following year. Sighting rates are apparently still lower than before.

Some members commented on the increase in high-speed ferries, whalewatching vessels and other ships and the potential for serious threats to cetaceans that do not show

avoidance to their noises. It was noted that within the next few decades, freighters and super tankers would have the capability of travelling at 60mph. An increase in average low frequency ambient noise of 10dB off the central California coast in the last two decades was reported. This increase could significantly lower a whale's communication range. It was noted that further research is needed to determine whether making vessels quiet necessarily confers a net benefit to whale populations.

SC/54/E8 reported on an investigation of the relevance of international law to marine noise. The Chair of the SWG on environmental concerns pointed out that legal opinions need to come from appropriate authorities. The author of SC/54/E8 noted that there was a growing recognition of disturbance in international law, especially relating to cetaceans, and recommended that scientifically supported definitions of what constitutes unacceptable or dangerous noise pollution, disturbance or harassment would help to inform the development and interpretation of existing and future law.

One member commented on the difficulty of defining unacceptable noise levels, as it would have to be species- and frequency-specific. C. Clark noted that one approach on potential impacts from anthropogenic noise separates impacts into physical harm and behavioural responses. Physical harm, often due to chronic exposure to noise, is evident as a permanent threshold shift (PTS) in hearing ability caused by damage to inner ear sensory receptors, while temporary threshold shift (TTS) is a modification of these receptors that, although not damaging, does serve as an indicator that further exposure is likely to lead to PTS. He further noted that important progress has been made in the ability to estimate levels of noise exposure for individual animals or populations of animals and that this might provide a way forward to better evaluate the potential for noise impacts.

Williams *et al.* (2002) reported results from a shore-based experimental study of behavioural responses of killer whales to a vessel operating in western Canadian waters at two operating speeds. Killer whales responded to high-speed experimental approach by adopting paths that were significantly less predictable than those observed during preceding no-boat conditions. The tendency for whales to swim further along a circuitous route may carry energetic costs to whales. He suggested that the boat would need to be 700m away for the whales' received noise level to equal the noise level received by the same boat operating at slow speed at 100m from the whale. One member commented that studies such as these are valuable as they demonstrate that noise level can be used to determine biologically relevant approach distances for vessels watching whales.

Bain (2002) attempts to model the cumulative effects of such short-term energetic costs. This study considered the increased energy expenditure due to avoidance responses and reduced energy acquisition due to acoustic impairment of foraging efficiency. The models suggest that population-level effects are negligible for killer whale populations well below carrying capacity. Hence population growth in the presence of disturbance cannot be used to conclude that disturbance will not affect the population at other densities as it approaches carrying capacity. The models suggested that missed prey due to noise was a more prominent mechanism than excess energy expenditure.

It was noted that the study demonstrates how physical acoustic and biological information can be merged and serves as an excellent model of how to integrate the two fields.

14.3 Review of research on effectiveness of and compliance with whalewatching guidelines and regulations

SC/54/WW1 reported on short-term impacts on Indo-Pacific bottlenose dolphins in Menai Bay, Zanzibar. Observations were made from tourist boats and from a research boat in order to evaluate the impact of violating guidelines. The results showed that the dolphins were more likely to change their group activity when guidelines were violated during boat approaches compared to when guidelines were followed. Further stress-related behaviours in dolphin groups were significantly more frequent when guidelines were violated and indicate that the behaviour of the Indo-Pacific bottlenose dolphins in Menai Bay is significantly affected by dolphin tourism in its present form. In the Menai Bay area, local scientists and operators meet to discuss research results in relation to guidelines and how the dolphin watching is conducted. The intent is to develop dolphin-watching activities that are conducted in a sustainable manner with a minimal impact on dolphins. The adoption, implementation and enforcement of suggested guidelines could be an important step towards the sustainable development of dolphin tourism in Menai Bay.

The Committee welcomed the type of research in SC/54/WW1 and **agreed** that such research should be encouraged.

14.4 New information on previously discussed topics

14.4.1 Dolphin feeding programmes

Corkeron presented an update on the feeding programme at Tin Can Bay, southeast Queensland, Australia, focusing on Indo-Pacific humpback dolphins. Details are discussed in SC/54/SM27. To date, no management programme, such as those in place in Monkey Mia or Tangalooma, has been established.

14.4.2 'Swim-with' whale and dolphin programmes

Rose presented information on three 'swim-with-whale' programmes. The number of commercial operations promoting swimming with large whales (e.g. humpback and minke whales) appears to be increasing. Rose suggested that a thorough review of these proliferating programmes be conducted, for discussion next year. Some members expressed concern with the swim-with programmes, particularly those that are not regulated, allow free swimming and encourage swimming with mothers with small calves.

The Committee **agreed** that research on the impacts of swim-with-whale programmes should be encouraged and **recommends** that a review of these programmes be a priority for next year, along with ongoing work on swim-with-dolphin programmes.

14.4.3 National guidelines and regulations

SC/54/WW3 reviewed whalewatching guidelines from six areas in Japan. The paper detailed target species, safety zones, minimal approach distances, and general codes of conduct for each area. There are no laws or ordinances in Japan that directly regulate whalewatching activities; however, there are several areas where voluntary codes of conduct have been established by operators, scientists or associations. One member noted that the situation in Japan is ideal for studying and comparing whale behaviour in whalewatching areas with and without written codes of conduct.

There was a brief discussion on the development of national whalewatching regulations. Some members felt that it would be difficult to standardise regulations due to several variable factors. Therefore, rules should be overarching with specifics tailored to suit target species, area use (i.e. feeding, breeding, resting and migrating areas) and vessel and operation types. One member noted that a co-management system in South Africa, with dialogue between government and operators, has been effective in improving whalewatching management.

The compendium on whalewatching guidelines and regulations around the world is now on the IWC website. Carlson requested that any new or changed guidelines or regulations be sent to her so that the site can be updated.

M. Simmonds suggested consideration might be given to the meaning of the term 'harassment' and/or what constitutes unacceptable disturbance. Some members were of the opinion that this was an extremely difficult task as there are several confounding variables that may affect whale behaviour. In addition, the term 'harassment' has legal implications and the discussion should be science-based. The Committee concluded that:

- (1) persistent changes in cetacean behaviour associated with the presence of whalewatching platforms may indicate a negative effect;
- (2) further research on the topic of disturbance is encouraged.

14.4.4 Other

Morton and Symonds (2002) provided results of a natural experiment on the deliberate introduction of high-amplitude noise (Acoustic Harassment Devices/AHDs) into a portion of the core habitat of resident and transient killer whales in British Columbia, Canada. Killer whale usage of the ensonified area declined while AHDs were in use, and returned to baseline levels when the devices were turned off. In the adjacent (control) area, killer whale presence remained stable across the 15-year study. Careful consideration of alternative explanations for the findings, including changes in prey distribution, led the authors to conclude that acoustic harassment must have displaced killer whales from one part of their range, while usage of the habitat immediately adjacent remained consistent.

SC/54/WW4 discussed behavioural responses of wintering humpback whales to vessels in Ecuador. The study aimed to identify components of whale behaviour that changed consistently when boats approached, to provide concrete signs that boat operators could look for to determine when they might be too close, or staying around whales too long. The land-based study compared whale behaviour when no boats were present to the behaviour of the same group as vessels approached, and found that whales increased swim speed significantly. Park managers were advised to caution boat operators that if they had to increase their boat speed to keep up with whales, that this might be a sign that they should end their whalewatch encounter.

Heckel *et al.* (2001) studied the influence of whalewatching on the behaviour of migrating gray whales in Todos Santos Bay on the northwest coast of the Baja California Peninsula. The study shows that during the southbound migration of gray whales, there were no significant differences in swimming direction between whale groups with and without whalewatching boats. By contrast, during the northbound migration, the differences were statistically significant. An additional suggestion was made to prevent such disturbances.

The Committee welcomed the above papers and noted that the whalewatching management-related research presented represents the type of studies necessary for the development of science-based regulation.

14.5 Other

SC/54/O7 described a novel DNA-based method for identifying krill species present in the faeces of baleen whales (see Annex J, item 7.4 for further details). It was noted that whalewatching vessels offer a platform of opportunity for the collection of cetacean faecal samples, and broad collaboration with researchers working in targeted parts of this industry is sought. Several researchers expressed interest in collaboration, and discussions were to continue outside the meeting.

A workshop was held on Philip Island, Australia in 2001, during which several papers on the issues of whale watching, scientific studies of measuring impacts from tourist activities and dolphin feeding programmes were presented. These papers will appear in a proceedings on the conference. Gales undertook to encourage the authors to present these papers for information at the next IWC meeting.

14.6 Work plan

The work plan developed by the sub-committee on whalewatching is given in Annex L. The Committee's overall discussions on its work plan are given under Item 19.

15. DNA TESTING

This item is discussed in response to Commission Resolution 1999-8 (IWC, 2000a, p.55).

15.1 Progress on genetic methods for species, stock, individual identification

SC/54/SD2 reported on the implementation of DNA Surveillance (<http://www.dna-surveillance.auckland.ac.nz>) as a web-based program for molecular genetic identification of cetaceans and cetacean products derived from strandings, fisheries bycatch, regulated exploitation and illegal hunting. It aligns a user-submitted DNA sequence with a validated and curated reference dataset of pre-aligned sequences and returns a phylogenetic tree (with bootstrap values if desired) showing with which species the submitted sequence clusters. It also returns a table summarising the evolutionary distances between the submitted sequence and each of the members in the reference dataset.

DNA Surveillance and the reference database were developed specifically for taxonomic identification. This approach differs from a standard BLAST search of GenBank. GenBank entries are not curated and can suffer from species or population misidentification, missing information and inconsistent terminology. This is a particular problem for cetacean species, as the morphological identification of a number of species is very difficult, and the sequences are usually not associated with identifiable reference material (e.g. from skin biopsies).

The initial reference sets comprise sequences (~500 bp) from the 5' end of the mitochondrial (mt) DNA control region (D-loop). Technical details regarding the sequencing of this region are available at the DNA Surveillance Web site. The mtDNA control region is highly variable and has proven to be an effective tool for the species identification of test specimens and for differentiating intra- and interspecific relationships (e.g. Baker *et al.*, 1996; Henshaw *et al.*, 1997; Dalebout *et al.*, 1998; SC/54/SD1). The reference sets

provide coverage of the taxonomic and geographic diversity of cetaceans and comprise 121 sequences from 67 species in 10 families. Sequences were derived from tissue samples analysed at the Laboratory of Molecular Ecology and Evolution, University of Auckland, or retrieved from GenBank. Each sequence was included only if the specimen from which it was obtained had been examined by an expert in cetacean morphology, and diagnostic skeletal material or photographic records were collected (Dizon *et al.*, 2000). In some cases, sequences were derived from DNA extracted from teeth and bones of museum holotypes. Each sequence is annotated with information on its provenance. Reference sets of cetacean cytochrome *b* sequences and sequences from other taxa are under development.

In response to a question about quality control, Baker noted that a workshop may be convened to develop quality-control criteria for the sequences in the register. He also noted that at this point only mtDNA control-region sequences are included in the register and that the methodology for developing these is well-established and available on various websites. A discussion ensued about the plans to expand the register and identification service to assignments below the species level. Concern was expressed about the difficulty of accomplishing this for most groups without very large reference datasets. It was suggested that a tree be provided placing the unknown specimen among the specimens represented in the register, rather than an assignment to a sub-specific taxon or population, but members believed that even this could result in users believing that the results were more reliable than they actually were. Baker agreed that this is a problem, especially for some groups such as the delphinine odontocetes and some others, and noted that the feedback to the user will include appropriate warnings in such cases. He also noted that one motivation for creating the system is to encourage contribution of sequences from others, to build the necessary large datasets needed for reliable population assignment.

15.2 Progress on collection and archiving of samples from catches and bycatches

In Norway, samples have been collected and archived from 2,676 minke whales (of a total of 2,758 taken by Norway, 1997-2001). No information on collection and archiving of samples in Japan was available to the Committee.

15.3 Reference databases and standards for a diagnostic register of DNA profiles

The Norwegian register, while not fully diagnostic, includes sequences for over 97% of the whales taken. The register is not yet fully operational and technical audits and other necessary steps to this end are in progress.

15.4 Work plan

The terms of reference for the working group for next year's meeting will remain the same, unless the Commission requests other information in the interim. The Committee's overall work plan is discussed under Item 19.

16. SCIENTIFIC PERMITS

16.1 Advice on effects of scientific permit catches

Further to its discussions of last year (IWC, 2002d, p.64), there had been no further work on this general issue during the intersessional period. It was noted that in terms of the Southern Hemisphere, the Committee was still working to obtain agreed abundance estimates (see discussion under Item 10.2). The Committee also noted that there had been no

progress by the intersessional group that had been established to generate a list of approaches potentially useful for quantifying the scientific benefit of research catches and the features of a proposal needed for such analyses (IWC, 2002d, p.65).

16.2 Suggestions for improving review procedures

The Committee had established an intersessional group to consider improvements to the way that the Committee reviews scientific permit results and proposals. Although that group did not submit an agreed report at this meeting, it was noted that the approach used this year to review the new North Pacific JARPN II proposal had proved successful i.e. first discussing the proposals in a Working Group. Given this, the Committee agreed that it would establish a Standing Working Group on Scientific Permit Proposals under Bjørge. It was noted that the workload of this SWG would vary depending on whether new proposals were being presented or whether major reviews of existing long-term proposals were scheduled. It was also noted that the existing Commission guidelines had developed over a number of years and included some duplication and overlap within the broad headings used. It was suggested that it might be possible intersessionally to attempt to streamline these (whilst retaining the references to the origins of the guidelines) for discussion next year with a view to presenting a suggested revised version for the Commission to consider.

16.3 Review of results from existing permits

16.3.1 Japan – Southern Hemisphere minke whales

SC/54/O18 summarised the 15th field season of the JARPA programme. Research was conducted in Area IV and the eastern part of Area III (Area IIIE) from 29 November 2001 to 9 March 2002. One sighting vessel (SV), three sighting and sampling vessels (SSVs) and one research base ship were engaged in the research. The searching distance of the SV was 5,970.2 n.miles and 745 primary sightings (1,751 individuals) of Antarctic minke whales were made. The three SSVs searched a total of 13,797.2 n.miles and made 1,122 (2,623 individuals) primary sightings of that species. The Antarctic minke whale was the most commonly seen species, followed by the humpback whale. The Antarctic minke whale occurred in extremely high densities in the east-south stratum and Prydz Bay in Area IV. Sightings of humpback whales were much higher than those of Antarctic minke whales in the north strata and the west-south stratum in Area IV. The distribution of humpback and minke whales did not overlap except in some areas near the ice-edge where both species were highly concentrated. The number of sightings of Antarctic minke whales equalled the highest number observed in the previous research in Areas IIIE and IV. The number of sightings for both humpback and fin whales was higher than the past JARPA survey records. The authors hypothesised that the recent increase of humpback whales may result in interspecies competition with Antarctic minke whales (although see the discussion under Item 10.4.1). A total of 493 Antarctic minke whales was targeted for sampling resulting in the catch of 440 individuals (110 from Area IIIE and 330 from Area IV). A total of 52 biopsy samples was obtained from humpback, blue, fin and right whales by the SV and SSVs. The SV conducted an oceanographic survey using a passive acoustic system, Electric Particle Counting and Sizing System (EPCS), CTD and XCTD. One of the SSVs also conducted an oceanographic survey using EPCS.

Studies using JARPA information (including papers SC/54/IA9, 14, 25 and SC/54/O18, 19) were presented in the relevant sub-committees and working groups.

16.3.2 Review of results from existing permit for feasibility study

The text below (Item 16.3.2.1) summarises the results of the JARPN II feasibility study under special permit reported by Japan (SC/54/O17) and presented to the Scientific Committee by Fujise. The Committee acknowledged Fujise for his informative presentation. Comments from the Scientific Committee are given under Item 16.3.2.2.

16.3.2.1 RESULTS REPORTED BY JAPAN

INTRODUCTION

The JARPN II feasibility study was designed to respond to issues arising in the 2000 JARPN Review Meeting (IWC, 2001) in order to better address the issue of competition between cetaceans and fisheries with the overall goal of contributing to the conservation and sustainable use of marine living resources, including whales, in the western North Pacific, especially within Japan's EEZ (Government of Japan, 2000). The priority for the research was feeding ecology and ecosystem studies. Other objectives were related to continuing studies on the stock structure and monitoring environmental pollutants.

JARPN II began as a two-year feasibility study in order to evaluate, among others, the practicability and performance of concurrent whale and prey surveys for estimation of prey preference. The 'feasibility' also applied to the addition of Bryde's and sperm whales to the research. The research area was off the coast of Tohoku and southern Hokkaido, (sub-areas 7, 8 and 9) which are Japan's richest fishing grounds and therefore provides a suitable area to study the interactions between cetaceans and fisheries. A total of 140 minke whales, 93 Bryde's whales and 13 sperm whales were sampled. The first feasibility survey of JARPN II was conducted from 1 August to 16 September 2000. The second year survey was conducted from 14 May to 3 August in 2001.

With regard to feeding ecology and ecosystem studies, the feasibility studies addressed questions such as: (1) whether information on the diet composition and daily and seasonal consumption can be obtained with adequate precision through the examination of stomach contents of the whales; (2) whether the weights of the stomach contents can be measured for large whales such as Bryde's and sperm whales as is the case for minke whales; (3) whether the first concurrent whale and prey surveys with six research vessels involved are practicable; and (4) whether these provide data to assess prey preferences. This latter point is important since it is a key parameter for most ecosystem models.

Regarding the stock structure of the common minke whale, following the discussions and conclusions of the JARPN review meeting, the objective focused only on investigating whether or not the W stock exists in sub-area 9, and if so, to investigate the spatial and temporal extent of its occurrence. Another objective of the two-year feasibility study was to investigate the pattern of mixing between the O- and J-stocks in sub-area 7¹⁵. Since there were no genetic samples for Bryde's whales in the research area, one of the objectives of the feasibility study was to determine whether

¹⁵ The stock structure of the North Pacific common minke whale is discussed under Item 6 and in SC/54/Rep1 and a map of the sub-areas can be found there.

samples for stock structure studies could be collected from this area, and whether the analysis of such samples could provide additional information on the stock structure.

The research plan also included the monitoring of PCBs, DDTs and other pollutants in whales and their prey as well as in their environment.

PREY CONSUMPTION BY CETACEANS

Prey species of minke whales varied both geographically and temporally (similar to the results obtained during JARPN). During August and September, Japanese anchovy was the most important prey species. Walleye pollock was an important prey species in sub-area 7. On the other hand, Pacific saury was consumed in low proportion compared to the results obtained during JARPN. This may be due to the low abundance of Pacific saury in recent years. There is evidence of competition between minke whales and commercial fisheries (SC/54/O17). For example, dip-net fishermen have complained about interference by minke whales more frequently in recent years. This topic needs to be addressed with further research. Estimates of the daily prey consumption were 1.4-8.2% of body weight. More precise daily consumption rates can be calculated with more data such as the caloric value of prey species on an area, seasonal and annual basis.

One of the objectives of the feasibility study was to check how to sample and measure Bryde's whale prey. Sampling cow/calf pairs did not produce useful results. Prey species of Bryde's whales varied temporally within the research area. The major prey species were krill and Japanese anchovy. They fed on different sizes of the same prey species (Japanese anchovy) compared to minke whales, which occurred in nearly overlapping areas. More data are needed to better understand the geographical and temporal changes of prey species. Most of the Bryde's whale sightings occurred close to the fishing grounds of skipjack tuna. On these grounds, both Bryde's whales and skipjack tuna feed mainly on Japanese anchovy. Therefore, further research is necessary to understand the nature of this competition. Estimates of the daily prey consumption were 3.3-8.2% of body weight.

Another of the important objectives of the feasibility study was to examine methods for sampling and examination of stomach contents of sperm whales. Sperm whales could be sampled at random except for the large bulls. Results from the JARPN II feasibility study (SC/54/O17) clearly showed that sperm whales did not eat only deep-sea squid but also squid occurring in the pelagic ecosystem. In addition, they were feeding on some fish species. The species of squid and fish were identified by examining beaks and otoliths, respectively. The body length and weight of the main prey species could be estimated using regression equations to the otolith length or lower rostral beak length. Sperm whales seem to feed on prey during the daytime in the meso- and epipelagic layers. As the sample size is small (13 animals), no conclusion can be drawn on the role and contribution of this species to the surface ecosystem, and further sampling is required.

PREY PREFERENCE OF CETACEANS

The most important objective in the feasibility study was to evaluate the practicability and performance of concurrent whale and prey surveys. Such concurrent surveys were conducted for the first time in the North Pacific and involved many research vessels operating at the same time (Government of Japan, 2000). Several small blocks were set

in the research area and both surveys were conducted concurrently in each small block. Stomach contents were examined and compared to the biomass of each prey in the sea, which was estimated with an acoustic device and mid-water trawl net.

There were no serious practical problems in the conduct of the concurrent surveys. Close cooperation between the two surveys is indispensable for good performance. Preliminary analyses showed evidence of prey preference of cetaceans. For example, the preference of minke and Bryde's whales for lantern fishes is judged as zero. Minke whales prefer Japanese anchovy to krill (SC/54/O17). Bryde's whales may prefer larger fish among small-sized anchovy. The prey preference of cetaceans can be estimated if the concurrent whale and prey surveys continue.

ECOSYSTEM MODELLING

Some initial analyses were conducted using the ecosystem models Ecopath and Ecosim. These analyses were conducted to assess the potential effectiveness of these models in relation to the goals of JARPN II. Ecopath and Ecosim models indicated possible competition between cetaceans and fisheries and that the ecosystem of the western North Pacific may be affected on a large scale by trophic interactions and changes of fishing. The results of many tests suggested the utility of the Ecopath and Ecosim models to study the western North Pacific ecosystem. Cetaceans, especially minke and sperm whales, are probably important key species in the western North Pacific pelagic ecosystem because removals of these species brought fluctuations in the biomasses of direct and indirect prey species (SC/54/O17). Long-term information on diet composition is needed to clarify the characteristics of the ecosystem. More precise estimates of other biological parameters are also necessary, particularly temporal and spatial migration and prey preference of cetaceans.

STOCK STRUCTURE

MtDNA analysis detected slight genetic heterogeneity among the minke whale samples collected from the western part of sub-area 9 in some years. These results suggest that putative W stock individuals, if they exist, enter sub-area 9 only every few years. However, analyses of nuclear DNA (microsatellite) and other biological data do not show any evidence of heterogeneity among samples collected from sub-areas 7, 8 and 9. Therefore, conclusions about the putative W stock in the east side of the western North Pacific are still pending.

Using the same maximum-likelihood method used to estimate the mixing rate of whales from the minke whale stock in the Yellow Sea, East China Sea and Sea of Japan (J-stock) and from the minke whale stock nearest the Pacific coast of Japan (O stock) in sub-area 11 (Pastene *et al.*, 1998), the J-stock proportion in sub-area 7 was estimated at 0.08 (SE = 0.08) and 0.07 (SE = 0.04) for the 2000 and 2001 JARPN II surveys, respectively. These rates are much smaller than those estimated for some months in sub-area 11, indicating that very few J-stock animals migrate into sub-area 7.

JARPN II in 2000 and 2001 sampled Bryde's whales in regions within sub-area 1 not covered previously. Even by adding samples obtained from JARPN II from regions in sub-area 1 not previously covered, no strong evidence of additional stock structure within this sub-area was found (SC/54/O17).

Analysis of mtDNA control region sequences and microsatellite DNA indicated that these genetic markers were variable enough to explore stock structure of North Pacific sperm whales (SC/54/O17).

POLLUTANT MONITORING

Information on the accumulation levels of contaminants in minke whales has been obtained. These data will be examined in relation to biological information such as sex, body length, age, gestation and lactation. For the concentration levels of organochlorines such as PCBs, DDTs and HCHs, some contaminants in seawater and air samples in the research area showed a decreasing pattern relative to past levels. However, no conclusive results were obtained due to the small sample size. With regard to the usefulness of skin samples for pollution studies, some parameters of toxic elements could be monitored using skin biopsy samples from minke whales. However, no conclusive results were obtained for these metals as the results of the present study do not coincide with those from the Antarctic whales.

16.3.2.2 COMMENTS AND DISCUSSION BY THE SCIENTIFIC COMMITTEE

Some members raised questions about the relationship of the objectives of the feasibility study as proposed and the results of the feasibility study as presented here, and the relationship of that to the proposal to be discussed. They noted that the feasibility questions addressed in SC/54/O17 did not appear directly in the original proposal for the feasibility study (Government of Japan, 2000). Further, the questions to which answers are reported on page 18 of SC/54/O17, are in fact for the most part simple, such as can weights of stomachs of whales be measured. They were answered in equally simple yes and no statements, answers that could have been given before the feasibility study was undertaken based on past experience of Japanese whaling and research capability. More importantly, however, the questions reported were primarily related to mechanical aspects of sampling. They were disappointed that the feasibility study did not address critical aspects of overall design of the programme, including the relationships between sampling methodologies, the data analysis methodologies and ecosystem modelling methodologies. The proponents noted that performance criteria for the JARPN II feasibility study were implicit in the research proposal submitted to the Committee in 2000. The performance was evaluated directly through analysis of data obtained. Thus, if the feasibility study provides results and data to support continuation of the study, it has performed well. Further, the proponents stated that this is the case for the 2000-2001 research carried out under the JARPN II feasibility study as shown in SC/54/O17. These aspects are further elaborated in the discussion of the new proposal below.

The authors of SC/54/O26 reported that performance criteria are not implicit but must be explicitly stated in measurable terms. They also noted that the idea of a feasibility study performing well because it had provided results to support the study's conclusion was a circular argument.

16.4 Review of new or revised proposals

16.4.1 JARPA

SC/54/O1 outlined the JARPA survey plan for the 2002/2003 field season. The objectives, survey items and methods are the same as last year. The survey for the coming season will cover Area V and the western half of Area VI.

The objectives of the programme have been elucidated previously and include the better determination of stock structure and the collection of samples suitable for catch-at-age analyses. The expansion to Area VI was to allow for the testing of new hypotheses on stock identity (Government of Japan, 1996).

The schedule for the 2002/2003 JARPA survey is as follows:

- (1) research vessels will leave Japan at the beginning of November and return in the middle of April 2003;
- (2) the sample size is 300 Antarctic minke whales in Area V and 100 Antarctic minke whales in Area VI with 10% allowances;
- (3) the type and number of vessels are the same as in the previous years – one research base vessel, three sighting and sampling vessels and one dedicated sightings vessel.

In addition, examination of the extent of the yearly variation of stock distribution patterns using other available sources of information (i.e. environmental correlates) is planned. Therefore, data will also be collected on prey species availability and on the nutritional condition of sampled whales.

COMMENTS AND DISCUSSION

It was noted that this is a continuation (14th year) of a long-term (16-year) research programme. The Committee held a major review of this programme in 1997 (IWC, 1998b), and the Committee draws the attention of the Commission to its previous considerations on this matter (IWC, 1999a, pp.45-46; IWC, 2000b, pp.54-56; IWC, 2001c, pp.57-58, 64-65).

Attention was drawn to the fact that in the coming season, there is overlap in the research areas between JARPA and the SOWER circumpolar surveys. The issue of avoiding any spatio-temporal overlap between the two programmes will be placed on the agenda of the SOWER planning meeting (see Item 10.1.2.2).

Tynan expressed concern that the JARPA research would be carried out in the Ross Sea, an area exhibiting some of the largest calving of the ice shelf, which has unknown and potentially serious ecological consequences for the ecosystem, including whales. In response it was noted that the JARPA vessels will be able to provide good information on this phenomenon, by monitoring the ice-edge information obtained from NIC as well as information from its own vessels where the southern stratum is 45 miles from the ice-edge. Oceanographic information is also collected.

Childerhouse referred to the comment that estimation of biological parameters should be carried out for known stocks and questioned whether the sample size is now sufficient to address the stock issue.

Pastene responded that with respect to the sample size for the stock structure issue in the expanded area, because the level of genetic difference between stocks of Antarctic minke whales is small, large sample sizes are generally required for genetic analysis ($n = 150-200$). However, for heterogeneity tests, samples must be divided into smaller groups depending on certain spatial and temporal factors. In fact, a sample size of 150-200 is required for each of the small groups.

Hatanaka explained further that the first objective of JARPA is to estimate the biological parameters to improve the stock management of the Southern Hemisphere minke whale. The sample size of JARPA in Areas IV and V was designed primarily to achieve this objective.

16.4.2 JARPN II

In the text below, summaries of the plans for further research under special permit (based on document SC/54/O2 and an oral presentation to the Scientific Committee by Kawahara) are listed first, followed by comments from the Scientific Committee. The Committee acknowledged Kawahara for his informative presentation.

The text is structured according to Guidelines for the Review of Scientific Permit Proposals (Donovan, 2001) and previous Committee reviews of special permit proposals. In addition to the report of the feasibility study (SC/54/O17) and the proposal (SC/54/O2), the Committee also received a critique of the proposal (SC/54/O26) and a number of other documents. One was written in response to SC/54/O26 by Hatanaka, Kato, Nishiwaki, Hakamada, Kanda, Yasunaga, Murase, Zenitani, Kawahara, Miyashita, Okamura, Fujise, Goto, Tamura, Matsuoka and Goodman. Other documents used were prepared by Haug, Schweder and Walløe, by Gales, by Tynan, by Tamura and by Víkingsson and Gunnlaugsson. The points raised in these have been integrated into the following summary of the Committee discussions.

A. The Proposal

The relevant guidelines are as follows.

1. A statement as to whether the permit proposal adequately specifies the four sets of information required under paragraph 30 of the Schedule (*Rep. int. Whal. Commn* 36:133).
2. Objective of the research (Schedule Paragraph 30).
3. Number, sex, size and stock of the animals to be taken (Schedule Paragraph 30).

Proposal (summary of SC/54/O2)

The overall aim of JARPN II is to contribute to improved understanding of trophic interactions in the marine ecosystem, and thereby contribute to the development of a holistic ecological management approach for the conservation and sustainable use of marine living resources in the western North Pacific, in particular within Japan's EEZ. JARPN II responds to FAO requests for development of ecosystem approaches to the management of marine living resources (FAO, 1999), and for studies on the interactions between fisheries and marine mammals in accordance with Paragraph 39 of the 2001 COFI meeting (FAO, 2002). JARPN II is consistent with IWC Resolution 2001-9 in which the Commission unanimously decided to make the study of interactions between whales and fish stocks a matter of priority (SC/54/O2). Other important objectives are: (1) monitoring of concentrations of environmental pollutants in cetaceans and their prey species; and (2) further elucidation of cetacean stock structure.

The proposed research has a broader scope than cetacean research, and therefore also addresses other research needs than those required for the completion of the Comprehensive Assessment (IWC, 1987; 1988). However, for the activities associated with sampling of cetaceans under special permit, the proposal outlines the four sets of information required in IWC Schedule Paragraph 30 (a: objective of the research; b: number, sex and stock of the animals to be taken; c: opportunities for international participation in the research; d: effects of the take on the stock).

The proposed sample sizes for baleen whales are set to provide necessary sample sizes for estimating the prey consumption with good precision ($CV = 0.2$) following the

procedures applied in the Norwegian research programme (Norway, 1990). The sample sizes were estimated as: 150 minke whales from the O Stock and the putative W-Stock (100 whales from sub-areas 7, 8, 9, 12 and 13, and 50 whales from inshore areas of sub-area 7); 50 Bryde's whales from the western North Pacific Stock; and 50 sei whales from the Asian Stock.

With regard to sperm whales, the continuation of a sample of 10 whales from the Western Division, is based on the reason outlined in the proposal for the JARPN II feasibility study.

The sampling of baleen whales will not be selective with regard to size and sex. For Bryde's whales, female/calf pairs will not be sampled, and larger males of sperm whales will be avoided due to technical problems in handling the large animals.

The proposal noted that fluctuations including 'species replacement' have been observed in the research area over the past 100 years (Wada, 1997). These fluctuations are repetitive with periods of 10-20 years. To monitor these processes, the programme will be continued without specifying the duration of the research. However, the research will be comprehensively reviewed every six years by the IWC Scientific Committee and/or other organisations. A report of each cruise will be submitted to the annual meetings of the Committee and to other relevant organisations. A report on the feasibility parts of the research (inshore take of 50 minke whales and take of sperm whales) as well as a recalculation of the required sample size for sei whales will be presented following the completion of two years of the research.

Comments and discussion by the Scientific Committee

Authors of a critique (SC/54/O26) of the JARPN II proposal stated that the experimental design was poor, that the proposal did not give sufficient detail in several areas and that it failed to give either specific hypotheses to be tested or performance measures for evaluating its success. They felt that these general issues were such that the proposal would not be acceptable for review by major national and international scientific funding agencies (for example, the European Commission or the US National Science Foundation).

Further, and important for proposal review, the authors of SC/54/O26 noted that publication of research results in international peer reviewed journals was often an important criteria used in proposal reviews, and JARPN and JARPN had led to relatively few peer reviewed publications.

Pastene noted that many international journals have a policy not to publish papers based on data or samples obtained by lethal sampling of cetaceans, and he asserted that the number of publications resulting from special permit catches in peer reviewed journals may be due to this fact. A small number of publications does not therefore mean a lack of, or shortage of scientific results of high quality from research under special permit.

Rather than scientific research in the original sense of 'scientific' whaling as adopted by the IWC, the authors of SC/54/O26 felt that JARPN II appears to be a long-term whaling operation without an end point. They felt that this research-whaling proposal constitutes a significant change in form over previous use of the provision of research under the Article VIII in not specifying an end point. Further, this research, along with other recent Japanese whaling under special permit, continues what is a significant change in

magnitude over earlier years. Since 1987/88 over 6,000 whales have been taken under special permits, 2.8 times more than all catches under special permits between 1949 and 1987.

The proponents responded that they did not agree that the design was poor, and noted that the performance had been evaluated in the two year feasibility study (see above review). When a feasibility study provides results and data to support continuation of the study, it has performed well. They noted that hypotheses are specified on page 12 of SC/54/O2. They also argued that the proposal fits within the terms of Article VIII of the International Convention for the Regulation of Whaling (ICRW). The research plans have a wide ecological scope, but with regard to the cetacean research part, the proposal has sufficient detail and transparency for an evaluation of objectives, research design, sample sizes, methodology and anticipated results. The sample sizes have been determined by scientific necessity.

The proposal (SC/54/O2) made a clear distinction between its primary objective (feeding ecology and ecosystem studies) and two additional objectives (monitoring of environmental pollutants and elucidating stock structure). Each of these is meant to contribute to the overall goal of the programme, that is to contribute to the conservation and sustainable use of marine living resources, including whales, especially within Japan's EEZ. Some members felt that the proposed annual catch is specified adequately, although the size and sex of the animals cannot be pre-determined due to a random sampling scheme. The question of possible effects of the takes on the whale stocks is addressed, and the possibility for participation by foreign scientists is mentioned. Thus, they felt, the proposal does adequately specify the four sets of information required under paragraph 30 of the Schedule.

Haug, Schweder and Walløe welcomed the proposed research and underlined that this comprehensive research will contribute to understanding the feeding ecology of cetaceans both in the western North Pacific, and in general. They further argued that feeding ecology and the spatial-temporal distribution of cetaceans are linked at three spatial-temporal scales: at the *macro scale* cetaceans migrate seasonally between feeding and breeding grounds; at the *meso scale* cetaceans move over days and weeks in search of preferred local abundance of food; and at the *micro scale*, whales dive and search for food within localised areas. Some members noted that JARPN II is focused on the micro scale; while in their experience to be useful for management it is necessary to understand feeding behaviour at the meso scale. It is also necessary to understand the behaviour of prey species at the meso scale. Thus, they and others felt that the research could be made more useful for management purposes if its focus were changed to some degree.

Walters congratulated Japan on the presentation of its research and proposal to continue this very valuable work, the primary objectives of which are feeding ecology and ecosystem studies. He also made reference to the decision of the FAO Committee on Fisheries (COFI) to endorse work of this type and concurred with the written comments by Víkingsson and Gunnlaugsson. Walters said that this work being undertaken by Japan is of major interest to the small island states in the Eastern Caribbean, which depend primarily on the living resources of the sea to feed their people. As such, he encouraged Japan not to be deterred by criticism whether constructive or otherwise to continue this research, which in time will give a very good understanding of the interactions between cetaceans and fisheries.

Conclusions

Concerns were expressed over the research design and that this research-whaling proposal constitutes a significant change in form over previous use of the provision of research under the Article VIII in not specifying an end point. Other members welcomed the research initiative of JARPN II, noting that it addressed important issues for the western North Pacific as well as in other areas.

In relation to the guidelines 1 through 3, the Committee **agreed** that the proposal contains the four sets of information required under paragraph 30 of the Schedule.

B. Objectives

The relevant guidelines are as follows:

1. Comments on the objectives of the research to be carried out under the proposed scientific permit, including in particular how they might relate to research needs identified by the Scientific Committee (*Rep. int. Whal. Commn* 36:133);
2. The proposed research is intended and structured accordingly to contribute information essential for rational management of the stock (*Rep. int. Whal. Commn* 37:25);
3. Is required for the purposes of management of the species or stock being researched (Resolution 1999-2);
4. The research addresses a question or questions that should be answered in order to conduct the comprehensive assessment or to meet other critically important research needs (*Rep. int. Whal. Commn* 38:27-28);
5. The number, age and sex of whales to be taken are necessary to complete the research and will facilitate the conduct of the comprehensive assessment (*Rep. int. Whal. Commn* 37:25).

Proposal (summary of SC/54/O2)

The overall goal is to contribute to the conservation and sustainable use of marine living resources including whales in the western North Pacific, especially within Japan's EEZ. To meet this goal, three specific objectives were defined:

- (1) studies of cetacean feeding ecology and ecosystems;
- (2) monitoring of environmental pollutants in cetaceans and in the marine ecosystem;
- (3) further elucidation of cetacean population structure.

STUDIES OF CETACEAN FEEDING ECOLOGY AND ECOSYSTEMS

Important research needs to be addressed were to improve the understanding of energy flow through the larger components (estimated as tons biomass) of the higher trophic levels in the ecosystem. Therefore, minke (164 ktons), Bryde's (408 ktons), sei whales (477 ktons) and sperm (1,889 ktons) whales were chosen for the study (SC/54/O2). These four species constitute close to 90% of the total cetacean biomass in the western North Pacific, and JARPN II aims to study the prey preference and prey consumption of these cetaceans.

The final goal of JARPN II is to provide data for building quantitative ecosystem models for the area. Therefore, information on distribution in space and time, biomass and biological information (including migration pattern, age, growth and feeding) of prey species will be needed. Most of the information on the fisheries resources is collected by the National Fisheries Research Institute.

MONITORING OF ENVIRONMENTAL POLLUTANTS IN CETACEANS AND THE ECOSYSTEM

There is concern related to the effects of environmental pollutants on marine resources, especially whale stocks. One important research need for maintaining a healthy marine environment is to monitor levels and trends of environmental pollutants and study exposure and biological effects in predatory organisms within the ecosystem.

FURTHER ELUCIDATION OF CETACEAN POPULATION STRUCTURE

Knowledge of population structure and stock identity is an important need for rational management of whale stocks. Unresolved problems in the research area are the putative existence of a W-stock of minke whales in sub-area 9, the occurrence of J-stock minke whales in sub-area 7, and the identity of minke whales in sub-areas 12 and 13. For Bryde's whales, areas not yet covered should be investigated, such as regions west of 180°.

Comments and discussion by the Scientific Committee

Some members noted that the proposal's three objectives addressed important areas for management and for Committee priorities. The feeding ecology objective addressed the IWC priority of studying the interaction between cetaceans and fisheries (IWC, 2002c), as has been urged by international organisations (i.e. FAO, ICES, NAFO, NAMMCO and IOTC). The pollution related objective was designed to complement the work in POLLUTION 2000+. The population structure objectives for minke and Bryde's whales relate to the development of RMP Implementations.

Relative to the feeding ecology objective, some members noted that the management of whales by the IWC under the RMP does not currently employ an ecosystem-based approach; whether it should do so had not been discussed to date. Further, they felt that the difficulties of sampling and modelling the myriad variable and complex trophic relationships involved in the marine ecosystem make it unlikely that the programme (certainly as currently designed) will yield results that would permit the development of a reliable predictive framework for use in any type of management system.

The proponents noted that there is no requirement that research under special permits should be focused on questions related to management using the RMP. Rather, they suggested that the results of JARPN II would be useful to improve management of all marine resources in the North Pacific. Further, they considered the 'myriad of variables and complex trophic relationships' to be a challenge, but not a reason to dismiss the need for research. Rather, the complexity makes the need for JARPN II all the more important as a start to understanding ecosystem relationships. Furthermore, they believed that the proposal used the widely accepted approach of using models to deal with complexity.

While the proposal suggests that cetaceans may be negatively affecting fisheries, some members noted that in addition to the direct effects of whale predation, in the complexity of ecosystems there are several ecological pathways through which whales could benefit fisheries. They noted examples from the eastern North Pacific, (California Current, Gulf of Alaska and the Bering Sea). One was the possible role of cetaceans in feeding on zooplankton allowing higher phytoplankton densities, which studies by Lasker (1975) and many others have shown are critical for larval fish first feeding and survival. Another was the possible role of cetaceans in feeding on larger fish, thereby reducing the effect of both their cannibalism and predation on younger fish. A further role of cetaceans is recyclers of carbon and nutrients within the ecosystem, contributing to the phytoplankton production and the microbial loop. Such trophic linkages illustrate the complex 'bottom-up' and 'top-down' influence of top predators, such as whales, on the structure and function of ecosystems. The assumption implicit within the JARPN II proposal that the removal of whales will enhance fisheries production does not begin to

address the complexities of the complete role of whales and other top predators in the structure, function and productivity of ecosystems. Unless such complexity is addressed within models, their function as a management tool for fisheries is misapplied.

The proponents replied that Lasker's critical period theory (Lasker, 1975) has been shown not to be the case in the western North Pacific (the research area of JARPN II) by studies of Watanabe *et al.*, (1995) documenting that the recruitment of pelagic fishes such as Japanese pilchard is determined after fish reach the juvenile stage. The proponents also stressed that the predation of cetaceans will affect both recruitment of fish and natural mortality after recruited. Therefore the effect of cetacean predation is more direct. The phenomenon that fish are cannibalistic on their own eggs may be unique in the up-welling waters off California and Peru as referred to. In the western North Pacific, fish predation is concentrated on copepods (for Japanese anchovy) and on krill (for Pacific saury).

Others, while agreeing that the relationships are complex, gave further examples of ecological pathways where the effects of cetaceans may be different, noting that all pathways in the system must be considered because it works as a whole. Another example was given, that of walleye pollock in the western North Pacific, where high adult biomass was known to reduce recruitment, suggesting that cetacean predation on the adult of this species could benefit not hinder fisheries productivity.

The proponents replied that studies of complicated marine ecosystems are being conducted in the western North Pacific. One approach is the 'bottom-up' type ecosystem approach (mostly project type), which starts from oceanographic condition, phytoplankton, zooplankton and fish. These studies are appropriate to examine long-term environmental changes such as the 'Regime Shift' in the North Pacific, but answers concerning competition between cetaceans and fisheries could not be derived from these studies. The proponents stressed that 'top-down' approaches are required to elucidate the latter problems. JARPN II is a 'top-down' type ecosystem study. Some members argued that JARPN II is pursuing direct competition between cetacean and fishery resources disregarding that: (1) much information has already been collected; (2) much of the prey of cetaceans is not consumed by humans; (3) fish, not whales, are the major predators of other fish; and (4) human overfishing (rather than whales) is largely responsible for the depletion of fish stocks in the North Pacific and elsewhere (Pitcher, 2001).

The proponents of the proposal replied that: (1) much of the existing data is only qualitative and insufficient for modelling purposes; (2) feasibility results show that much of the prey consumed by whales is comprised of species targeted by fisheries for human consumption (walleye pollock, Pacific saury, common squids); (3) that because fish prey on fish it is important to understand not only direct relationships between cetaceans and fisheries resources, but also prey-predator relationships of other species in order to develop ecosystem models; and (4) the fact that overfishing is the primary cause of depletion of fish stocks is not an argument against the conduct of the research since it implies the need for better fisheries management.

The authors of SC/54/O26 replied that this response missed the major point of their argument. The major premise of the JARPN II programme is that cetaceans are the main cause of fishery problems. The points they made above (fish being the major predators of fish, and human over-exploitation of fish stocks being the major reason for

their decline) *invalidate* this premise. They continued that no one would dispute that better fisheries management is required; however, this should not be management that ignores the real causes of fish stock declines and is based instead upon the culling of cetaceans. The proponents responded that this was an inaccurate characterisation of both the premise of the JARPN II programme and the proponents' views concerning the need for improved fisheries management.

Some members noted that while the sample sizes for minke, Bryde's and sei whales appear appropriate, given the at least six-year timeframe, the sample size for sperm whales is lower than can be expected to give statistically significant results. Some members also noted that there was no mention of using historic data, market samples and bycatch samples to resolve questions of seasonality of presence of the J-stock of minke whales. Proponents noted that historical samples have been used previously (Goto *et al.*, 2000), although sample sizes are small in many cases. Market samples cannot be used because localities and dates of catches are unknown. The proponents argued that bycaught whales are not useful to study feeding habits because their stomach contents represent the fish caught by the net.

Further specifications were requested to examine how the sample sizes were calculated and established to adequately answer the questions identified for the completion of the research. The proponents responded that for JARPN II, required sample size of common minke whales, Bryde's whales and sei whales in sub-areas 7, 8 and 9 were re-examined based on the results of JARPN between 1994 and 1999 as well as the feasibility study of JARPN II in 2000 and 2001. In addition, the data of past commercial whaling was used for calculation of the sample size of sei whales. The method used was the same as that applied in North Atlantic minke whales (Norway, 1990). The purpose of these statistical examinations is to estimate the prey consumption by minke, Bryde's and sei whales with appropriate accuracy ($CV = 0.2$) in the period of the year in which the survey is conducted.

Conclusions

In relation to the guidelines 1-4, some members argued that the feeding ecology objective is both relevant to the interests of the IWC, and that it addresses other critically important research needs. Others argued that the assumptions inherent in the proposal about that objective were too simple, and unduly emphasised direct negative effects of cetacean predation over the balance of the several potentially negative and positive effects of fishery resources and cetaceans on each other. Therefore, they concluded that the objective as structured and proposed is not relevant to the interests of the IWC.

Some members pointed out that while the Committee has identified pollution as a priority issue, the pollution-related objective does not relate to the specific goals of the POLLUTION 2000+ project. The proponents argued that the proposal aims to address wider goals than that, including long term monitoring of levels. The Committee **agreed** that this objective is relevant to the interests of the IWC.

The stock structure objective addresses those species for which an RMP *Implementation* is under development. The Committee **agreed** that this objective is relevant to the interests of the IWC. However, some members contended that, because of sampling design, the JARPN II programme would not yield results that would adequately meet this objective, and disagreed that lethal sampling was required. Other members disagreed with these statements.

C. Methodology

The relevant guidelines are as follows:

1. Comments on the methodology of the proposed research and an evaluation of the likelihood that the methodology will lead to achievement of the scientific objectives. These comments may also include evaluation of the methodology in terms of current scientific knowledge (*Rep. int. Whal. Commn* 36:133);
2. The objectives of the research are not practically and scientifically feasible through non-lethal research techniques (*Rep. int. Whal. Commn* 37:25);
3. ... whether the information sought could be obtained by non-lethal means (Resolution 1999-2);
4. The research addresses a question or questions that cannot be answered by analysis of existing data and/or use of non-lethal research techniques (*Rep. int. Whal. Commn* 38:27-28);
5. Whales will be killed in a manner consistent with the provisions of Section III of the Schedule, due regard being had to whether there are compelling scientific reasons to the contrary (*Rep. int. Whal. Commn* 37:25);
6. The research is likely to yield results leading to reliable answers to the questions being addressed (*Rep. int. Whal. Commn* 38:27-28).

Proposal (summary of SC/54/O2)

Research methods, including the establishment of survey tracklines, follow those of the two-year feasibility study of JARPN II conducted in 2000 and 2001 (Fujise *et al.*, 2001; SC/54/O16; SC/54/O17). A zigzag survey track line was established to take into consideration the need: (1) to randomly cover the survey area; (2) to obtain a wide area of coverage; (3) whale migration patterns; and (4) vessel logistics including cost. Major changes in the full-scale research are: (1) the addition of 50 minke whales taken by small-type whaling catcher boats; (2) the inclusion of 50 sei whales; (3) an eastward extension; and (4) stratification of the research area for the feeding ecology and ecosystem studies (see fig. 2 of SC/54/O2).

No selection will be made as to sex and size in the sampling except for bull sperm whales that are too heavy to lift onto the *Nisshin Maru* (over 10m of body length) and the Bryde's whale cow/calf pairs that will not be sampled. The sampled whales are measured in the same way as in JARPN.

Whales sampled under special permit will be killed in a quick and effective manner by means of explosive harpoons consistent with the provisions of Section III of the Schedule. When whales are not killed instantaneously by the primary killing method, an appropriate secondary method will be chosen according to the species and condition. For minke whales, a large calibre rifle will be used; for Bryde's, sei and sperm whales a large calibre rifle or a second explosive harpoon will be used if necessary.

All sampled whales will be processed in accordance with Article VIII (2) of the ICRW. Tissues will be taken and DNA data be registered for individual identification and market control.

FEEDING ECOLOGY AND ECOSYSTEM STUDIES

Stomach contents of sampled whales will be examined for number, weight and body size by prey species (Haug *et al.*, 1995). For fully digested prey, hard tissues (otoliths and squid beaks) will be used for species identification and body size estimations.

Concurrent prey species studies will be conducted by acoustic recording of prey species abundance and horizontal and vertical distribution. Echo recordings will be verified using mid-water trawl, drift nets and hand jigs. The catches will be sorted by species and weighed. At each operation, about 100 individuals of the main species will be selected at

random and measured to the nearest cm, while 10 individuals will be collected for further biological measurements including stomach contents.

Prey consumption by cetaceans will be estimated using two methods: (1) based on energy content of prey and standard metabolism (e.g. Lockyer, 1981; Folkow *et al.*, 2000; Watanabe *et al.*, 2000); and (2) based on temporal changes of the weight of stomach contents in a day (Bushuev, 1986; Tamura *et al.*, 1997; Tamura and Fujise, 2000). Seasonal consumption of each prey species by whales will be estimated from consumption per day, composition of prey species and the number of whales in the area.

Cetacean prey preference will be estimated by comparing the prey composition in stomachs of whales and prey abundance in the environment based on the concurrent whale and prey surveys in a narrow area (Lindstrøm and Haug, 2001). Two indices will be used to express the prey preference: the relative frequency of occurrence by number, and the individual number index (Lindstrøm *et al.*, 1998).

MONITORING OF ENVIRONMENTAL POLLUTANTS IN CETACEANS AND THE ECOSYSTEM

Samples of blubber, liver, kidney, muscle, other tissues and blood from each sampled whale, and some prey species from stomach contents and trawl surveys will be collected and analysed for pollutants. Concentrations of contaminants in organisms at lower trophic levels, sea water and air will also be analysed. Chemicals to be analysed include the heavy metals, organochlorines (PCBs, DDTs, HCHs, HCB and CHLs) and dioxin related compounds (PCDDs, PCDFs and coplanar PCBs) (Honda *et al.*, 1982; Iwata *et al.*, 1993; Tanabe *et al.*, 1994; Aono *et al.*, 1997; Kang *et al.*, 1997; Tanabe, 1998). Sex hormones, P450, AH receptor and other 'biomarkers' will be analysed (e.g. Saito *et al.*, 1986; Subramanian *et al.*, 1987).

STOCK STRUCTURE

Studies of stock structure will follow the methods outlined for JARPA. Samples from all sampled whales and biopsy samples will be analysed for genetic variations using allozymes, mtDNA sequencing of control region and microsatellites (Wada and Numachi, 1991; Goto and Pastene, 2000; Goto *et al.*, 2001).

To address O-stock versus W-stock issues data will be analysed following the recommendation from the Scientific Committee that all J-stock whales should be removed for all comparisons (IWC, 2002d, p.98). Mixing rate between O- and J-stocks in sub-area 7 will be estimated by two methods: (1) the maximum-likelihood method (Kishino *et al.*, 1994; Pastene *et al.*, 1998) based on allele/haplotype frequencies obtained from the genetic markers; and (2) individual assignment using mtDNA sequencing profiles complemented with other independent biological and ecological markers. If the putative W stock is confirmed in offshore areas, the mixing rate between O- and W-stocks will also be examined using genetic markers.

Comments and discussion by the Scientific Committee

FEEDING ECOLOGY AND ECOSYSTEM STUDIES

Some members felt that the ecological methodology proposed to be used was sound and that the methods proposed are those most likely to meet the objective. They argued that direct examination of stomach contents from lethal samples is preferable to biochemical analysis of tissue samples, such as fatty acid and isotope analyses. The latter methods cannot provide as detailed a picture of the diet (including individual species identification, segment of prey,

or seasonal and regional variation). Further, stomach samples allow the simultaneous comparison with fishery survey results.

Other members noted that if this objective is to be pursued, the methods proposed to be used are not the best ones. Some noted that there were promising non-lethal methods that would yield more reliable results. They felt, for example, that stable isotope analysis of biopsy tissue would provide a long-term signal of diet, and its variation in time. This was more useful than stomach analysis, which provides only a snapshot view of recently consumed prey that can be a misleading indicator of overall diet, especially for species like minke whales with a large variation in prey species over space and time.

The proponents pointed out that as noted, the advantage of stable isotope and fatty acid analysis is to provide a long-term signal of diet, but that this method can only elucidate the trophic level of prey on average. However, it cannot identify species nor which segments of the populations are being consumed. Further, these methods cannot provide any resolution in space and time. This is important since there is seasonal and geographical change of prey of minke whales and Bryde's whales in the research area. This means that Japanese anchovy, and Pacific saury and lantern fish would be treated as one group. This is the most important reason to use stomach content analysis that will provide long-term information on the variation of prey.

Based on Norwegian experience with minke whale feeding ecology, the stomach evacuation method was problematic. For this method to be used successfully, the rate of emptying the forestomach, where samples are proposed to be collected in order to minimise the variability in results due to the variable rates of digestion, must be determined. Gales noted that several factors affect the rates of digestion, which begins in the forestomach and continues throughout the complex gastrointestinal tract. Some factors relate to variations in the behaviour of the cetacean itself (e.g. level of activity, meal size, method of passing indigestible parts). Other factors relate to the nature of the prey (e.g. taxa, size, energy content, relative digestibility, presence of relatively indigestible hard parts). These factors result in various biases in calculations based on prey remains in stomachs. Some members felt that the proposal did not adequately address how these methodological issues would be addressed, thus making the utility of the results uncertain. However, Tamura responded that the research method will be forestomach samples, where digestion begins, and that this will allow quantitative reconstruction of prey species composition.

The second statistical method of estimating prey consumption used in the Norwegian studies of minke whales, involving scaling prey species composition from stomach contents according to the energy requirements of the animal, was regarded as more useful. Gales noted, however, that current estimates of metabolic rates of other baleen whales are extrapolations, based on volume to surface area ratios and on food intake. These estimates must be regarded as indicative only. The risk of inaccuracy is high, and they fail to completely consider the effects of season and diurnal activity patterns.

Tamura stated that it is possible to raise the reliability of predation rate estimates by combining methods of stomach evacuation and field metabolism.

Vikingsson believed that the calculations in appendix 2 of SC/54/O2, which divides the total consumption into prey composition by species, are premature at present but that the proposed research is likely to strengthen the basis for such

calculations. He agreed that there are many problems of interpretation associated with the stomach content analysis. Some of these can be accounted for by taking into account different digestibility of prey and by comparison with a sub-sample containing only fresh prey. Problems associated with digestibility increase when sampling is conducted further along the digestive tract. It is generally recognised that analysis of diet based on scats is less precise than that of stomach contents. On top of that, sampling of faeces in the sea creates various additional problems associated with representativeness of the samples, for example due to limited knowledge of defecation behaviour of whales and of different sinking rates of particles in the sea.

It was also pointed out that one difficulty with analysis of stomach contents, both directly and biochemically, is distinguishing which items are actually from the stomachs of the animals directly preyed upon, that is prey of prey.

Tamura noted that the prey of prey cannot be detected from other methods either e.g. faeces samples (see below). Tynan stated that in studies of smaller organisms such as plankton species, oceanographers had developed sophisticated opening and closing nets.

New methods were described that have been (fatty acid and stable isotope) and are being developed (genetic analysis) to determine prey composition that can be applied not only to non-lethal tissue samples but also to faecal samples. These methods vary in their degree of specificity, with some allowing only general trophic level or general prey taxa, while one new genetic method (SC/54/O7) allows identification of the krill component of diet. Developers of that method feel that it is likely to soon be capable of species level identification of all components of the diet. Kato noted that while faeces can be collected for some species, this is very difficult for sei, Bryde's and minke whales.

The proponents noted that non-lethal methods are problematic. Problems include the inability to identify prey of prey species, and that daily prey consumption cannot be calculated. Further, there may be problems with some of these methods for detecting very small otoliths from prey species such as Japanese anchovy. Some members noted that the advantages and disadvantages of various methods for determining the diet composition of marine mammals have already been discussed and summarised at a NAMMCO workshop held in Norway in September, 2001. They also noted that methods of stable isotopes and fatty acids will be used in conjunction with stomach sampling in JARPN II.

Cooke noted that estimation of prey consumption using the stomach evacuation method required diurnally distributed sampling in order to reliably determine how long food remained in the forestomach, but this was not envisaged for JARPN II. The alternative method, of scaling up relative diet composition to an estimate of absolute food consumption based on total energy requirement, was problematic when using data from only a limited season. Because whales can store energy, their average total energy requirements are a poor guide to the amount of energy assimilated over a limited season.

Relative to the diurnal issue, the proponents plan to conduct laboratory studies to estimate digestion rates of stomach contents. Further, they responded that there are no data on night feeding of either minke or Bryde's whales. Relative to the seasonal issue, they agreed that the seasonal limitations of the proposed research make determining annual rates difficult, but noted that their purpose is to estimate the prey consumption during the research period. The research period will be extended to early spring and late autumn to cover most of the feeding season.

Some members noted that the method of determining prey preferences was problematic. The method essentially involves comparison of prey observed in stomach content samples to the existence of potential prey, determined by echolocation and trawl samples in the region of feeding whales. The inference to be drawn here is indirect at best, and assumes that other factors such as patchiness of prey density do not affect what a whale chooses to prey on at that particular time. Uncertainties in prey preference are a critical component in understanding the overall feeding patterns of whales.

The proponents stated that preference at an individual level is important in feeding ecology, but in JARPN II, the focus is put on the prey preference of cetaceans for the group as an input parameter to the ecosystem models (SC/54/O17). In most of the ecosystem models, the population models for each fish and marine mammal are integrated with the prey and predator interactions. Prey and predator interactions are defined with several factors: abundance of predators, days staying in the area, daily rations and diet compositions. Diet compositions could be estimated directly from the stomach contents. Diet compositions would be affected by the biomass of each prey, distributional overlaps with predator and prey, and prey preference of predator. Therefore prey preference in the ecosystem model should be an effective parameter to adjust for the difference between diet composition in the stomach and prey composition in the sea, with reflecting the distributional overlap. As the target area is stratified in most of the ecosystem models to express the distribution pattern and migration, distributional overlap will be considered on a stratum basis. Thus, the concurrent whale and prey surveys conducted in JARPN II are at an adequate spatio-temporal scale to estimate prey preference for the ecosystem model.

Some members noted that the sei whale is known to primarily prey on copepods, and that the proposal fails to cite the work of Nemoto and Kawamura (1977) who analysed over 21,000 sei whale stomachs. Those authors showed that only 3.4% of those stomachs included fish while 82% included copepods. The new samples would add little to that wealth of information.

The proponents noted that Nemoto and Kawamura (1977) examined samples collected between 1952 and 1971 between latitude 33° and 55° N, and that the conclusions there about copepod consumption pertained to the Bering Sea and near the Aleutian Islands. This research area is totally different from the JARPN II research area, and the 50 whales proposed will add significant new information. Those authors also reported that sei whales in the southern western Pacific Ocean and those from around Japan eat mainly fish, not copepods. This latter conclusion was also supported by earlier work by Mizue (1951) and Kawamura (1973), who noted that sei whales consumed anchovies, Japanese sardines, mackerel, Pacific saury and common squid in that region. Thus the diet of this species varies regionally. In addition, those studies were more than 30 years old and therefore difficult to incorporate into ecosystem models, as many aspects of the ecosystem are likely to have changed over that period.

Some members noted that it is widely recognised that sperm whales feed on deep-water squid, as the proposal acknowledges, and that this is based on examination of a large number of the stomachs of the more than 400,000 taken in the Southern Hemisphere in the 20th century. The proponents noted that the feasibility study demonstrated that sperm whales also take pelagic zone squid as well as fish, as described in appendix 3 of SC/54/O17. However, Best raised

a question about the interpretation of those results. He said that those results indicated that the pelagic species listed as the most important was only found in one whale, and although this species comprised 95% of the stomach contents by weight, it was likely represented by as few as six individuals. Thus he concluded that there is little evidence for sperm whales consuming other than deep-water squid. The proponents noted that other species listed in appendix 3 of SC/47/O17 indicated with a * and ** symbols were also pelagic. Best raised the possibility that these may be prey of prey. Tamura responded that they did not use separated beaks and thus the results do not include the prey of prey.

Some members noted that the ability of Ecopath and Ecosim to take account of biological interactions is dependent on the accuracy of the input data for all species in the ecosystem as well as the validity of the assumptions of modelling technique. Although JARPN II proposes to use an ecosystem framework to examine these biological interactions, little or no information is given in the proposal on the input data beyond cetacean species. Only limited information is presented on the concurrent prey and no information is presented on phytoplankton, zooplankton (beyond krill), benthic species, detritus and fish/squid species not covered by the prey surveys (such as deep water species). Although sensitivity analyses may determine that certain species are less important for exploring specific questions, such analyses have not been presented here, and these lacuna are fatal to this proposal's credibility.

The proponents responded that historical data on the catch statistics and resource surveys are available. For example, a drift net survey targeting flying squid has been conducted for more than 10 years along the longitudinal line 155°E. These data can be used to estimate 'vulnerability'. On the other hand, the concurrent prey survey in JARPN II is specifically designed to acquire local prey abundance to estimate the prey preference of cetaceans. National fisheries research institutes have conducted extensive fishery resource surveys covering a wide area to estimate the stock abundance. Both resource survey and JARPN II data will be used in the model. Sensitivity analyses and other work are being conducted for Ecopath with Ecosim using data from JARPN II. Certainly some species are less important in the model. However, they are still included because the results are preliminary ones and additional data are being collected.

Some concerns were expressed concerning the absence of specifying a time step for the models, the need for winter sampling to meet the usual annual averaging approach used in Ecopath/Ecosim applications, how to apply this model to systems with migratory species, and lack of information of residence time of the migratory species. Further, the proposal fails to provide details of how fisheries in the region, the recent decline of fish stocks, and the implied lack of mass-balance are to be handled in the modelling process.

The proponents stated that one of the weak points of Ecopath with Ecosim may be using a yearly time step. It is desirable to conduct winter sampling but data from spring/summer/autumn have higher priority at present. The same can be said regarding the treatment of migration. Ecopath with Ecosim is being spatially extended as Ecospace now. Also the information on migration and residence time is incorporated in the Multispec model, while it makes the input data enormous. The merits of both Ecopath and Multispec models are being explored and an integrated model will be built in the future. Information on fisheries is incorporated in both Ecopath with Ecosim and Multispec models in different ways. Since Japan has the

necessary data and is the biggest fishing country in the western North Pacific and since catch and bycatch data are also collected in other countries such as Russia, Korea and China, there is no serious problem on this point.

Norwegian scientists noted that based on their experience, stomach evacuation methods are difficult to use for minke whales, and possibly for other cetacean species. In contrast, the metabolic rates of minke whales are well understood. Using this approach, however, requires large scale (macro to meso scale) information about the resource base, abundance as well as spatio-temporal distribution throughout the year. The proposal does not identify the degree to which this information is available in Japanese waters. Other members agreed that stomach sampling provides only micro-scale information, whereas the energetic requirements approach requires sampling over the entire feeding season while the proposed sampling covers only a portion of that period.

It was noted that one approach to obtain better spatial and temporal coverage was using satellite tagging. The results of a large scale tagging experiment (with parallel biopsy sampling) would be a highly valuable non-lethal component of the research programme. Tynan agreed, and suggested that combining these approaches with telemetric measurements of dive patterns would be valuable.

The proponents noted that three National Fisheries Research Institutes are responsible for resource monitoring and stock assessment for seven fishery resources, including saury, walleye Pollock and common squid. A large amount of data and information including historical aspects are provided to the JARPN II programme. The proponents are making an effort to develop satellite tagging methods. They also described changes in Japanese fisheries management.

Some members noted that models such as Ecopath, Ecosim and Multispec have not yet been used for management (Aydin and Friday, 2001). They noted that although the culling of cetaceans may free biomass for use by other species, the ability of such models to accurately predict which species in the ecosystem will benefit from this freed biomass, and the magnitude of any increase in commercial fish biomass, is unknown. Further, preliminary studies of simplified food-web models indicate that there is considerable uncertainty in the response even when climate variability is ignored. One major uncertainty that determines much of this behaviour is the required 'vulnerability' parameter, which controls the degree to which trophic relationships are bottom-up or top-down controlled.

Norwegian scientists noted that contrary to what is asserted above, the original version of Multispec, which addressed only fish-to-fish interactions, has been used in the process of fisheries management of cod, herring and capelin in the Barents Sea. They explained that the catch limit for capelin is computed by first using Multispec to estimate the expected mortality of capelin due to cod predation in the presence of herring and other food items for cod. If that mortality leaves capelin above a threshold level otherwise determined, the difference is allowed as a fishery harvest. The capelin-cod interaction is modelled through the use of empirically determined spatial-temporal distributions and the diet preferences and consumption rates for cod. They noted that the fishery resource survey requirements for determining these inputs are substantial.

The likely ability of research programmes such as that proposed and the earlier study by Norway to meet their objectives was suggested to be a function of the proportion of the mortality due to all top predators that is caused by cetaceans. In a model with cod, herring, capelin and minke whales, with mortality of fish due to harp seals and other

predators left as residual mortality, the abundance of minke whales was found to significantly influence the continuing catch of cod (more whales, less cod caught) indicating that minke whales contribute a large proportion of the total mortality (Schweder *et al.*, 2000). Haug suggested that the consumption by minke whales was about half that of harp seals.

Kawahara referred to historical variations in fish abundance, and suggested that the effect of cetacean predation may vary with the variation in relative abundance of the respective fish species. Okamura reported verbally on some preliminary Ecopath simulation studies that considered a much larger number of both cetaceans (six species) and fish (five species) top predators. Pinnipeds were regarded not important in the study area. Okamura further noted that given the many assumptions involved, total mortality due to cetaceans exceeded that due to other species by two to one. The authors of SC/54/O26 noted that the cetacean consumption estimates have not been reviewed, and questioned the validity of these statements.

MONITORING OF ENVIRONMENTAL POLLUTANTS IN CETACEANS AND THE ECOSYSTEM

The argument was raised that a range of the questions of relevance to the pollution objective could be addressed by non-lethal sampling. Other members were concerned that biopsy samples are restricted to skin and outermost part of the blubber, and that the limited control over the sampling site would compromise the utility of samples collected in that manner. Further, lethal samples allow collection of supplementary information, although there was no consensus on the requirement of such lethal sampling.

STOCK STRUCTURE

The most serious criticisms from some members were raised regarding stock structure objectives for minke and Bryde's whales. It was noted that only 16 and 29 samples were taken to address the O/W stock question, which remains a major source of uncertainty in *Implementation Simulation Trials*. This sample size is completely inadequate to make progress on reducing this uncertainty. Proponents replied that JARPN II is not designed to optimally determine stock structure, and therefore gives only low priority to this objective. However in these two surveys 1,190.6 n. miles and 5,776.9 n.miles of searching effort were covered in sub-area 9, and bad weather prevented the collection of more samples. Samples are obtained through systematic surveys.

It was further noted that the proposal made no mention of designing experiments to avoid further takes of J-stock animals, although the stock status remains unknown and incidental bycatch mortalities remain high. Further, no mention is made that with respect to obtaining further data on the mixing rate of J-stock into sub-areas 7 and 11, there are substantial historical samples and samples from current bycatch that should be analysed and published before further catches are allowed. The proponents responded that there is no plan to sample minke whales in sub-area 11. Regarding sub-area 7, the observed mixing rate of J-stock animals is low in this area and changes by month. The Seattle Workshop (SC/54/Rep1) agreed that the data to be used to condition the simulations would be based on a mixed stock analysis of the data for sub-area 7, pooled over both month and sex. It was agreed that the *Implementation Simulation Trials* include a value for mixing rate of J-stock of 2.8% for this sub-area (SC/54/Rep1). Therefore they estimate the take of J-stock animals will be only less than 3% on average.

Historical samples of minke whales in sub-areas 7 and 11 have been already examined by mtDNA and microsatellite (Goto *et al.*, 2000). Bycatch samples have been and will be analysed for stock identification, but these samples cannot be directly used for mixing rate calculations because of the lack of representativeness.

The authors of SC/54/O26 noted that the proposal identified 'weak genetic differences' for Bryde's whales, but it does not give any details. SC/54/O17, appendix 10, table 4 compares JARPN II ($n=84$) to samples from the coastal waters off Ogasawara ($n=103$), and shows a χ^2 p -value of 0.02. This is not 'weak' evidence. Other comparisons to the central North Pacific ($n=95$) showed non-significant differences, but no statistical power calculations are given and the sample sizes are low compared to those for minke whales. Further, concerns were raised that Ogasawara was proposed as a future site for scientific whaling despite the uncertainties about stock structure and considering the past heavy commercial harvest that occurred several times in this region.

The proponents noted that the expression 'weak genetic differences' should be interpreted in a wider context because examination of genetic heterogeneity among localities was made using different genetic markers and different statistical methods. Only one of a large number of comparisons was significant. Further, the data being compared were collected about 20 years apart and any differences could be temporal rather than spatial. The proponents stated that there is no plan to sample around Ogasawara Island.

The proponents also noted that methods for appropriate statistical power calculations are still under discussion. Further, the other biological and mark-recapture studies are consistent with the genetic results, as they provide no evidence for the occurrence of additional stock structure in the western North Pacific. They also noted that Bryde's whales do not remain in this area year-round and that the Committee's Comprehensive Assessment did not agree that there is an independent stock around Ogasawara Island (IWC, 1996).

In addition to these specific points, several general points were raised. Some members noted that samples for genetic analysis of stock structure should be obtained from biopsy tissue samples (not lethal sampling); such sampling is routinely conducted elsewhere in the world. The proponents responded that such sampling would require a large sampling effort, and that lethal random sampling as planned in this programme has the advantage of combining genetic and non-genetic methods.

The authors of SC/54/O26 also pointed out as a general criticism that in every case where population structure has been found, genetic data alone were sufficient to make the case. In cases where major uncertainties remained, such as for pelagic North Pacific minke whales, JARPN II will not resolve those uncertainties because it is not designed to optimally determine stock structure for use in RMP *Implementations*. Specifically, there are no plans to sample on the breeding grounds (as is recommended every year) or the wider feeding grounds, but rather sampling will continue on migration or in only small parts of the feeding grounds.

The proponents argued that the above criticism does not take account of priorities among the research objectives. JARPN II places lower priority on stock structure studies and therefore is not intended to be optimally designed for this purpose. Further, they felt that stock structure should be studied in the migration corridor as well as on the breeding and feeding grounds, even if interpretation is difficult, because mixing among stocks in this area is very important.

They also noted that they have conducted non-lethal research in the low latitude areas to clarify breeding grounds for large cetaceans and that the results have been inconclusive for minke whales.

Finally, the authors of SC/54/O26 noted that extensive samples are available from historical commercial catches and no mention is made of mapping where remaining samples come from, or analysing those samples to allow for a more modern assessment of population structure prior to further whaling. The proponents responded that most of the historical samples had been analysed for the assessment of stock structure. However, further scientific permit sampling is needed mainly for the objective of feeding ecology and ecosystem modelling.

Conclusions

In summary, several members argued that a range of questions of relevance to all identified research objectives could be addressed by non-lethal sampling techniques, e.g. for pollutant monitoring (biopsy sampling for fatty acid and stable isotope analysis), for stock structure (photo identification, biopsy sampling and faecal sampling), and for feeding ecology (faecal sampling).

The proponents argued that lethal sampling was necessary to meet the research objectives, especially for feeding ecology and pollution. Quantitative data on prey are required for modelling purposes. At present, non-lethal sampling techniques are inadequate for this purpose. Others noted that they did not agree that the feeding ecology objective was appropriate, and therefore did not feel that lethal sampling was required. For the stock structure objective, they argued, non-lethal biopsy sampling would allow much larger sample sizes and hence allow greater statistical power.

The proponents argued that the performance of the RMP depends on the accuracy of the reproduction curve, and lethal sampling allows data on biological parameters that are difficult to obtain without lethal methods. Further, data on morphology, and external and internal parasites are essential for stock identification. Further, stock structure work is mainly focused on minke whales, where biopsy sampling is difficult in the open sea. Finally, highest priority is given for feeding ecology studies, where lethal sampling to obtain stomach and other samples is required. However, non-lethal sampling techniques (biopsy sampling for fatty acid and stable isotope analysis) will also be used.

It was asserted that it was not the case that the performance of the RMP depends on the accuracy of the 'reproduction curve'.

Relative to guidelines (1) and (6), some members felt that the experimental design and methods to be used were inadequate to meet the proposal's objectives. Others felt that the proposed research would allow the highest priority objective, feeding ecology, to be addressed adequately.

Relative to guidelines (2)-(4), some members felt that non-lethal means could be used for all aspects of the proposed research. Others felt that this was true for parts of the lower priority objectives of pollution and stock structure, but not for the first priority objective.

Relative to guideline (5) the Scientific Committee noted that should whales be killed under this proposal, the proposal describes methods for killing in a manner consistent with the provision of Section III of the Schedule.

D. Effect of catches on the 'stock'

The relevant guidelines are:

- (1) A review of the most recent information on the stock or stocks concerned, including information on any exploitation, stock analysis and recommendations by the Scientific Committee to

date (including, where appropriate, alternative analyses and conclusions and point of controversy) (*Rep. int. Whal. Commn* 36:p.133);

- (2) An evaluation of the specification in the permit proposal of 'possible effect on conservation of the stock'. As appropriate, the Scientific Committee may carry out its own analysis of the possible effects (*Rep. int. Whal. Commn* 36:133);
- (3) The research can be conducted without adversely affecting the overall status and trends of the stock in question or the success of the comprehensive assessment of such stocks (*Rep. int. Whal. Commn* 37:27-28).

Proposal (summary of SC/54/O2)

A total of 150 minke whales will be sampled annually, assuming 90 from sub-areas 7 and 30 from each of the sub-areas 8 and 9. Incidental catches (IWC, 2001c) are taken into account when the effects of stock are estimated using HITTER simulations. Two scenarios are used for the O-stock: (1) all whales from sub-areas 7, 8, 9, 11 and 12 are from the O-stock; (2) all whales from sub-areas 7, 8, and 11 are from the O-stock; in sub-areas 9 and 12 the percentages of O-stock are 70% and 81.3%, respectively; the other whales are assumed to be W-stock, see Pastene *et al.* (2002) for explanation. A male sex ratio of 79.2% (based on results from JARPN II, 2000-2001) was assumed for the sampled whales. Incidental takes by sex in sub-areas 2, 7, and 11 are taken into account. The best estimates of total 1+ abundance for the O-stock are 25,591 (5% lower limit 16,894) used in scenario 1, and 20,872 (5% lower limit 13,907) in scenario 2. These estimates are based on specifications of the North Pacific minke whale trials (IWC, 2001e).

HITTER runs were conducted for the two scenarios (using both the best estimate of abundance and the lower 5% limit) and MSYR of 1-5%. All cases examined show that the proposed catches allow the population of mature females to increase over a 30-year period (2002-2032).

For Bryde's whales two scenarios are considered (1: all whales from sub-areas are from one stock; 2: all whales in sub-area 1 are from one stock). Abundance estimates for 1992 (Shimada and Miyashita, 1997) of 21,403 (5% lower limit 15,856) in 1992 is used in scenario 1, and 19,301 (5% lower limit 13,913) for scenario 2. In the HITTER simulations MSYR of 1-6% are used, and the simulations show that the proposed catches allow the population of mature females to increase over a 30-year period (2002-2032) for all cases simulated.

For sei whales, an abundance estimate of 28,369 (CV = 0.405) for 1999 is applied (appendix I of SC/54/O2). A sex ratio of 1:1 is assumed. The HITTER runs show that the proposed catches allow the population of mature females to increase over a 30-year period (2002-2032) for all cases studied.

No calculations were made for the sperm whales. However, an annual take of 10 whales from the Western Division stock was assumed to be below the critical level to affect the stock given the large size of this population.

Comments and discussion by the Scientific Committee

Some members noted that analyses of possible effects based on the HITTER population model reported in appendix 6 of SC/54/O2 for western North Pacific stocks of minke, Bryde's and sei whales, even under the most conservative assumptions considered, showed continued growth of these stocks over the next 30 years under the proposed sample sizes. The results for each species were discussed separately.

MINKE WHALES

Some members referred to the preliminary results of minke whale *Implementation Simulation Trials* presented to the Committee at its last meeting (Allison, 2002, pp.124-5). They judged from those results that the proposed minke whales sample sizes may adversely affect the stock defined for the *Implementation Trials* as that nearest the Pacific coast of Japan (herein referred to as the O-stock). In two example trials that resulted in acceptable levels of final depletion, the average allowed catches were 2.4 and 18.4 animals annually, with even the upper 96th percentiles (17.6 and 34.4) being far lower than the 50 minke whales proposed to be taken.

The proposal proponents responded that the RMP is designed to provide a long-term sustainable harvest quota for commercial operations, and further that the *Implementation* process has not in any case been completed. Also, they noted that another example *Implementation Trial* (C7F) gave higher average annual catch limits (52.9) with 96% percentile of 98.7 animals in sub-area 7 (excluding incidental catch). Further, they argued that research under Special Permit as specified in Article VIII of the Convention has no relation to the RMP. The fundamental principle is that the research catch should not pose a threat to the stock, and they felt that the calculated effect of the research takes given in the proposal has confirmed that this would be the case.

Some members also raised concern about the effect of this whaling operation on the J-stock and the compounding of the level of possible unintentional removals of this stock with the substantial present bycatch, which itself exceeds the example *Implementation* results noted above. These members contended that the status of this J-stock is poor, and they felt strongly that this research under Special Permit could pose a threat to this stock, especially because of the unlimited duration of the study.

They noted that the proposal acknowledges this potential problem by partially mitigating it by restricting the JARPN II sampling in some months in sub-area 11 (April and July). However, 22% and 35% of the minke whales in this area are J-stock animals in June and August respectively. In addition, the mitigation does not include sub-area 7, where 13 and 22% of minke whales are J-stock females in May and August, respectively, and 13% are J-stock in September. They felt that further season-area restrictions are required to avoid a negative impact on the status of J-stock animals.

The proponents pointed out that there is no plan to enter sub-area 11, and noted that the mixing rate of J-stock animals is low and changes by month and year, and therefore the Seattle Workshop agreed (SC/54/Rep1) that the *Implementation Trial* structure includes a value for catch mixing rate of J-stock of 2.8% for sub-area 7, pooled over both month and sex. They conclude that the estimated take of J-stock animals will be less than 3% of the sampled animals, on average, and they feel that this is a negligible effect.

Several members requested that an evaluation of the effect of the research under Special Permit on the J-stock be reported next year if this research is conducted.

BRYDE'S WHALES

Some members thought that, although the HITTER calculations suggest that proposed catches of the Bryde's whale stock should not adversely affect the overall status of the stock, there is strong evidence ($p < 0.02$) for stock differences between Ogasawara and the coast of Japan, as discussed above. This observation is contrary to the suggestion that Ogasawara should be a preferred site for lethal sampling in JARPN II (SC/54/O2). These members felt that targeting whaling around Ogasawara is particularly

undesirable because of heavy commercial exploitation in this area during the past and consequently the unknown status of Bryde's whales in that area. The proponents responded that several statistical methods were used in genetic analyses to compare localities in the North Pacific and only one resulted in significant heterogeneity between Ogasawara and JARPN II samples. They stated that there is no plan to sample Bryde's whales around Ogasawara Island.

SEI WHALES

Concerns were raised by some members with the estimate of sei whales of 28,400 used in the model. This figure appears to be based on an unreviewed estimate of 4,909 derived from JARPN 1997 and JARPN II 2001 surveys, with subsequent extrapolation using Japanese Scouting Vessel (JSV) data. They noted that the Committee had previously concluded that estimates of abundance using these types of surveys (e.g. fig. 3, SC/54/O16) does not lead to estimates that are comparable to estimates from dedicated surveys (SC/54/Rep1). They also noted that the Committee has not endorsed abundance estimates based on extrapolations using JSV data. Further, they noted that only selected surveys were used for the 4,909 estimate, specifically those that had the highest encounter rates. Finally, they queried why data from other dedicated vessel surveys that have been used to condition *Implementation Trials* for other species (minke whale) were not also used.

Given these uncertainties and questions, they judged that the estimate of 28,400 is unreliable and unacceptable for use in determining the likely effect of whaling under special permit on the sei whale stock. They concluded that the proposed catches are higher than the coastal catches taken during each of the last three years of the commercial fishery, and that such a high catch level should not have been proposed without new reliable information on which to base an assessment, such as stock structure.

The proponents replied that, in fact, the minke whale abundance estimate for sub-area 9 based on the sighting data from JARPN (Miyashita and Fujise, 1997) is used for the *Implementation Simulation Trials* (SC/54/Rep1). Systematic sighting surveys were conducted in the JARPN research. Furthermore, the program DISTANCE version 3.5 was used to obtain the present abundance estimate in the research area. The characteristics of the JSV data are the consistency in recording of sightings over a long period since the 1960s and the wide area coverage. While it cannot be used for direct abundance estimation because it has no sighting distance data (e.g. radial distance, angle), it is useful as a relative abundance index (Miyashita *et al.*, 1994). Therefore if there is no direct estimate, extrapolation using JSV from the directly estimated area is appropriate. In other words, JSV data can be used for extrapolation. For these reasons the abundance estimate in the survey area is reliable.

Further, the proponents stated that JARPN covered 40-90 days during May to September every year. Sei whales in the JARPN research area were widely distributed in June and July, as is indicated by the World Wide Map of the Cetaceans (Miyashita *et al.*, 1995). Because there was not enough sighting effort in these months except for the years 1997 and 2001, the data for those particular seasons were used for the analysis. The main distribution area of sei whales in summer is the colder waters north of the Arctic convergence. The area was very partially surveyed by the dedicated sighting survey in 1990, which was used in Buckland *et al.* (1992) for minke whales. Furthermore the main survey area in 1990 was the Sea of Okhotsk where sei

whales are rare. Therefore, a reasonable abundance estimate for sei whales was derived from the past dedicated sighting survey.

Noting the concern raised that the HITTER simulation runs were carried out with only a point estimate of abundance for this species, the proponents also provided a summary of some additional HITTER runs based on the lower end of the confidence interval (14,747-54,575) using a newly calculated bootstrap variance of the extrapolated estimate of 28,400 (SC/54/O2, appendix I). These calculations indicated replacement yields in 2002 that varied from 152-720 as MSYR varied from 1-6% (Table 8).

Table 8

The effect on the stock of western Pacific sei whales of taking 50 animals (25 males and 25 females) from 2002 to 2031. Depletion is given for mature female component.

Hit 1999 total (1+) population of 14,747 (5% lower limit)						
Statistic	MSYR (1+) (%)					
	1	2	3	4	5	6
K (1+)	49,486	43,433	38,963	35,435	32,508	30,234
Depletion – 1976	17.9%	13.0%	8.7%	5.4%	2.8%	1.5%
Depletion – 2002	27.9%	29.9%	31.4%	32.6%	33.7%	34.8%
Depletion – 2012	30.6%	37.1%	43.8%	50.5%	56.9%	63.0%
Depletion – 2022	33.7%	45.9%	58.7%	70.3%	79.7%	86.2%
Depletion – 2032	37.2%	55.6%	73.2%	85.4%	91.9%	95.0%
RY – 2002	152	297	430	548	646	720
MSY (+1)	297	521	701	850	975	1,088

From these calculations, the proponents concluded that the population would continue to increase under the proposed sample size (assuming equal proportions of males and females in the catches). Based on these calculations and observations of an increasing encounter rate over eight years of surveys, they argued that the stock has recovered and that the proposed sample sizes would not jeopardise the conservation of the stock.

SPERM WHALES

Although no attempt was made to systematically evaluate the possible effects of the take of 10 sperm whales annually, the animals were noted to be a very small proportion of the most recent abundance estimate of 102,112 (Kato and Miyashita, 1998). Some members argued that the abundance estimate given in the proposal is unreliable and likely heavily positively biased because a correction factor used was developed in a study in the Antarctic where the sex and group composition is very different. They felt that this factor, which would increase the abundance estimate, was entirely inappropriate for the study area, where most sightings are of groups of females and young whose surfacing patterns make them much more available for sighting.

The proponents replied that while it is true that the group size and composition is different in the study area, the correction used is appropriate because very frequently the first sighting is a singleton, but during confirmation the other school members aggregate. In addition, additional downward biases of this estimate include lack of sighting effort in the Bering Sea and around the Aleutian Islands,

mean school size was based only on primary sightings, and recent recovery in density in coastal waters suggested by the frequent strandings was not reflected in the estimation.

It was also pointed out that Japanese sperm whale catch data was falsified and represents underestimates of the true catch, further adding to the uncertainty of the status of the population. Proponents argued that nonetheless, the proposed catches are a small fraction of the abundance estimate of 102,112, and the sampling of only 10 whales would have a negligible effect on the population.

The authors of SC/54/O26 commented that the annual increase of 11% in the encounter rate given in appendix 1 of SC/54/O2 has not been subject to review, and that it probably does not reflect population growth rate since this rate of growth is biologically impossible for sperm whales. Further, they referred to research by Whitehead *et al.* (1997) suggesting that sperm whale growth rates are actually extremely low in response to catches of mature males and the consequent lack of 'acceptable' mates for females. The proponents replied that increase of the encounter rate by 11% per year was observed based on the dedicated sighting data from 1983-1996 off the northern Pacific coast of Japan where the most important past whaling grounds were located. In the 1980s, the encounter rate in this area was very low, perhaps because of the effect of past whaling. However, in the 1990s, after the introduction of the moratorium on commercial whaling, the encounter rate increased. The most plausible explanation of this increase seems to be that sperm whales expanded their habitat to the coastal area and returned to their original niche as a result of population recovery. This is supported by the recent frequent strandings and sightings by the general public.

Some members noted that the proposal did not mention that two stocks have been described in coastal Japanese waters (Kasuya and Miyashita, 1988), one of which is likely depleted, and that these waters may include nursery schools. Further, the proposal did not mention the possibility of using frozen historical material for stock structure. This material should be used before additional samples are collected.

The proponents replied that stored samples cover only a small portion (eastern side) of sub-area 9, but not sub-areas 7 and 8 where JARPN II surveys are proposed. The two stock hypothesis referred to has not been examined by DNA methods, and additional data including the historical samples will enable testing of the two stock hypothesis. More importantly, the justification for additional catches of sperm whales is not stock structure, but rather the ecosystem component of the research programme.

Conclusions

It was noted that no information was provided on struck but lost whales in the JARPN II feasibility study, and the Scientific Committee advised that this information should be provided for the continued JARPN II research under Special Permit.

In relation to guidelines (1)-(3), some members judged that based on the information in the proposal there was substantial risk of stock depletion from the proposed sample sizes for both the O-stock and the J-stock of common minke whales, as well as for Bryde's whales should they be taken around Ogasawara Island. These members also judged there was no basis for evaluating the effect of catches on sei whales because the sole abundance estimate involves selective use of surveys as well as extrapolations using JSV data, and the lack of information about stock structure made it uncertain how to evaluate the effect of coastal catches relative to an abundance estimate from the western North

Pacific. A similar concern was expressed regarding sperm whales because of an inappropriate dive-time correction of the abundance estimate.

Other members judged that the proposed research samples would not pose a threat to the O- and the J-stocks, and that the perceived risks for minke whales are being overemphasised. Further, there is no risk for Bryde's whales in the Ogasawara area because this species is not resident and not planned to be taken here. Selective use of survey did not occur in the abundance estimation of sei whales. Rather, based on the distribution of the species in June and July, the survey data in 1997 and 2001 were chosen for calculation of an abundance estimate, which was extrapolated with JSV data. As the research area of JARPN II extends from the coastal area to the offshore area, with the latter being especially important for sei whales, the effect of coastal catches is limited. They believed that the abundance estimates for sei and sperm whales are reliable.

E. Research cooperation

The relevant guideline is:

1. Comments on the adequacy and implications of specified arrangements for participation by scientists of other nations (*Rep. int. Whal. Commn* 36:133).

Proposal (summary of SC/54/O2)

Participation of foreign scientists, especially those from neighbouring countries, is welcome, as long as their qualifications meet the requirements set by the Government of Japan.

Comments and discussion and conclusion

Kim understood that the JARPN II programme is intended to contribute to the overall improvement in knowledge and methodology necessary for the management of fisheries resources as well as whales in the western North Pacific. As the research approach to be used in the programme is new and important in this regard, it would be helpful that the programme be introduced to fisheries science societies within the range states in order to encourage and assist in their participation.

In relation to the guideline, the Scientific Committee **agreed** that adequate provisions for participation by scientists from other nations have been made.

17. WHALE SANCTUARIES (ANNEX N)

17.1 Review of the Indian Ocean Sanctuary

At last year's Committee meeting it was noted that the Commission was expecting thorough reviews of the Indian Ocean Sanctuary (IOS) in 2002 and Southern Ocean Sanctuary (SOS) in 2004 (IWC, 2002d, p.67). In addition, it was noted that the Committee has received two proposals for new sanctuaries in recent years. At that time, the Commission had provided limited guidance as to what it expected from the Committee's reviews of sanctuaries, and an intersessional Steering Group was appointed to develop:

- (1) a process by which the Committee would complete a review; and
- (2) evaluation criteria for the reviews, taking into account the Commission's previous comments and any further advice that might be offered by the Commission.

The review process and evaluation criteria were intended to be used on a trial basis by the Scientific Committee to review the Indian Ocean Sanctuary this year, and if necessary,

would be modified and improved in order to review the Southern Ocean Sanctuary (SOS) in 2004.

During the subsequent Commission meeting, a set of 'Instructions from the Commission to the Scientific Committee to Review Sanctuaries and Sanctuary Proposals' was developed (IWC, 2002a). The intersessional Steering Group on Sanctuary Reviews developed a proposed framework to evaluate the effectiveness of the IOS taking the Commission's Instructions into consideration and additional criteria it considered useful during the review process. These latter criteria focused on the evaluation of: (1) whether the objectives of the IOS have been met; and (2) research in the IOS Sanctuary and its relevance to the Comprehensive Assessment of Whale Stocks.

This year, a Working Group was established to review the IOS and its report is given as Annex N. The Working Group was instructed to limit its Terms of Reference to large whales, but some members thought the review should include small cetaceans.

The IOS was established in 1979 but no scientific objectives were stated in the original proposal. In 1987, scientific aspects of the Sanctuary were reviewed and a list of objectives was prepared based on previous discussions of the proposal and the role of the IOS by the Commission and the Committee (Leatherwood and Donovan, 1991). In reviewing these objectives, the Committee **agreed** that whales were protected from commercial whaling in the Indian Ocean since the Sanctuary was established. There was some discussion of whether other listed objectives had been achieved. Some members indicated that the IOS serves no scientific and conservation purposes because it has been made redundant by the moratorium, and by the RMP if the moratorium was lifted. Others noted that neither the moratorium nor the RMP negate the value of sanctuaries as management tools. They also felt that it is becoming apparent that the time required to evaluate the effectiveness of a sanctuary is much longer than might have been anticipated. Some members noted that lack of research in certain areas prevented the IOS from playing a role as a control region relative to areas where whaling has taken place.

In regard to the information available for large whale stocks in the IOS, the Committee **agreed** that:

- (1) Progress has been made on some stocks of large whales, namely right whales and humpback whales off South Africa and western Australia, but that this is insufficient for a comprehensive assessment of stocks in the entire IOS.
- (2) Studies are underway on some of the other stocks (e.g. Bryde's whales, pygmy blue whales and humpback whales in the Northern Indian Ocean, pygmy blue whales in Australia and in the western Indian Ocean).
- (3) Some species, especially Bryde's whales, are hardly studied.
- (4) Not all of the research that has occurred in the IOS can be definitively attributed to the formation of the IOS; some felt that there was a strong link between the formation of the IOS and their own research, while others asserted that their own research would have occurred regardless of the formation of the IOS.

In reviewing the effectiveness of the IOS with respect to the Instructions provided by the Commission, it became clear that there was a broad range of views among members. It was noted that lack of consensus in earlier discussions suggested that there may be insufficient time to complete the full agenda unless an alternative mechanism for arriving at

detailed statements incorporating all viewpoints was established. Given the general tenor of previous discussions, three small groups were established that broadly encompassed the range of views expressed. Their terms of reference were to:

- (1) evaluate the effectiveness of the IOS according to the Commission's Instructions (Annex N, Appendix 3);
- (2) make recommendations to any aspect of the IOS the sub-group thought might be appropriate to improve it (Annex N, Appendix 3); and
- (3) develop recommendations for the Commission's Instructions for Reviews of Sanctuaries and Sanctuary Proposals (Annex N, item 6).

Each sub-group was assigned a Convenor and was named in the order in which the rapporteurs received their reports (sub-groups A, B and C).

After producing their reports, the Working Group reconvened and attempted to assess whether there was consensus among the sub-groups for each Instruction. The following section contains a compilation of the views expressed by these three sub-groups. Items below are listed according to the Commission's Instructions in Annex N (Appendix 3). Full sub-group reports A-C are given as Annex N, Appendices 4-6 respectively.

(1) Give attention to assessing how well the scientific aspects of the agreed objectives of the sanctuary have been met, and how well they might be met if the sanctuary continues.

SUB-GROUP A

There are no agreed objectives for the IOS so it is difficult to respond directly to the question. However, it can be noted that the IOS serves no scientific or conservation purpose primarily for the following reasons: (1) it has been made redundant by the moratorium; (2) research in the IOS has not provided sufficient information to assess stocks of large whales; (3) even if the moratorium is lifted, the RMP provides more than adequate conservation measures; and (4) its boundaries are ecologically inappropriate. Continuation of the sanctuary will not resolve these issues. For these reasons the sanctuary should be abolished.

SUB-GROUP B

The IOS effectively provides direct protection from commercial whaling to the breeding stocks of all large whales in the Indian Ocean although the precise locations of some of these breeding areas are still unknown. Much of the research in the IOS is aimed at the identification and assessment of other threats. A difficulty in evaluating the Sanctuary is determining which of the research and other activities in the IOS have taken place as a direct or indirect consequence of the sanctuary designation, and which may have occurred anyway. It is also becoming increasingly apparent that the time period required to reach an adequate assessment of something such as the effectiveness of a sanctuary is likely to be much longer than might have been anticipated.

SUB-GROUP C

The objectives have been met in part, but not to any great extent. The major contributions have been continuation of South African right whale and West Australian humpback and right whale surveys, although these would probably have continued with or without the IOS. Some work on humpback and blue whales in the western Indian Ocean has taken place. However, there has been an absence of the

major pelagic surveys necessary if the IOS was to have played its intended role as a control region. In particular, there is no such work on pelagic Bryde's whales, the primary concern of the IOS when motivated. More resources need to be committed if the IOS is to play this intended control role. The IOS may, however, serve to assist to promote some fundraising efforts for research, although this should not be a function of a sanctuary.

COMMITTEE EVALUATION

There was no consensus among the three sub-groups on how well the scientific aspects of the agreed objectives of the IOS have been met, or on how well they might be met if the sanctuary continues. Details regarding areas where opinions differed are presented in the sub-groups' full reports in Annex N, Appendices 4-6. Similarly, there was no consensus within the Committee.

(2) Provide advice on the status and trends of whale stocks in the sanctuary in so far as these are known.

SUB-GROUP A

Meaningful advice cannot be provided on the status and trends of whale stocks in the sanctuary because neither systematic sighting surveys (except for some work on humpback and right whales) nor commercial whaling have been conducted in the sanctuary since its establishment.

SUB-GROUP B

The status of stocks in the sanctuary is summarised in Annex N, table 1. The sanctuary contains examples of: (1) populations which are depleted but known to be recovering; (2) populations which are depleted where the current trend is unknown; (3) populations such as minke whales, which are probably not depleted, but the current trend is under assessment by the Scientific Committee; and (4) populations which are probably not depleted but whose current trend is unknown.

SUB-GROUP C

See Annex N, Appendix 6.

COMMITTEE EVALUATION

The Committee **agreed** that sufficient information exists to review the status and trends of humpback and right whale stocks in western Australia and southern Africa. There is insufficient information available to review the status and trends of other large whale stocks in the IOS.

(3) Assess whether the sanctuary distinguishes between species and stocks that are depleted and apparently slow to recover, those that are increasing rapidly, and those that are abundant and not threatened.

SUB-GROUP A

The IOS does not distinguish between species and stocks. The prohibition on commercial whaling applies to all species and stocks irrespective of the status of stocks. This is one of the major arguments against the IOS in that it provides protection for stocks even when scientific advice demonstrates that such protection is not required for conservation reasons.

SUB-GROUP B

The IOS gives complete protection from commercial whaling to populations in all of the four categories listed above, but distinction between the categories can still be made for research and conservation purposes.

SUB-GROUP C

The IOS does not distinguish between such species and stocks.

COMMITTEE EVALUATION

The Committee **agreed** that the IOS provision does not distinguish between species and stocks that are depleted and apparently slow to recover, those that are increasing rapidly, and those that are abundant and not threatened; the IOS contains populations in each of these categories.

(4) Assess the present and potential threats to whale stocks and their habitats in the area of the sanctuary and how the sanctuary addresses these. Such factors may include inter alia: whaling, fishing, oil and gas exploitation, including seismic surveys, shipping, whalewatching, climate change, other environmental factors.

SUB-GROUP A

No information is available to assess the threats to whale stocks and their habitats. The IOS addresses only commercial whaling. Commercial whaling is not a potential threat because any resumption of whaling would only occur under the risk-averse RMP. The IOS does not address aboriginal subsistence whaling, fishing, oil and gas exploration, whalewatching, climate change or other environmental factors.

SUB-GROUP B

Although the IOS currently only provides direct protection to whales from commercial whaling, much of the research in the IOS is aimed at the identification and assessment of other threats. The results of the research have importance for the development of national protective measures and for the development of future regional and international measures.

SUB-GROUP C

There is at present an aboriginal sperm whale fishery in Indonesia. Potential for unregulated whaling is always present. Known fisheries considerations include: drift and gillnet entanglements off Oman (humpback, Bryde's), Zanzibar, and in shark nets off South Africa (humpbacks, right whales); pot line entanglements off Australia; and potential ship strikes in all areas. The group was not aware of any areas where diminished prey due to fishing was affecting whale populations. Oil and gas explorations are taking place and may have detrimental effects near South Africa, Mozambique, Oman, the straits of Hormuz and Arabian Gulf, and Australia. Whalewatching should be covered by domestic regulations as for example in Australia and South Africa. There is, however, no such coverage in some areas, for example Madagascar. Northern IOS stocks may be vulnerable to climate change as they are without the option to move to polar grounds. Coastal habitat degradation and shipping, for example, may be concerns around Arabia.

COMMITTEE EVALUATION

The Committee **agreed** that currently the IOS protects whales from commercial whaling. It also **agreed** that additional threats may be occurring, which have to be rigorously assessed in the future.

(5) Consider relationship of the sanctuary with other existing whale protection measures from anthropogenic and environmental factors.

SUB-GROUP A

The IOS does not improve protection of whales. It simply duplicates the unnecessary protection afforded by the moratorium on commercial whaling. Neither does it improve the conservation of breeding sites, migratory routes and/or feeding grounds. The IOS does not complement either the Commission's current management regime (the moratorium) nor will it complement the proposed regime of the RMP/RMS, because safe quotas will only be adopted for abundant stocks to ensure whaling is sustainable.

SUB-GROUP B

The Commission's RMS is still under development but it is envisaged that the RMS and sanctuaries would represent mutually complementary management measures.

SUB-GROUP C

See Group C's comment on Items 6.1-6.3 below.

COMMITTEE EVALUATION

There was no consensus on the relationship of the IOS with other existing whale protection measures from anthropogenic and environmental factors.

(6) Assess the anticipated effects of the proposed sanctuary in terms of: (6.1) improving protection of whales, in breeding areas, feeding grounds and/or migratory routes; (6.2) improving the conservation of breeding sites, migratory routes and/or feeding ground; and (6.3) complementing existing or potential protection including the Commission's management regime and regional and international agreements concerning biodiversity and conservation of nature.

SUB-GROUP A

- (6.1) The IOS does not improve protection of whales. It simply duplicates the unnecessary protection afforded by the moratorium on commercial whaling.
- (6.2) Neither does it improve the conservation of breeding sites, migratory routes and/or feeding grounds.
- (6.3) The IOS does not complement either the Commission's current management regime (the moratorium) nor will it complement the proposed regime of the RMP/RMS, because safe quotas will only be adopted for abundant stocks to ensure whaling is sustainable.

SUB-GROUP B

- (6.1) The IOS provides protection for the breeding stocks of all Indian Ocean baleen whales. The boundary at 55°S confers protection to feeding grounds of Bryde's and sei whales, the main feeding grounds for southern right whales, and part of the feeding grounds of Southern Hemisphere fin whales. Southern Hemisphere blue and humpback whales and Antarctic minke whales migrate outside the Indian Ocean Sanctuary. Female and juvenile sperm whales are protected throughout their range.
- (6.2) The issues of habitat protection have only recently been considered by the IWC and to date no international measures have been taken. Whale habitat is specifically included in some national marine protected areas in the Indian Ocean.

- (6.3) CCAMLR requires that the fisheries management take into account the needs of dependent species. The IOS provides protection to those dependent species during the part of the year for which they are outside the CCAMLR area.

SUB-GROUP C

- (6.1) The IOS offers no such further protection given the moratorium. Furthermore, were the moratorium lifted, species migrating beyond its borders would not enjoy full protection.
- (6.2) The IOS does not improve the conservation of any of these.
- (6.3) The IOS could provide a control area, should the RMP be applied globally. However, it may be more appropriate to consider different areas within the Southern Hemisphere for different species.

COMMITTEE EVALUATION

There was no consensus on the role of the IOS in terms of: improving protection of whales in breeding areas, feeding grounds and/or migratory routes; improving the conservation of breeding sites, migratory routes and/or feeding ground; or complementing existing or potential protection including the Commission's management regime and regional and international agreements concerning biodiversity and conservation of nature.

- (7) Provide advice on whether the boundaries of the sanctuary are ecologically appropriate.*

SUB-GROUP A

Boundaries of the IOS were established simply to cover as wide an area as possible without regard to ecological principles or specific conservation needs for whale stocks. The boundaries of the IOS neither cover the entire range of large whale stocks that migrate through or into the area, nor are they limited to critical habitats for the species. For this reason, the IOS boundaries are not ecologically appropriate and are not consistent with the common concept of a sanctuary.

SUB-GROUP B

The current boundaries are simply defined in terms of latitude and longitude and include an ecologically coherent area with land boundaries forming the majority of the eastern, western and northern boundaries. Most previous discussions regarding the boundary largely concentrated on the southern boundary. The original proposal was to cover the entire Indian Ocean including the Southern Ocean sector, but for operational reasons this was revised to 55°S while recognising that this had only limited ecological significance. The current sanctuary boundaries provide opportunities for comparison of the potentially unique (in terms of genetics, behaviour and physiology) northern Indian Ocean whale stocks with southern Indian Ocean stocks across the same ocean basin.

SUB-GROUP C

For many species, the boundaries do not encompass their full distributional range, and so are not appropriate. Other options considered to be superior to the IOS include: (1) extending the IOS southward to the ice-edge, together with possible east-west broadening to encompass the assessed range of biological stocks, (2) limiting the IOS to a northern part of the area, given the unique situation there of whales precluded from polar migration and (3) selecting a

longitudinal slice of the Southern Hemisphere to serve as a control region, with the choice based upon simulation studies to assess optimality. This choice may be species-specific.

COMMITTEE EVALUATION

There was no consensus on whether the boundaries of the sanctuary are ecologically appropriate.

- (8) Provide advice on whether the sanctuary addresses the issue of critical habitat and non-critical whale habitat.*

SUB-GROUP A

The sanctuary does not address any habitat issues. It is simply a blanket prohibition on commercial whaling in the area. The issue of critical habitat is, however, addressed by the RMP, which does not provide quotas in breeding areas.

SUB-GROUP B

Since the competence of the IWC to include habitat protection measures in its Schedule has not yet been established, the sanctuary provision *per se* contains no measures for habitat protection. However, the Sanctuary is of sufficient size to encompass the complete habitat for some populations.

SUB-GROUP C

Not in general, but a sanctuary restricted to the northern part of the area could more defensibly be argued to do so.

COMMITTEE EVALUATION

The Committee **agreed** that the sanctuary does not specifically address the issue of known and unknown critical and non-critical whale habitat; this issue needs to be addressed in the future.

- (9) Evaluate whether the sanctuary may contribute to or impede the conduct of scientific research useful for meeting the IWC objectives and facilitate coordinated and integrated research and monitoring programmes*

SUB-GROUP A

While initially, the establishment of the sanctuary is reported to have resulted in an increase in research funding from NGOs and some research on sperm whales reported to be useful for meeting the IWC objectives, it also resulted in a decrease in national research funding in the area, except for Sri Lanka. Although a number of long-term research projects have been suggested, very few such projects have been initiated. The IOS has therefore impeded the conduct of scientific research useful for meeting the IWC objectives. This is confirmed by the absence of any recent reports of such research in the list of bibliographic references prepared for the IWC Sanctuary Review Steering Group.

SUB-GROUP B

An important consideration when considering the level of research in the IOS is that the coastal states are predominantly developing countries. The increase in research effort since 1992 is partly a reflection of the increase in cetacean research worldwide, but some projects have been initiated in response to the sanctuary designation. One of the difficulties in evaluating the IOS is knowing which activities are a direct result of the IOS and which would have happened without it. In the case of research, the sub-group mainly relied on whether the reports of the

research indicated that the existence of the IOS had been of benefit. Indirect benefits that were referred to included: a focus on regional initiatives and cooperation; a greater awareness of cetaceans in coastal states; facilitation of the initial phase of integrated research between Indian Ocean and Southern Ocean; additional sources of funding.

SUB-GROUP C

The current combination of the IOS and SOS impedes research, as the associated inability to compare stocks both under exploitation and unexploited in a control area detracts from capabilities to estimate demographic parameters relevant to the IWC objective of sound management on a scientific basis. Species-specific sanctuaries in parts of the Southern Hemisphere could, however, play some useful role towards that end.

COMMITTEE EVALUATION

There was no consensus on whether the IOS contributes to or impedes conduct of scientific research useful for meeting IWC objectives or facilitating coordinated and integrated research and monitoring programmes.

(10) Provide advice on whether the sanctuary is consistent with the precautionary approach.

SUB-GROUP A

No widely accepted or pragmatic definition of the precautionary approach provides for the implementation of measures for the total protection of whales irrespective of their conservation status. Further, no such definition recommends unnecessary or duplicative measures such as the Indian Ocean Sanctuary. By contrast, although the RMP is unnecessarily precautionary and wasteful of resources, its implementation would be consistent with broadly accepted definitions of the precautionary approach.

SUB-GROUP B

The central tenet of the precautionary approach is that lack of information shall not delay potentially necessary conservation measures. The adoption of the IOS in 1979 at a time when relatively little was known about the whale populations in the region, was a precautionary measure adopted by the IWC. While the RMP is designed to be more precautionary than its predecessors, the establishment of an appropriately designed system of sanctuaries can be regarded as a precautionary safeguard to mitigate the effects of possible failure of the RMP to adequately protect whale stocks after the current moratorium ends.

SUB-GROUP C

Superficially, a positive answer would seem obvious. However, the precautionary approach, taken to extremes, implies no utilisation of any natural resources. A pragmatic and balanced interpretation is necessary, taking account of the precautionary nature of the RMP, and the fact that the data contrast provided by limited exploitation is a necessary component of input to the development of a sound scientific basis for management. In this context, the precautionary approach should be seen as consistent with a set of species-specific sanctuaries of limited scope only.

COMMITTEE EVALUATION

There was no consensus on whether the IOS is consistent with the precautionary approach.

CONCLUSION

Lack of consensus in evaluating the scientific aspects of the IOS is not surprising considering that the sanctuary's original proposal did not clearly state its scientific objectives. The Committee recognised that the review process would benefit from explicitly stated objectives in Sanctuary proposals. In addition, there was some difficulty in interpreting some of the evaluation criteria and some of the Instructions from the Commission. While there was little consensus in evaluating the IOS, nevertheless, a considerable amount of substantive advice in response to the questions in the Commission's Instructions was provided by the working group.

17.2 Other

IWC/54/16 introduced a proposal for a South Pacific whale sanctuary submitted by Australia and New Zealand and noted that the content was the same as the previous year, but that it had been reformatted in accordance with the Instructions from the Commission although not all instructions were addressed. A record of the discussion of this document is given in IWC (2002d, p.67) and hence there was no need for further discussion.

It was noted that a proposal for a South Atlantic Sanctuary would be resubmitted to the Commission this year and that its supporting document remains the same as that presented to the Committee in 2001.

SC/54/O11 reported on the declaration of a whale sanctuary by the Government of the Cook Islands. The Cook Islands Whale Sanctuary (CIWS) was declared on 19th September 2001. It covers an area of approximately one million n.miles².

The Committee was notified that the Tristan da Cunha Island Council officially adopted the Tristan da Cunha Whale Sanctuary in November 2000. It includes the 12 n.miles territorial waters of the Islands of Tristan, Inaccessible, Nightingale and Gough. The sanctuary is designed to protect all cetacean species inhabiting or using these waters and is in place for an indefinite period of time.

17.3 Suggestions for improving the review process

As requested by the Commission, the Scientific Committee has provided some advice on the Instructions from the Commission and the evaluation criteria (Annex N, item 6). The Committee recognised that the review process could be further developed and **agreed** that it should try to develop suggestions for evaluation criteria to make them more precise and operational. This work will be initiated intersessionally by the Steering Group to review sanctuaries and sanctuary proposals. A proposal for a more precise set of review criteria will be presented to the Commission next year.

The Committee noted that, for future work, some mechanisms by which sanctuary proposals and the review process would benefit should be developed, including: (1) reviewing IWC sanctuaries in combination when biologically relevant; and (2) introducing Marine Protected Area (MPA) scientific concepts into sanctuaries and sanctuary proposals. The Committee also noted that a mechanism through which the Commission could assist member countries in developing sanctuary proposals should be discussed. This mechanism should include, in particular, identifying the objectives of the sanctuary and establishing a scientific monitoring programme that allows evaluation of

these objectives. These mechanisms will be developed by the intersessional Steering Group to review sanctuaries and sanctuary proposals.

The Committee **agreed** that priority should be given to further developing the evaluation criteria given the review of the SOS in 2004. It also **agreed** that the review process of this sanctuary will benefit if the review is initiated next year by collating the information required to follow the Commission's Instructions for Sanctuary Reviews.

18. RESEARCH AND WORKSHOP PROPOSALS AND RESULTS

18.1 Review results from previously funded research proposals

Results from previously funded research were reviewed in the appropriate sub-committees and working groups. Details are included in Annex E (satellite tagging and tracking of two fin whales off West Greenland), Annex G (progress with data entry and analysis options in DESS), Annex H (Antarctic Humpback Whale Catalogue) and Annex K (research on common dolphins in coastal waters of Pacific South America).

18.2 Review proposals for 2002/2003

No proposals were received.

18.3 Workshop on Methods for Whale Research

This workshop had originally been proposed by the Commissioners of the USA and Japan, not the Committee itself (IWC, 2002d, p.69) and had not been funded out of the Committee's research budget (IWC, 2002d, p.72). The invitation to host the meeting in Tokyo was for the period 4-8 February 2002, but it had not been possible to find outside experts available at that time. Subsequent efforts by Read, Chair of the Steering Group, had failed to find a period when the necessary experts had been available. Indeed, he reported a lack of enthusiasm for the workshop from the people he approached. Many members shared the view that the Committee had discussed and will continue to discuss these matters frequently and they expressed doubts that such a workshop would advance the work of the Committee. Others believed that if it had occurred before the review of JARPN II it might have provided useful input to the review process (Item 16.4.2). Hatanaka and Smith thanked Read for his efforts. They regretted that the workshop could not be advanced. The Committee **agreed** that a workshop on research methods would not be fruitful without outside experts and that it would be a low priority for research funding, compared to other workshops it had proposed (see Item 21).

19. COMMITTEE PRIORITIES AND INITIAL AGENDA FOR THE 2003 MEETING

As in recent years and with the Committee's agreement, the Convenors met after the close of the meeting and drew up the following as the basis of an initial agenda for the 2003 meeting. They took into account:

- (a) the priority items agreed by the Committee last year and endorsed by the Commission and, within them, the highest priority items agreed by the Committee on the basis of sub-committee discussions;

- (b) general discussions in the plenary session and in particular the need to reduce the workload of the Committee and, as far as possible streamline the sub-committee system to avoid conflicts in the need for personnel;
- (c) discussions over the budget in the full Committee.

The Committee recognised that priorities may be revised in the light of the Commission's decisions. Following the Commission meeting, the Chairman will circulate to the Committee a summary of the Commission's conclusions as they affect next year's work, along with a preliminary draft agenda. This will also provide a framework for determining invited participants to the 2003 meeting.

The Committee **reiterates** that suggestions for future in-depth or pre-implementation assessments must be accompanied by thorough written reviews of the available information and an outline of the work that would need to be undertaken to complete an assessment.

The Standing Working Groups and Standing Sub-Committees must, of course, meet. Otherwise, the sub-committee structure is flexible and should be seen as a way to most efficiently address the Committee's priority items. With this in mind, it was agreed to have the following sub-committees, noting that should other specific issues arise, then the option to appoint *ad hoc* Working Groups remains. The number of sessions allocated to each group will be strictly limited and similar to the number indicated below. Items of lower priority will only be discussed if time allows. It is again stressed that papers considering anything other than priority topics may not be addressed.

RMP (14)

As last year, this sub-committee will concentrate on two areas:

(a) General issues

Priority topics will be:

- (1) adjustment of the convergence criteria for the CATCHLIMIT program;
- (2) consider results from the Intersessional Working Group on Abundance Estimation;
- (3) consider implications of choice of component of population to which MSYR, MSYL and density dependence apply in RMP trials.
- (4) define levels of information required for *Pre-Implementation Assessments* and for proceeding to an *Implementation*.
- (5) spatio-temporal considerations in the context of the RMP.

(b) Preparations for Implementation

The priority topics will be:

- (1) completion of North Pacific minke whale *Implementation* (including review results of intersessional meeting);
- (2) North Atlantic minke whale *Implementation Review*. It is proposed that discussion of this begins two days prior to the Annual Meeting.

Bycatches and other anthropogenic removals (BC – 7)

This year the Working Group will (in the context of the RMP) concentrate on the estimation of bycatch only.

The priority topics will be:

- (1) bycatch based on fisheries data and observer programmes;

- (2) bycatch based on genetic data;
 - (a) proposal for a workshop
 - (b) analytical tests for assignment to stocks and/or areas
 - (c) use of capture-recapture methods for estimation of bycatch from market data.

AWMP (9)

This Standing Working Group will continue the development process and will have had an intersessional workshop in Seattle. Priority topics will be:

- (1) selection of an *SLA* for Eastern North Pacific gray whales;
- (2) review of results from Greenlandic Research Programme and revise programme;
- (3) progress on development of potential *SLAs* for Greenland fisheries;
- (4) annual review of catch data and management advice for minke and fin whales off Greenland;
- (5) annual review of catch data and management advice for humpback whales off St Vincent and The Grenadines.

Southern Hemisphere whales other than Antarctic minke whales (SH – 6)

Priority topics will be:

- (1) review progress on the Comprehensive Assessments of Southern Hemisphere humpback and blue whales and determine timetable and work plan.

Bowhead, right and gray whales (BRG – 4)

Priority topics will be:

- (1) new and/or conflicting biological information on bowhead, right and gray whales;
- (2) revised new abundance estimate for BCB bowhead whales;
- (3) review progress on previous recommendations.

In-Depth assessments (IA – 14)

Priority topics will be:

- (1) issues relating to the abundance estimation of Southern Hemisphere minke whales;
- (2) review results of most recent SOWER circumpolar cruise and plan for the next.

Stock definition (SD – 7)

This Working Group will also hold an intersessional Workshop. Priority topics will be:

- (1) statistical and genetic issues (Testing of Spatial Stock Models);
- (2) options for units to conserve including management implications;
- (3) development of stock and harvesting archetypes suitable for consideration in whaling management;
- (4) review of new information on responses of cetacean sub-stocks to severe depletion.

Environmental concerns (E – 8)

Priority topics will be:

- (1) review results from workshop on marine mammal-fisheries interactions (2-3);
- (2) high latitude climate change (2-3).

It will also devote limited (2-3) time to:

- (a) Steering Group report on POLLUTION 2000+ ;
- (b) progress report on SO-GLOBEC/CCAMLR;

- (c) review of results from the workshop on habitat degradation (if held);
- (d) Arctic issues;
- (e) progress on State of the Cetacean Environment Report (SOCER).

DNA (2)

This Working Group will provide the annual progress report to the Commission required by Resolution 1999-8.

Priority topics will be:

- (a) genetic methods for species, stock and individual identification;
- (b) collection and archiving of tissue samples from catches and bycatches;
- (c) reference databases and standards for diagnostic DNA registries.

Small cetaceans (SM – 10)

Priority topics will be:

- (1) review of the status of small cetaceans in the Black Sea;
- (2) review of the existence of directed and incidental takes of small cetaceans in member countries, with a view to requesting data in the future;
- (3) review of progress on previous recommendations.

Whalewatching (WW – 5)

Priority topics will be:

- (1) review the reports of Intersessional Working Groups;
 - (a) data collection;
 - (b) whalewatching management;
 - (c) compendium of data forms used on whalewatching platforms;
 - (d) directory of relevant researchers
- (2) review of research on the effectiveness of national whalewatching guidelines and regulations;
- (3) review of new information on whale and dolphin swim-with programmes.

Sanctuaries (S – 2)

Priority topics will be:

- (1) review work of intersessional Steering Group;
- (2) preparation for review of Southern Ocean Sanctuary.

Scientific permits (P – 2)

Priority topics will be:

- (1) proposals to facilitate the review process;
- (2) review results of existing permits;
- (3) review plans for new and continuing permit proposals.

20. DATA PROCESSING AND COMPUTING NEEDS FOR 2002/2003

The Committee identified the requests for intersessional work by the Secretariat given in Table 9. Allison noted that it should be possible to complete all the items listed before next year's Scientific Committee meeting, unless much additional work arose from the Intersessional Meeting on North Pacific minke whales. The Committee recognised that a final decision on priorities would need to be made after the Commission meeting to take into account Commission deliberations. The Committee **agreed** that Allison will liaise with the Chair of the Scientific Committee and the

Table 9
Computing tasks/needs for 2002/03

Task	Estimated time
AWMP	
Amend control program to implement modifications to GE trials including the inertia model and changes to be specified, condition trials and circulate to developers.	1-2 months
Create input files for and condition GR trials, produce population trajectories.	1-2 months
Run GE trials for candidate SLAs and prepare comparison plots and tables for Intersessional meeting.	2 weeks
Work resulting from Intersessional meeting.	??
RMP	
Investigate the conditioning output for the North Pacific minke whale <i>Implementation Simulation Trials</i> , to resolve any inconsistencies, in collaboration with the NP conditioning steering group (see Agenda Item 6.4.1).	3 + months
Conduct the final set of <i>ISTs</i> as specified at the Intersessional Meeting.	1 month
Undertake simulation trials to assist the Committee in understanding the implications of the choices of modelling density dependence and defining MSYL in the <i>Implementation Simulation Trials</i> (see Agenda Item 5.2).	1 month
Adjust the convergence criteria in the new CATCHLIMIT program to be robust when less precise integration is used.	2 weeks
Other	
Validation of the 2001/02 and 2002/03 SOWER cruise data and incorporation into the sightings database.	6 months
Completion of validation of the 1999/2000 joint IWC/CCAMLR cruise data (being undertaken by Hedley).	?
Validation of the 2000/01 joint IWC/SO GLOBEC cruise data.	?
Encode the basic individual records from the revised Soviet catch data and document inconsistencies in the data. The earliest data will be coded first. (The detailed biological data will not be encoded in this first phase.)	1-2years

Convenors of the relevant sub-committees to decide if priorities need to be changed in the light of Commission decisions and to review progress during the year.

21. FUNDING REQUIREMENTS FOR 2002/2003

Table 10 summarises the complete list of recommendations for funding made by the Committee. The total required to meet its preferred budget is £376,235. The Committee

recommends all of these proposed expenditures to the Commission. However, it understood that the projected amount available for funding is £275,261, of which £96,045 is committed funds. It therefore reviewed the full list, taking into account its work plan, priorities and the possibility that some of the work requiring funding could be postponed to a future year while other items represented unique opportunities that would not be available again. Should the Commission be unable to fund the full list of items in Table

Table 10
Scientific Committee recommendations for research funding in 2002/3 (amounts in £ sterling).

Item	For	Reference	Preferred budget	Reduced budget
AWMP*				
Intersessional workshop	Invited Participants	Item 8.7 and Annex E	12,000	9,000
Greenland Research programme*	Satellite tagging	Item 8.4.1, 9.1.3 and Annex E	18,000	18,000
Developer's fund*	Development of SLAs	Item 8.7 and Annex E	8,400	8,400
RMP				
Intersessional meeting	Invited Participants	Item 6.1.4 and Annex D	10,000	7,000
IA				
SOWER circumpolar cruise	Scientists, equipment, planning meeting	Item 10.1.2.2 and Annex G	94,440	80,000
Further minke whale abundance estimates:	Developmental support	Item 10.2.3.1 and Annex G	5,000	5,000
	Develop/apply BBM model/spatial models	Item 10.2.3.1 and Annex G	8,000	8,000
	Develop/apply Hazard model	Item 10.2.3.1 and Annex G	1,040	0
	Evaluate standard methods/other analyses	Item 10.2.3.1 and Annex G	3,000	3,000
E				
SO-GLOBEC related research	Planning meeting, cruise support, analysis	Item 12.1.2 and Annex J	25,000	21,500
POLLUTION 2000+	Complete Phase I	Item 12.2 and Annex J	54,410	15,000
Habitat degradation workshop	Invited Participants	Item 12.3.2 and Annex J	15,500	0
Preparation of SOCER	Editorial work	Item 12.3.1 and Annex J	3,000	0
H				
Antarctic humpback whale catalogue*	Towards improving catalogue	Item 10.4.3 and Annex H	5,100	5,100
BRG				
Joint USA-Russian western gray whale research*	Continuation of programme	Item 10.6.5 and Annex F	34,245	34,245
SD				
Intersessional workshop	Invited participants	Item 11.4 and Annex I	17,500	7,000
SC				
Invited participants	Invited participants	Item 21	27,900	27,900
DESS *	Analysis and support	Item 10.1.1 and Annex G	32,000	32,000
Sundries (bank charges etc.)*			1,700	1,700
Total			376,235	282,845

*Committed items

10, the Committee **agreed** that the final column given in the table represents a budget that will allow progress to be made by its major sub-committees and working groups. Progress will not be possible in some important areas, as outlined below and the Committee **requests** that the Commission or individual member governments provide additional funding in these areas. The Committee **strongly recommends** that at a minimum, the Commission accepts its reduced budget of £282,845, although it recognises that this is about £7,500 over the projected amount available.

A summary of each of the items is given below, by sub-committee or working group. Full details can be found under the relevant Agenda Items and Annexes as given in Table 10.

(a) Items recommended for funding under the reduced budget

Aboriginal Whaling Management Procedure

(1) AWMP INTERSESSIONAL WORKSHOP

The Commission has agreed that development of the AWMP is a high priority item. Without intersessional workshops, it would have taken at least three more years to develop the *Bowhead SLA*. Work to complete a similar exercise for gray whales and make progress on the Greenland fisheries case requires a similar strategy. With such a workshop it may be possible to recommend a gray whale *SLA* at next year's meeting; without one it will certainly not. The Committee therefore strongly recommends that a four-day intersessional workshop be held, probably in December. Although £12,000 was originally budgeted, if the meeting is held in conjunction with one of the other workshops (RMP or SD), it may be possible to reduce the costs to around £9,000. The workshop will concentrate on reviewing the first results of *Evaluation* and *Robustness Trials* for gray whales and initiating the major review of the Greenland Research Programme. The US NMFS National Marine Mammal Laboratory has again offered to host the workshop, so the only cost to the Commission is for invited participants.

(2) AWMP DEVELOPERS FUND

The developers fund has been invaluable in ensuring fast completion of AWMP trials and other essential tasks of the Standing Working Group. The Committee noted that this is included as a separate item of expenditure in the Commission's provisional budget.

(3) GREENLAND RESEARCH PROGRAMME

The Committee is unable to provide advice on these stocks. The Committee stresses that obtaining adequate information for management should be seen as of very high priority by both the national authorities and the Commission. Without this information, the Committee will not be able to provide safe management advice in accord with the Commission's management objectives, or develop a reliable *SLA* for many years, with potentially serious consequences for the status of the stocks involved. The Committee noted that the present money for satellite tagging to address issues of stock structure and movement is carried over from last year.

Revised Management Procedure

(4) RMP INTERSESSIONAL MEETING

The Committee is concerned about the length of time taken to complete the *Implementation* for North Pacific minke whales. The Committee recognises that substantial intersessional work is still required if final *Implementation Trial* results are to be available at next year's meeting. It is impractical to complete most of the substantial work

required via e-mail; an intersessional workshop is essential. Although £10,000 was originally budgeted, if the meeting is held in conjunction with one of the other workshops (AWMP or SD), it may be possible to reduce the costs to around £9,000.

In-depth Assessments

(5) SOWER CIRCUMPOLAR CRUISE

Completion of this set is essential to the work of the Committee in response to the Commission's resolution, in particular with respect to Antarctic minke whales but also blue whales and other species. The Government of Japan has kindly offered the use of two research ships in 2002/2003 and the preferred budget in Table 10 reflects the remaining costs of the cruise (Appendix 2 of Annex G). The reduced budget in Table 10 is the minimum required if the cruise is to take place. This requires cuts in the equipment budget and elsewhere.

(6) FURTHERING ESTIMATION OF ANTARCTIC MINKE WHALE ABUNDANCE

The Commission has given high priority to obtaining new abundance estimates and trends in Antarctic minke whales. Although a better understanding of the issues has been reached at this meeting, little progress can be made if most of these development projects are not funded. A considerable amount of in-kind support is included with these projects.

Environment

(7) SO-GLOBEC RELATED RESEARCH – SOWER 2000

Item 12.1.2 describes the Committee's collaboration with SO-GLOBEC. Support for this activity was considered a preferred priority, as it complements the enormous in-kind support the IWC receives for the SOWER 2000 cruises. The reduced budget will cover only the minimum number of IWC-funded observers (two per cruise) required for IWC participation in SO-GLOBEC, as well as providing partial support for the coordinator. The field studies to be supported represent a unique opportunity in the coming year to conduct research on Southern Ocean whales and their ecosystem as mandated by IWC Resolutions 1998-3 and 1998-6.

(8) POLLUTION 2000+ RESEARCH ON BIOLOGICAL EFFECTS OF CONTAMINANTS IN CETACEANS

The POLLUTION 2000+ programme is an important and fundamental research programme that has been given high priority in the past by both the Committee and the Commission (e.g. Resolution 2000-7, IWC, 2001b, pp.56-57). In addition to completion of analyses currently in progress, the 2002-2003 work plan for POLLUTION 2000+ includes an intersessional meeting to synthesise results among the laboratories involved, and an intersessional meeting of the Steering Group to finalise Phase 1 of this programme and to determine activities to be conducted under Phase 2. Within this work plan, the highest priority projects are the collection of samples and PCB analyses under the bottlenose dolphin sub-project, and completion of the harbour porpoise post-mortem calibration project. The budget to complete the entire 2002-2003 work plan will require £140,500, of which the majority will be sought through external direct or 'in kind' funding. To complete the highest priority projects mentioned above, £54,410 from the IWC is required. The reduced budget amount will only allow analysis of a portion of the existing samples, thereby considerably delaying completion of Phase 1. Interested member governments are urged to consider providing additional funds.

*Humpback whales***(9) ANTARCTIC HUMPBACK WHALE CATALOGUE**

The Committee is already committed to funding this project, which represents only a partial cost of running the catalogue and is of great benefit to its in-depth assessment of Southern Hemisphere humpback whales. The work required to *inter alia* make the IWC IDCR/SOWER photographs more accessible is described in Annex H, Appendix 4.

*Bowhead, right and gray***(10) JOINT USA-RUSSIAN WESTERN GRAY WHALE RESEARCH**

The importance of this work to the conservation of the critically endangered western gray whale is stressed under Item 10.6.5. The funding has kindly been donated by the USA.

*Stock definition***(11) INTERSESSIONAL WORKSHOP**

Consideration of the appropriate 'unit-to-serve' is fundamental to the successful implementation of the RMP and is critical to the conservation and management of all cetacean species. The Committee reaffirmed the importance of the simulation work. Setting up extensive simulation trials is complex, and the Committee **agreed** that an intersessional workshop is essential in order to make reasonable progress on spatial structure simulation. Apart from those interested in actually developing methods, this meeting would ideally require two other types of participant: first, one or more Scientific Committee members with extensive experience in setting up large simulation trials, particularly in an RMP or AWMP context; and second, experts from outside the usual IWC circles who can provide input on appropriate genetic, statistical, and ecological considerations to be used in developing the simulations. Further details on the proposed workshop can be found in Annex I, Appendix 3. Although £17,500 was originally budgeted, if the meeting is held in conjunction with one of the other workshops (AWMP or RMP) without meeting room costs, it may be possible to reduce the costs to around £7,000.

*Scientific Committee***(12) INVITED PARTICIPANTS FUND**

The Committee draws attention to the valuable contribution made to its work by the funded Invited Participants. They are essential to the work of the Committee and represent excellent value as they receive only travel and subsistence costs and thus donate their time.

(13) DESS

The IWC's DESS (Database Estimation Software System) is vital to the Committee's work on abundance estimation, particularly with respect to future work on the abundance of Antarctic minke whales and the *Implementation Review* of North Atlantic minke whales. This is the third year of a three-year contract.

(b) Items not recommended for funding under the reduced budget*Environment***(1) HABITAT DEGRADATION WORKSHOP**

The Commission (Resolution 2000-7) has encouraged work in this area. Progress on the conceptual framework that the workshop would consider was made at an intersessional meeting (Simmonds *et al.*, 2002a) and a new workshop proposal was subsequently produced (Simmonds *et al.*, 2002b). ACCOBAMS has endorsed the workshop plans.

ICRAM in Italy has offered to host the meeting, so the item in the Committee's preferred budget is needed only for invited participants.

(2) PREPARATION OF SOCER

The Commission (Resolution 2000-7) has encouraged work in this area. A working group within the SWG will aim to produce a draft SOCER (State of the Cetacean Environment Report) for next year's meeting. This report will be distributed as a Committee document in the spring of 2003. It is intended to be a preliminary attempt at a form of the report that will be developed over the years into an objective product and an easily followed submission process. It is aimed at providing a non-technical summary of the positive and negative events and developments in the marine environment relevant to cetaceans.

22. WORKING METHODS OF THE COMMITTEE**22.1 Increasing participation of scientists from developing countries**

The Committee reviewed the proposed addition of rule A.6 (i) to its Rules of Procedure considered last year (Pinto de Lima and Palazzo, 2002). It **agreed** the proposed wording, noting the importance of a number of features: (1) the Chair retains the right of selection as indicated in the rule; (2) Invited Participants proposed for conversion to national delegate status under the rule are permitted to decline; (3) use of the rule was appropriate only by developing countries.

Zeh noted that no responses to her circular communication requesting suggestions regarding research priorities in developing countries had been received before the meeting. There was not adequate time to consider this matter further during the meeting, or to follow up on additional ideas for helping scientists from developing countries gain the necessary expertise to address conservation and management issues in their own countries (see IWC, 2002d, p.74). The Committee **agreed** that it would discuss these topics further next year.

22.2 Participation by member nations in the Committee's work

Near the close of the meeting, Smith expressed disappointment concerning the reduced participation by Japan in some aspects of the Committee's work in recent years. His remarks, the remarks of Walløe and a response from Komatsu are given in Annex P.

22.3 General methods of improving the Committee's efficiency and effectiveness

Several suggestions were made regarding working methods of the Committee. Some of these are given below and others were taken directly into account in the Convenors' discussions of Initial Agenda and Work plan (see item 19.).

22.3.1 Late arrivals

Childerhouse expressed his concern at the trend in recent years for some scientists to arrive only for plenary discussions. In particular, this can result in a considerable waste of time spent revisiting sub-committee discussions in plenary. Whilst agreeing that it was appropriate for the final consideration of sub-committee and working group reports to occur in plenary, many members noted that this was in large part intended to reflect the fact that concurrent sessions meant that it was not possible to attend each sub-committee;

they thus shared the concerns of Childerhouse of the disruption this practice can have on the Committee's proceedings. It was emphasised that these comments do not apply to cases where countries do not have adequate resources to send a scientist for the whole period, but rather to countries that had other delegates already attending the full meeting.

22.3.2 Citation and restrictions on citation of documents and working papers

The review (including further analysis if required) of scientific papers is critical to the work of the Scientific Committee and the transparency of its management advice to the Commission. Some concern arose at the meeting that this may be compromised by either authored working papers or documents being submitted to the Committee with the heading along the lines of 'Not to be cited (or used) without the permission of the author(s)'. The general policy of the Scientific Committee is relevant to this issue.

WORKING PAPERS

These are intended to expedite resolution of disagreements or stimulate debate within the meeting. They officially disappear at the end of the meeting (unless appended to the Committee or sub-committee reports with the author's permission). They have no status once the meeting is closed and thus cannot be cited in authored documents or manuscripts for publications.

However, if they are to assist in the work of the Committee it does not seem appropriate to include any restriction of citation *in the context of the meeting at which they are submitted*. Certainly, unless appended or incorporated into the text of the report, they cannot be used in the provision of management advice. In conjunction with the policy in the paragraph above, the Committee therefore **agreed** that working papers should not be submitted with such restrictions.

SCIENTIFIC COMMITTEE PAPERS

Authored documents submitted to the Committee reside in the Secretariat, are publicly available on request and are considered part of the public domain. The policy of the *Journal of Cetacean Research and Management* on citation of authored documents is consistent with the Committee's policy: authored documents are publicly available and can be cited as such – the citation style makes clear that these are unpublished manuscripts¹⁶.

The policy of the Journal is that if authors specify on the title page that the paper should not be cited without the permission of the author, that must be respected. Although not all authors make such a specification, it is in any case good practice (as well as courteous) to inform authors of unpublished papers that one intends to cite them and make use of the data therein. This is important as, for example, by the time of citation the document may have been submitted/accepted for publication (or already published), in which case it is more appropriate to cite the (to be) published version. It was noted that in the case of JCRM, the Journal could consider undertaking notification of authors in this regard.

¹⁶ Editorial policies on the form of citation of SC authored documents differs from journal to journal. Some journals consider these documents as 'gray literature' and restrict citations to footnotes or to reference as 'personal communication'. To avoid these restrictions, authors submitting manuscripts to peer-reviewed journals may wish to inform the editors of the policy of the JCRM and the format for citation therein.

In general, it does not seem unreasonable to include such a citation provision on a paper that has perhaps been written at the last minute in order to stimulate discussion or present the results of a preliminary analysis which subsequently the author feels (or is told) is flawed.

However, if a paper is to form the major basis for a recommendation by the Committee, it is not acceptable for such a strong restriction on citation to be placed. The Committee **agreed** that it is appropriate for the Chair of the Committee or relevant sub-committee to ask that such a restriction either: (1) be removed; or (2) be replaced by one that makes it clear that the restriction excludes citation in the context of Scientific Committee meetings and documents. This latter option gives protection to the authors of *inter alia* first publication rights.

22.3.3 Reducing the amount of wasted papers

Donovan briefly outlined a proposal to reduce the number of papers copied for, but then thrown away by, participants. The current practice is that all Committee members receive every paper submitted to the meeting. The Secretariat will use the website to allow members to sign up for certain categories of papers in advance of the meeting. On arrival, Committee members will therefore receive only a subset of the total papers submitted. They will be able to request additional papers (either electronically or on paper) from the complete list of documents later. The Committee welcomed this initiative and **agreed** that it should be tried out for the coming meeting. It also welcomed the increased use of the website for Committee business, and Donovan noted that it would become an increasingly useful tool to the Committee's work in the coming year.

22.3.4 Observers on surveys

Late in the meeting, the issue of adequate attention to field methods used in abundance surveys and the role of independent observers was raised. The Committee noted that it has discussed aspects of this issue in the past. It did not have time to discuss the matter this year and **agreed** to include it on next year's agenda.

23. ELECTION OF OFFICERS

The three-year terms of Zeh as Chair and DeMaster as Vice-Chair end at the end of IWC 54. The heads of delegations therefore met to agree a process for conducting the election. Considerations regarding the election process and proposed changes to the Committee's Rules of Procedure to reflect their decisions are given in Annex Q. The Committee **agreed** to the modified rules as given in Annex Q. Although the modified rules cannot officially take effect until a subsequent election, they were followed by the heads of delegations for the election. The head of the Icelandic delegation protested the denial of his right to vote.

The Committee was delighted to welcome DeMaster as the new Chair and Bjørge as the new Vice-Chair.

24. PUBLICATIONS

The year 2001 was an extremely productive year with respect to the IWC's scientific publications. The third volume of *The Journal of Cetacean Research and Management* was completed, comprising three issues published in May, September and December. Publication of some 34 papers (328pp.), covering a wide range of topics and with authors from 20 countries, illustrates its increasing

contribution to the field of cetacean research. In addition, the 453 page supplement to the fourth volume of the Journal, containing the 2002 Report of the Scientific Committee was published in April 2002. Also published since the last meeting was the second Special Issue in the Journal series (Right Whales: worldwide status – edited by P.B. Best, J.L. Bannister, R.L. Brownell Jr and G.P. Donovan). This hard-backed volume of over 300 pages contains the Reports of the Cape Town and Boston Right Whale Workshops, and 28 peer-reviewed papers reporting the current status of right whale stocks.

For reasons well known to the Committee, publication of the long-awaited gray whale special issue has been consistently delayed. It has finally been decided that those papers that have been completed shall be included in dedicated but regular issues of the Journal. The first of these will be the Spring 2002 issue.

Finally, Donovan reiterated the importance of Committee members urging their respective institutes and colleagues to subscribe to the Journal and to submit high quality papers to it. Now that it has been in existence for three years, it will be included in the Science Citation Index.

The Committee congratulated Donovan and his team for the quantity and quality of the publications produced since the last meeting, and recognised the important contribution the Journal made to the work of the Committee and to the wider issues of the management and conservation of whales. They also congratulated him on finally realising that despite his eternal optimism, some people never change when it comes to the gray whale special issue!

25. OTHER BUSINESS

The Committee congratulated two of its members, Parsons and Rose, who had met at a previous Committee meeting, on their engagement.

Appreciation was expressed to the Government of Japan and the people of Shimonoseki for the exceptional level of support and hospitality provided to the Committee during the meeting. The Secretariat staff was thanked for its huge contributions to the smooth progress of the Committee's work. The Committee gave Zeh a standing ovation for her outstanding service as Chair of the Committee. She carried out her duties with diligence, fairness, good humour and kindness to all members. Zeh thanked all the members for the help they had given her during her term of office and congratulated the newly elected officers.

26. ADOPTION OF REPORT

The report was adopted at 18:00 on 9 May 2002.

REFERENCES

- Ainley, D.G. 1985. Biomass of birds and mammals in the Ross Sea. pp. 498-515. In: W.R. Siegfried, P.R. Condy and R.M. Laws (eds.) *Antarctic Nutrient Cycles and Food Webs*. Springer-Verlag, Berlin. 700pp.
- Allison, C. 2002. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 10. The detailed results for trial NPM101-J1. *J. Cetacean Res. Manage. (Suppl.)* 4:123-5.
- Anonymous. 1979. Japan. Progress report on cetacean research, June 1977-May 1978. *Rep. int. Whal. Commn* 29:117-20.
- Aono, S., Tanabe, S., Fujise, Y., Kato, H. and Tatsukawa, R. 1997. Persistent organochlorines in minke whales *Balaenoptera acutorostrata* and their prey species from the Antarctic and the North Pacific. *Environ. Pollut.* 98:81-9.
- Aydin, K. and Friday, N. 2001. The early development of Ecosim as a predictive multi-species fisheries management tool. Paper SC/53/E3 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Baillie, J. and Groombridge, B. (eds.). 1996. *IUCN Red List of Threatened Animals*. World Conservation Union, Gland, Switzerland.
- Bain, D.E. 2002. A model linking energetic effects of whale watching to killer whale (*Orcinus orca*) population dynamics. *Mar. Mammal Sci.* :Submitted.
- Baker, C.S. and Funahashi, N. 2000. Molecular genetic identification of whale products: proposed international validation and investigation of species, stock and individual origins. Paper SC/52/SD8 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- Baker, C.S., Cipriano, F. and Palumbi, S.R. 1996. Molecular genetic identification of whale and dolphin products from commercial markets in Korea and Japan. *Mol. Ecol.* 5:671-85.
- Baker, C.S., Lento, G.M., Cipriano, F. and Palumbi, S.R. 2000. Predicted decline of protected whales based on molecular genetic monitoring of Japanese and Korean markets. *Proc. R. Soc. Lond. Ser. B.* 267:1191-9.
- Bannister, J.L. and Hedley, S.L. 2001. Southern Hemisphere group IV humpback whales: their status from recent aerial survey. *Mem. Queensl. Mus.* 47(2):587-98.
- Best, P.B. 1993. Increase rates in severely depleted stocks of baleen whales. *ICES J. Mar. Sci.* 50(3):169-86.
- Best, P.B., Sekiguchi, K. and Findlay, K.P. 1995. A suspended migration of humpback whales (*Megaptera novaeangliae*) on the west coast of South Africa. *Mar. Ecol. Prog. Ser.* 118 (1-3 Mar):1-12.
- Best, P.B., Peddemors, V.M., Cockcroft, V.G. and Rice, N. 2001. Mortalities of right whales and related anthropogenic factors in South African waters, 1963-1998. *J. Cetacean Res. Manage.* (special issue) 2:171-6.
- Branch, T.A. and Butterworth, D.S. 2001a. Estimates of abundance south of 60°S for cetacean species sighted frequently on the 1978/79 to 1997/98 IWC/IDCR-SOWER sighting surveys. *J. Cetacean Res. Manage.* 3(3):251-70.
- Branch, T.A. and Butterworth, D.S. 2001b. Southern Hemisphere minke whales: standardised abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys. *J. Cetacean Res. Manage.* 3(2):143-74.
- Buckland, S.T., Cattanach, K.L. and Miyashita, T. 1992. Minke whale abundance in the northwest Pacific and the Okhotsk Sea, estimated from 1989 and 1990 sighting surveys. *Rep. int. Whal. Commn* 42:387-92.
- Burnham, K.P. and Anderson, D.R. 1998. *Model Selection and Inference. A Practical Information-Theoretic Approach*. Springer-Verlag, New York. 353pp.
- Burt, M.L. and Stahl, D. 2001. Minke whale abundance estimation from the 1998/99 IWC-SOWER Antarctic Cruise in Area IV. Paper SC/53/IA3 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Bushuev, S.G. 1986. Feeding of minke whales, *Balaenoptera acutorostrata*, in the Antarctic. *Rep. int. Whal. Commn* 36:241-5.
- Butterworth, D.S., Punt, A.E., Geromont, H.F., Kato, H. and Fujise, Y. 1999. Inferences on the dynamics of Southern Hemisphere minke whales from ADAPT analyses of catch-at-age information. *J. Cetacean Res. Manage.* 1(1):11-32.
- Clapham, P.J. and Brownell, R.L. 1996. The potential for interspecific competition in baleen whales. *Rep. int. Whal. Commn* 46:361-7.
- Clapham, P.J. and Hatch, L.T. 2000. Determining spatial and temporal scales for population management units: lessons from whaling. Paper SC/52/SD2 presented to the IWC Scientific Committee, June 2000, Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- Clapham, P.J. and Mead, J.G. 1999. *Megaptera novaeangliae*. *Mamm. Species* 604:1-9.
- Clapham, P., Robbins, J., Brown, M., Wade, P. and Findlay, K. 2001. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on the Comprehensive Assessment of Whale Stocks – In-depth Assessments. Appendix 5. A note on plausible rates of population growth in humpback whales. *J. Cetacean Res. Manage. (Suppl.)* 3:196-7.
- Cooke, J.G. 2001. A modification of the radial distance method for dual-platform line transect analysis, to improve robustness. Paper SC/53/IA31 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].

- Cooke, J.G. and Leaper, R. 1998. Results of simulations studies of a hazard probability approach to estimation of whale density and effective strip width. Paper SC/50/RMP20 presented to the IWC Scientific Committee, April 1998 (unpublished). [Paper available from the Office of this Journal].
- Cui, G., Punt, A.E., Pastene, L.A. and Goto, M. 2002. Bayes and Empirical Bayes approaches to addressing stock structure questions using mtDNA, with an illustrative application to North Pacific minke whales. *J. Cetacean Res. Manage.* 4(2):123-34.
- Dalebout, M.L., van Helden, A., Van Waerebeek, K. and Baker, C.S. 1998. Molecular genetic identification of southern hemisphere beaked whales (Cetacean: Ziphiidae). *Mol. Ecol.* 7:687-94.
- Dalebout, M.L., Lento, G.M., Cipriano, F., Funahashi, N. and Baker, C.S. 2002. How many protected minke whales are sold in Japan and Korea? A census by microsatellite DNA profiling. *Animal Conservation* 5(2):143-52.
- Dizon, A., Baker, S., Cipriano, F., Lento, G., Palsbøll, P. and Reeves, R. 2000. Molecular Genetic Identification of Whales, Dolphins, and Porpoises: Proceedings of a Workshop on the Forensic Use of Molecular Techniques to Identify Wildlife Products in the Marketplace, La Jolla, CA, USA, 14-16 June 1999. US Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-SWFS-286. 52pp+xi. [Available from: <http://www.nmfs.gov>].
- Donovan, G. 2001. Report of the Scientific Committee. Annex Y. Guidelines for the Review of Scientific Permit Proposals. *J. Cetacean Res. Manage. (Suppl.)* 3:371-2.
- FAO. 1999. Report of the Twenty-third Session of the Committee on Fisheries. Rome, Italy, 15-19 February 1999. *FAO Fish. Rep.* 595:1-70.
- FAO. 2002. Report on the Twenty-fourth session of the Committee on Fisheries, Rome, Italy, 26 February – 2 March 2001. *FAO Fish. Rep.* :In press.
- Folkow, L.P., Haug, L., Nilssen, K.T. and Nordøy, E.S. 2000. Estimated food consumption of minke whales *Balaenoptera acutorostrata* in Northeast Atlantic waters in 1992-1995. *NAMMCO Scientific Publications* 2:65-80.
- Fujise, Y., Pastene, L.A., Tamura, T., Bando, T., Murase, H., Kawahara, S., Watanabe, H., Ohizumi, H., Mogoe, T., Kiwada, H., Nemoto, K. and Narita, H. 2001. Progress report of the feasibility study of the Japanese Whale Research Program under Special Permit in the western North Pacific – Phase II (JARP II) in 2000. Paper SC/53/O10 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Givens, G.H. 1997. Separable multicriterion design and performance optimization of AWMPs. Paper SC/49/AS4 presented to the IWC Scientific Committee, September 1997 (unpublished). 21pp. [Paper available from the Office of this Journal].
- Givens, G.H. 1999. Multicriterion decision merging: competitive development of an aboriginal whaling management procedure. *J. Am. Stat. Assoc.* 94:1003-4.
- Givens, G. 2000. *Strike Limit Algorithm* optimisation: a realistic example. *J. Cetacean Res. Manage.* 2(1):75-83.
- Gong, D. and Wang, S. 1999. Definition of Antarctic oscillation index. *Geophys. Res. Lett.* 26(4):459-62.
- Goto, M. and Pastene, L.A. 2000. Population structure in the western North Pacific minke whale based on RFLP and sequencing analyses of mtDNA control region, using data from 1994-1999 JARP surveys. Paper SC/F2K/J11 presented at the JARP Review Meeting, Tokyo, Japan, 7-10 February 2000 (unpublished). 16pp. [Paper available from the Office of this Journal].
- Goto, M., Abe, H. and Pastene, L.A. 2000. Estimation of the mixing proportion of the 'J' and 'O' stocks in sub-area 11 using uni- and bi-parental genetic markers. Paper SC/F2K/J27 presented at the JARP Review Meeting, Tokyo, Japan, 7-10 February 2000 (unpublished). 18pp. [Paper available from the Office of this Journal].
- Goto, M., Kanda, N. and Pastene, L.A. 2001. Genetic examination of western North Pacific minke whales including samples from JARP II. Paper SC/53/RMP11 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Government of Japan. 1996. The 1996/97 research plan for the Japanese Whale Research Program under Special Permit in the Antarctic. Paper SC/48/SH3 presented to IWC Scientific Committee, June 1996, Aberdeen (unpublished). 11pp. [Paper available from the Office of this Journal].
- Government of Japan. 2000. Research plan for cetacean studies in the western North Pacific under special permit (JARP II)(feasibility study plan for 2000 and 2001). Paper SC/47/SH3 presented to the IWC Scientific Committee, May 1995 (unpublished). 9pp. [Paper available from the Office of this Journal].
- Gribble, N.A., McPherson, G. and Lane, B. 1998. Effect of the Queensland Shark Control Program on non-target species. Whale, dugong and dolphin: a review. *Mar. Freshw. Res.* 49:645-51.
- Hakamada, T., Matsuoka, K., Nishiwaki, S., Murase, H. and Tanaka, S. 2001. Abundance trend of Southern Hemisphere minke whales in Areas IV and V using JARPA sighting data. Paper SC/53/IA12 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Hatanaka, H. and Miyashita, T. 1997. On the feeding migration of Okhotsk Sea-West Pacific stock minke whales, estimates based on length composition data. *Rep. int. Whal. Commn* 47:557-64.
- Haug, T., Gjosaeter, H., Lindstrom, U. and Nilssen, K.T. 1995. Diet and food availability for north-east Atlantic minke whales (*Balaenoptera acutorostrata*), during the summer of 1992. *ICES J. Mar. Sci.* 52:77-86.
- Heckel, G., Reilly, S.B., Sumich, J.L. and Espejel, I. 2001. The influence of whalewatching on the behaviour of migrating gray whales (*Eschrichtius robustus*) in Todos Santos Bay and surrounding waters, Baja California, Mexico. *J. Cetacean Res. Manage.* 3(3):227-37.
- Henshaw, M.D., LeDuc, R.G., Chivers, S.J. and Dizon, A.E. 1997. Identifying beaked whales (family Ziphiidae) using mtDNA sequences. *Mar. Mammal Sci.* 13(3):487-94.
- Honda, K., Tatsukawa, R. and Fujiyama, T. 1982. Distribution characteristics of heavy metals in the organs and tissues of striped dolphin, *Stenella coeruleoalba*. *Agric. Biol. Chem.* 46(12):3011-21.
- International Whaling Commission. 1987. Report of the Scientific Committee. *Rep. int. Whal. Commn* 37:28-145.
- International Whaling Commission. 1988. Report of the Scientific Committee. *Rep. int. Whal. Commn* 38:32-155.
- International Whaling Commission. 1992. Report of the Scientific Committee. Annex G. Report of the sub-committee on small cetaceans. *Rep. int. Whal. Commn* 42:178-234.
- International Whaling Commission. 1995. Chairman's Report of the Forty-Sixth Annual Meeting, Appendix 4. IWC Resolution 1994-4. Resolution on a Review of Aboriginal Subsistence Management Procedures. *Rep. int. Whal. Commn* 45:42-3.
- International Whaling Commission. 1996. Report of the Scientific Committee. *Rep. int. Whal. Commn* 46:50-97.
- International Whaling Commission. 1997a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 47:59-258.
- International Whaling Commission. 1997b. Report of the Scientific Committee. Annex E. Report of the sub-committee on Southern Hemisphere baleen whales. *Rep. int. Whal. Commn* 47:128-52.
- International Whaling Commission. 1998a. Chairman's Report of the Forty-Ninth Annual Meeting. *Rep. int. Whal. Commn* 48:17-52.
- International Whaling Commission. 1998b. Report of the Intersectoral Working Group to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic, Tokyo, 12-16 May 1997. *Rep. int. Whal. Commn* 48:377-412.
- International Whaling Commission. 1998c. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48:53-127.
- International Whaling Commission. 1998d. Report of the Scientific Committee. Annex G. Report of the sub-committee on Comprehensive Assessment of Southern Hemisphere humpback whales. *Rep. int. Whal. Commn* 48:170-82.
- International Whaling Commission. 1998e. Report of the Scientific Committee. Annex I. Report of the Standing Working Group on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP). *Rep. int. Whal. Commn* 48:203-36.
- International Whaling Commission. 1998f. Report of the Scientific Committee. Annex S. Modified Guidelines for Progress Reports. *Rep. int. Whal. Commn* 48:292-5.
- International Whaling Commission. 1999a. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 1:1-52.
- International Whaling Commission. 1999b. Report of the Scientific Committee. Annex I. Report of the Standing Sub-Committee on Small Cetaceans. *J. Cetacean Res. Manage. (Suppl.)* 1:211-25.
- International Whaling Commission. 1999c. Report of the Scientific Committee. Annex P. Proposal for Developing a Cooperative Research Programme to Address Critical Research Needs for the Greenland Stocks. *J. Cetacean Res. Manage. (Suppl.)* 1:262.
- International Whaling Commission. 2000a. Chairman's Report of the Fifty-First Annual Meeting, Appendix 9. IWC Resolution 1999-8. Resolution on DNA testing. *Ann. Rep. Int. Whaling Comm.* 1999:55.
- International Whaling Commission. 2000b. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 2:1-72.

- International Whaling Commission. 2000c. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 7. Initial trial specifications for western North Pacific Bryde's whales. *J. Cetacean Res. Manage. (Suppl.)* 2:118-23.
- International Whaling Commission. 2000d. Report of the Scientific Committee. Annex E. Report of the Standing Working Group (SWG) on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP). *J. Cetacean Res. Manage. (Suppl.)* 2:125-54.
- International Whaling Commission. 2000e. Report of the Scientific Committee. Annex I. Report of the Sub-Committee on Small Cetaceans. *J. Cetacean Res. Manage. (Suppl.)* 2:235-57.
- International Whaling Commission. 2001a. Chairman's Report of the 52nd Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2000:11-63.
- International Whaling Commission. 2001b. Chairman's Report of the Fifty-Second Annual Meeting. Appendix 1. Resolutions adopted during the 52nd Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2000:55-8.
- International Whaling Commission. 2001c. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 3:1-347.
- International Whaling Commission. 2001d. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 3:90-125.
- International Whaling Commission. 2001e. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 10. Specifications of the North Pacific minke whaling trials. *J. Cetacean Res. Manage. (Suppl.)* 3:114-25.
- International Whaling Commission. 2001f. Report of the Scientific Committee. Annex I. Report of the Working Group on Stock Definition. *J. Cetacean Res. Manage. (Suppl.)* 3:229-38.
- International Whaling Commission. 2001g. Report of the Scientific Committee. Annex J. Report of the Standing Working Group on Environmental Concerns. *J. Cetacean Res. Manage. (Suppl.)* 3:239-62.
- International Whaling Commission. 2001h. Report of the Scientific Committee. Annex J. Report of the Standing Working Group on Environmental Concerns. Appendix 5. Draft report of intersessional e-mail correspondence group to draft terms of reference for consideration of competition between fisheries and cetaceans. *J. Cetacean Res. Manage. (Suppl.)* 3:261-2.
- International Whaling Commission. 2001i. Report of the Scientific Committee. Annex K. Report of the Standing Sub-Committee on Small Cetaceans. *J. Cetacean Res. Manage. (Suppl.)* 3:263-91.
- International Whaling Commission. 2001j. Report of the Scientific Committee. Annex T. Report of the Working Group on the Greenland Research Programme. *J. Cetacean Res. Manage. (Suppl.)* 3:361-2.
- International Whaling Commission. 2001k. Report of the Scientific Committee. Annex U. Report of the Working Group on Nomenclature. *J. Cetacean Res. Manage. (Suppl.)* 3:363-7.
- International Whaling Commission. 2001l. Report of the Workshop to Review the Japanese Whale Research Programme under Special Permit for North Pacific Minke Whales (JARPN), Tokyo, 7-10 February 2000. *J. Cetacean Res. Manage. (Suppl.)* 3:377-477.
- International Whaling Commission. 2002a. Chair's Report of the 53rd Annual Meeting. Annex E. Instructions from the Commission to Scientific Committee for Reviews of Sanctuaries. *Ann. Rep. Int. Whaling Comm.* 2001:65.
- International Whaling Commission. 2002b. Chair's Report of the Fifty-Third Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2001:5-106.
- International Whaling Commission. 2002c. Chair's Report of the Fifty-Third Annual Meeting. Annex C. Resolutions Adopted During the 53rd Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2001:54-60.
- International Whaling Commission. 2002d. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 4:1-78.
- International Whaling Commission. 2002e. Report of the Scientific Committee. Annex E. Report of the Standing Working Group (SWG) on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP). *J. Cetacean Res. Manage. (Suppl.)* 4:148-77.
- International Whaling Commission. 2002f. Report of the Scientific Committee. Annex F. Report of the Sub-Committee on Bowhead, Right and Gray Whales. *J. Cetacean Res. Manage. (Suppl.)* 4:178-91.
- International Whaling Commission. 2002g. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on the Comprehensive Assessment of Whale Stocks — In-Depth Assessments. *J. Cetacean Res. Manage. (Suppl.)* 4:192-229.
- International Whaling Commission. 2002h. Report of the Scientific Committee. Annex H. Report of the Sub-Committee on the Comprehensive Assessment of North Atlantic Humpback Whales. *J. Cetacean Res. Manage. (Suppl.)* 4:230-60.
- International Whaling Commission. 2002i. Report of the Scientific Committee. Annex H. Report of the Sub-Committee on the Comprehensive Assessment of North Atlantic Humpback Whales. Appendix 5. Specification of stock structure hypotheses and input data for the assessment model. *J. Cetacean Res. Manage. (Suppl.)* 4:258-9.
- International Whaling Commission. 2002j. Report of the Scientific Committee. Annex M. Report of the Working Group on Estimation of Bycatch and Other Human-Induced Mortality. *J. Cetacean Res. Manage. (Suppl.)* 4:361-71.
- International Whaling Commission. 2002k. Report of the Scientific Committee. Annex U. E-mail Correspondence Groups and Terms of Reference. *J. Cetacean Res. Manage. (Suppl.)* 4:412-3.
- International Whaling Commission. 2002l. Report of the Scientific Committee. Annex L. Report of the Sub-Committee on Whale-watching. *J. Cetacean Res. Manage. (Suppl.)* 4:339-60.
- Iwata, H., Tanabe, S., Sakai, N. and Tatsukawa, R. 1993. Distribution of persistent organochlorines in the oceanic air and surface seawater and the role of ocean on their global transport and fate. *Environ. Sci. Technol.* 27:1080-98.
- Jefferson, T.A. 2000. Population biology of the Indo-Pacific hump-backed dolphin in Hong Kong waters. *Wildl. Monogr.* 144:1-65.
- Jefferson, T.A. and Karczmarski, L. 2001. *Sousa chinensis*. *Mamm. Species* 655:1-9.
- Jepson, P.D., Bennett, P.M., Allchin, C.R., Baker, J.R., Kuiken, T., Rogan, E., Lockyer, C., Law, R.J., Walton, M.J. and Kirkwood, J.K. 1998. Chronic PCB exposure is associated with infectious disease mortality in harbour porpoises stranded in England and Wales, 1990-1996. *Eur. Res. Cetaceans [Abstracts]* 12:352.
- Kang, Y.S., Matsuda, M., Kawano, M., Wakimoto, T. and Min, B.Y. 1997. Organochlorine pesticides, polychlorinated biphenyls, polychlorinated, polychlorinated dibenzo-p-dioxins and dibenzofurans in human adipose tissue from western Kyungnam, Korea. *Chemosphere* 35:2107-17.
- Kasamatsu, F., Matsuoka, K. and Hakamada, T. 2000. Interspecific relationships in density among the whale community in the Antarctic. *Polar Biol.* 23:466-73.
- Kasuya, T. and Miyashita, T. 1988. Distribution of sperm whale stocks in the North Pacific. *Sci. Rep. Whales Res. Inst., Tokyo* 39:31-75.
- Kato, H. and Miyashita, T. 1998. Current status of the North Pacific sperm whales and its preliminary abundance estimates. Paper SC/50/CAWS2 presented to the IWC Scientific Committee, April 1998 (unpublished). [Paper available from the Office of this Journal].
- Kawamura, A. 1973. Food and Feeding of Sei Whale Caught in the Waters South of 40° in the North Pacific. *Sci. Rep. Whales Res. Inst., Tokyo* 25:219-36.
- Kim, Z.G. 2001. Plan for whale sighting survey in the eastern waters of Korea, Spring 2002. Paper SC/53/RMP27 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Kishino, H., Kitada, S. and Hiramatsu, K. 1994. Sampling scheme for the estimation of the stock composition in the mixed population based on genetic data. *Nippon Suisan Gakkaishi* 60(3):359-64. [In Japanese].
- Kondo, I. 2001. *Rise and Fall of Japanese Coastal Whaling*. Sanyo-sha, Tokyo. 449pp. [In Japanese].
- Kwok, R. and Comiso, J.C. 2002. Southern Ocean climate and sea ice anomalies associated with the Southern Oscillation. *Journal of Climate* 15:487-501.
- Larsen, F. 1995. Abundance of minke and fin whales off West Greenland, 1993. *Rep. int. Whal. Commn* 45:365-70.
- Lasker, R. 1975. Field criteria for survival of anchovy larvae: the relation between inshore chlorophyll maximum layers and successful first feeding. *Fish. Bull., U.S.* 73(3):453-62.
- Leatherwood, J.S. and Donovan, G.P. (eds.). 1991. *Marine Mammal Technical Report. 3. Cetaceans and Cetacean Research in the Indian Ocean Sanctuary*. United Nations Environment Programme, Nairobi, Kenya. viii+287pp.
- Lien, J. 1994. Entrapments of large cetaceans in passive inshore fishing gear in Newfoundland and Labrador (1979-1990). *Rep. int. Whal. Commn* (special issue) 15:149-57.
- Lindström, U. and Haug, T. 2001. Feeding strategy and prey selectivity in common minke whales (*Balaenoptera acutorostrata*) foraging in the southern Barents Sea during early summer. *J. Cetacean Res. Manage.* 3(3):239-49.

- Lindström, U., Harbitz, A., Haug, T. and Nilssen, K.T. 1998. Do harp seals *Phoca groenlandica* exhibit particular prey preferences? *ICES J. Mar. Sci.* 55:941-53.
- Lockyer, C. 1981. Estimation of the energy costs of growth, maintenance and reproduction in the female minke whale, (*Balaenoptera acutorostrata*), from the Southern Hemisphere. *Rep. int. Whal. Commn* 31:337-43.
- Martien, K.K. and Taylor, B.L. 2001. A new method of generating hypothesized population structures for continuously distributed species using genetic data. Paper SC/53/SD7 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Mattila, D.K., Clapham, P.J., Vásquez, O. and Bowman, R.S. 1994. Occurrence, population composition, and habitat use of humpback whales in Samana Bay, Dominican Republic. *Can. J. Zool.* 72(11):1898-907.
- Mikhalev, Y.A. 1997. Humpback whales, *Megaptera novaeangliae* in the Arabian Sea. *Mar. Ecol. Prog. Ser.* 149:13-21.
- Mitchell, E. and Reeves, R.R. 1983. Catch history, abundance, and present status of northwest Atlantic humpback whales. *Rep. int. Whal. Commn* (special issue) 5:153-212.
- Miyashita, T. and Fujise, Y. 1997. Abundance estimate of the western North Pacific minke whale in sub-area 9 with notes on the results of dedicated surveys. *Rep. int. Whal. Commn* 47:543-51.
- Miyashita, T., Shigemune, H. and Kato, H. 1994. Outline of sighting strategy of scouting vessels attached to Japanese whaling fleets. *Rep. int. Whal. Commn* 44:273-6.
- Miyashita, T., Kato, H. and Kasuya, T. (eds.). 1995. *Worldwide Map of Cetacean Distribution Based on Japanese Sighting Data*. National Research Institute of Far Seas Fisheries, Shimizu, Japan. 140pp.
- Mizue, K. 1951. Food of whales (In the adjacent waters of Japan). *Sci. Rep. Whales Res. Inst., Tokyo* 5:81-90.
- Morton, A.B. and Symonds, H.K. 2002. Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia, Canada. *ICES J. Mar. Sci.* 59:71-80.
- Naito, Y. 1982. Sightings records of minke whales in the pack ice and adjacent waters off the coast of Enderby Land. *Rep. int. Whal. Commn* 32:929-33.
- NAMMCO. 1998. *Annual Report 1997*. North Atlantic Marine Mammal Commission, Polar Environment Centre, N9296, Tromsø, Norway. 260pp.
- Nemoto, T. and Kawamura, A. 1977. Characteristics of food habits and distribution of baleen whales with special reference to the abundance of North Pacific sei and Bryde's whales. *Rep. int. Whal. Commn* (special issue) 1:80-7.
- Nicol, S., Pauly, T., Bindoff, N.L. and Strutton, P.G. 2000. "BROKE" a biological/oceanographic survey off the coast of East Antarctica (80-150°) carried out in January-March 1996. *Deep-Sea Res. II* 47:2281-98.
- Norway. 1990. Norwegian proposal for a scientific permit to take 5 minke whales (*Balaenoptera acutorostrata*) of the northeast Atlantic stock in 1990. Paper SC/42/NHMi20 presented to the IWC Scientific Committee, June 1990 (unpublished). 7pp. [Paper available from the Office of this Journal].
- Pastene, L.A., Goto, M. and Kishino, H. 1998. An estimate of the mixing proportion of 'J' and 'O' stocks minke whales in Sub-Area 11 based on mitochondrial DNA haplotype data. *Rep. int. Whal. Commn* 48:471-4.
- Pastene, L.A., Goto, M. and Kanda, N. 2001. Comments on the estimations of the J and O stocks mixing proportion and level of by-catches of common minke whale using mitochondrial DNA data from the retail market surveys. Paper SC/53/RMP13 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Pastene, L., Goto, M. and Kanda, N. 2002. Proposal on an update to the defaults on stock structure in item 3 of Appendix 15 of Annex D (RMP sub-committee report). Paper SC/J02/NP7 presented to the Scientific Committee Workshop on North Pacific common minke (*Balaenoptera acutorostrata*) Implementation Simulation Trials held in Seattle, USA, 19-22 January, 2002 (unpublished). [Paper available from the Office of this Journal].
- Perryman, W.L., Donahue, M.A., Perkins, P.C. and Reilly, S.B. 2002. Gray whale calf production 1994-2000: Are observed fluctuations related to changes in seasonal ice cover? *Mar. Mammal Sci.* 18(1):121-44.
- Pinto de Lima, R. and Palazzo, J.T. 2002. Report of the Scientific Committee. Annex S. Comments and a Proposed Way Forward Regarding the Enhancement of Participation of Developing Country Scientists in the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 4:408-9.
- Pitcher, T.J. 2001. Fisheries managed to rebuild ecosystems? Reconstructing the past to salvage the future. *Ecol. Appl.* 11:601-17.
- Price, W.S. 1985. Whaling in the Caribbean: historical perspective and update. *Rep. int. Whal. Commn* 35:413-20.
- Punt, A.E. 1999. Report of the Scientific Committee. Annex R. A full description of the standard BALEEN II model and some variants thereof. *J. Cetacean Res. Manage. (Suppl.)* 1:267-76.
- Punt, A.E. and Butterworth, D.S. 1997. Preliminary evaluation of a (generic) strike limit algorithm for aboriginal subsistence whaling with comments on performance statistics and simulation trials. Paper SC/49/AS7 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 22pp. [Paper available from the Office of this Journal].
- Punt, A.E. and Butterworth, D.S. 1999. On assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales (*Balaena mysticetus*) using a Bayesian approach. *J. Cetacean Res. Manage.* 1(1):53-71.
- Punt, A.E. and Butterworth, D.S. 2002. An examination of certain of the assumptions made in the Bayesian approach used to assess the eastern North Pacific stock of gray whales (*Eschrichtius robustus*). *J. Cetacean Res. Manage.* 4(1):99-110.
- Reijnders, P.J.H., Rowles, T., Donovan, G.P., O'Hara, T., Bjørge, A., Larsen, F. and Kock, K.-H. 1999. Planning Workshop to Develop a Programme to investigate Pollutant Cause-effect relationships in Cetaceans: 'POLLUTION 2000+'. Annex C. POLLUTION 2000+: after Barcelona. *J. Cetacean Res. Manage.* (special issue) 1:77-83.
- Reuter, E. 1936. Die synoptische Darstellung 1/2 jährigen Druckwelle. *Veroff. Geophys. Inst. Univ. Leipzig* 7:257-95.
- Rice, D.W. 1998. *Marine Mammals of the World. Systematics and Distribution*. Special Publication No. 4. The Society for Marine Mammology, Lawrence, Kansas. 231pp.
- Rosenbaum, H.C., Razafindrakoto, Y., Vahoavy, J. and Pomilla, C. 2001. A note on recent sightings of southern right whales (*Eubalaena australis*) along the east coast of Madagascar. *J. Cetacean Res. Manage.* (special issue) 2:177-80.
- Saito, S., Nagamine, Y., Oshima, I., Kita, T., Fujise, Y. and Tatsukawa, R. 1986. Serum components of small cetaceans in north-western Pacific waters. *Agric. Biol. Chem.* 50:30-9.
- Schweder, T., Hagen, G.S. and Hatlebakk, E. 2000. Direct and indirect effects of minke whale abundance on cod and herring fisheries: A scenario experiment for the Greater Barents Sea. *NAMMCO Scientific Publications* 2:120-32.
- Shimada, H. and Miyashita, T. 1997. Population abundance of the western North Pacific Bryde's whale estimated from the sighting data collected from 1988 and 1996. Paper SC/49/NP4 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 7pp. [Paper available from the Office of this Journal].
- Shimadzu, Y. 1980. Basis of fishing effort for minke whaling in the Antarctic. *Rep. int. Whal. Commn* 30:425-33.
- Simmonds, M., Notarbartolo di Sciarra, G., Reijnders, P., Taylor, M., Fortuna, C., Perry, C., Stachowitsch, M. and Fossi, C. 2002a. Report of the Scientific Committee. Annex J. Report of the Standing Working Group on Environmental Concerns. Appendix 3. Report of the Scoping Group Meeting for the Habitat Degradation Workshop, June 11-12 2001, Rome, Italy. *J. Cetacean Res. Manage. (Suppl.)* 4:314-7.
- Simmonds, M., Reijnders, P.J.H., Stachowitsch, M., Rose, N. and Perry, C. 2002b. Report of the Scientific Committee. Annex J. Report of the Standing Working Group on Environmental Concerns. Appendix 4. Revised proposal for an intersessional Workshop on Cetacean Habitat Degradation. *J. Cetacean Res. Manage. (Suppl.)* 4:318-9.
- Skaug, H.J. and Schweder, T. 1999. Hazard models for line transect surveys with independent observers. *Biometrics* :29-36.
- Subramanian, A.N., Tanabe, S., Tatsukawa, R., Saito, S. and Miyazaki, N. 1987. Reduction in the testosterone levels by PCBs and DDE in Dall's porpoises of the northwestern North Pacific. *Mar. Poll. Bull.* 18(12):643-6.
- Tamura, T. and Fujise, Y. 2000. Daily and seasonal food consumption by the western North Pacific minke whale. Paper SC/F2K/J24 presented at the JARPN Review Meeting, Tokyo, Japan, 7-10 February 2000 (unpublished). 18pp. [Paper available from the Office of this Journal].
- Tamura, T., Ichii, T. and Fujise, Y. 1997. Consumption of krill by minke whales in Area IV and V of the Antarctic. Paper SC/M97/17 presented to the JARPA review meeting, Tokyo, May 1997 (unpublished). 9pp. [Paper available from the Office of this Journal].
- Tanabe, S. 1998. Analytical methods of dioxins and PCBs in wildlife. pp. 90-100. In: *An Investigating Manual of Contaminated Status of*

- Dioxins in Wildlife*. Center for Natural Environmental Studies, Tokyo. [In Japanese].
- Tanabe, S., Sung, J.-K., Choi, D.-Y., Baba, N., Kiyota, M., Yoshida, K. and Tatsukawa, R. 1994. Persistent organochlorine residues in northern fur seals from the Pacific coast of Japan since 1971. *Environ. Pollut.* 85:305-14.
- Thiele, D., Hofmann, E., Friedlaender, A., Moore, S. and McDonald, M. 2001. Preliminary report on IWC-SO GLOBEC collaborative research in the western Antarctic peninsula study area, March-June 2001. Paper SC/53/E8 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Thomas, L., Strindberg, S., Marques, F.F.C., Borchers, D.L., Buckland, S.T., Anderson, D.R., Burnham, K.P., Hedley, S.L. and Pollard, J.H. 2001. Distance 4.0. Beta 4. Research Unit for Wildlife Population Assessment, University of St Andrews, UK. <http://www.ruwpa.st-and.ac.uk/distance/>.
- Thompson, D.W.J. and Wallace, J.M. 1998. The Arctic Oscillation signature in the wintertime geopotential height and temperature fields. *Geophys. Res. Lett.* 25:1297-300.
- Van Loon, H. 1967. The half-yearly oscillations in middle and high southern latitudes and the coreless winter. *J. Atmos. Sci.* 24:472-86.
- Van Waerebeek, K. 1994. A note on the status of the Dusky dolphins (*Lagenorhynchus obscurus*) off Peru. *Rep. int. Whal. Commn* (special issue) 15:525-7.
- Vinnikov, K.Y., Robock, A., Stouffer, R.J., Walsh, J.E., Parkinson, C.L., Cavalieri, D.J., Mitchell, J.G.B., Garrett, D. and Zakharov, V.F. 1999. Global warming and northern hemisphere sea ice extent. *Science* 286:1934-7.
- Wada, S. 1997. Review of small pelagic resources and their fisheries in Japan. In: M. Devaraj and P. Martosuborto (eds.) *Proceedings of the First Session APFIC Working Party on Marine Fisheries, Bangkok, 13-16 May 1997. Small Pelagic Resources and their Fisheries in the Asia-Pacific Region*. FAO Regional Office for Asia and Pacific, Bangkok.
- Wada, S. and Numachi, K. 1991. Allozyme analyses of genetic differentiation among the populations and species of the *Balaenoptera*. *Rep. int. Whal. Commn* (special issue) 13:125-54.
- Wade, P.R. 1997. A revised gray whale analysis using both southbound total population counts and northbound calf counts. Paper SC/49/AS24 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 23pp. [Paper available from the Office of this Journal].
- Wade, P.R. 2002. A Bayesian stock assessment of the eastern Pacific gray whale using abundance and harvest data from 1967-1996. *J. Cetacean Res. Manage.* 4(1):85-98.
- Wang, J. and Ikeda, M. 2000. Arctic oscillation and Arctic sea-ice oscillation. *Geophys. Res. Lett.* 27:1287-90.
- Watanabe, T., Matsuoka, K., Tamura, T. and Fujise, Y. 2000. Oceanographic conditions of the western subarctic gyre region based on oceanographic data during the JARPN 1994-1999. Paper SC/F2K/J26 presented at the JARPN Review Meeting, Tokyo, Japan, 7-10 February 2000 (unpublished). 18pp. [Paper available from the Office of this Journal].
- Watanabe, Y., Zenitani, H. and Kimura, R. 1995. Population decline of the Japanese sardine *Sardinops melanostictus* owing to recruitment failures. *Can. J. Fish. Aquat. Sci.* 52(8):1609-16.
- Weller, D.W., Burdin, A.M., Würsig, B., Taylor, B.L. and Brownell, R.L. 2002. The western North Pacific gray whale: a review of past exploitation, current status and potential threats. *J. Cetacean Res. Manage.* 4(1):7-12.
- Weru, S. 2001. Rapid baseline survey of large marine animals, with special emphasis on humpback whales, in Kenya. *KWS Technical Series*, submitted. [Available from the author: werus@africaonline.co.ke]
- Whitehead, H., Christal, J. and Dufault, S. 1997. Past and distant whaling and the rapid decline of sperm whales off the Galápagos Islands. *Conserv. Biol.* 11(6):1387-396.
- Williams, R., Bain, D.E., Ford, J.K.B. and Trites, A.W. 2002. Behavioural responses of male killer whales to a 'leapfrogging' vessel. *J. Cetacean Res. Manage.* 4(3):305-310.
- Witting, L. 2000. On the exploitation of populations selected by density dependent competitive interactions. Paper SC/D2K/AWMP6 presented to the Third Workshop on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP), December 2000, Seattle (unpublished). [Paper available from the Office of this Journal].
- Witting, L. 2001. On inertial dynamics in whale populations. The case of the eastern North Pacific gray whale. Paper SC/53/AWMP6 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Yuan, X. and Martinson, D.G. 2000. Antarctic sea ice extent variability and its global connectivity. *Journal of Climate* 13:1697-717.

Annex A

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Annex B1

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 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 Catches and other statistical material
 - 3.3.2 Progress of data coding and validation projects
 - 3.3.3 Progress on program verification and other computing tasks
4. Cooperation with other organisations
 - 4.1 CMS
 - 4.1.1 Scientific Council
 - 4.1.2 ASCOBANS
 - 4.1.3 ACCOBAMS
 - 4.2 ICES
 - 4.3 IATTC
 - 4.4 ICCAT
 - 4.5 CCAMLR
 - 4.6 Southern Ocean GLOBEC
 - 4.7 NAMMCO
 - 4.8 FAO – Committee on Fisheries
 - 4.9 UNEP
 - 4.10 Other
 - 4.10.1 PICES
 - 4.10.2 ECCO
5. Revised Management Procedure (RMP) – general issues
 - 5.1 Adjustment of the convergence criteria for the CATCHLIMIT program
 - 5.2 Population component to which MSYR, MSYL, density-dependence should apply
 - 5.3 Evaluation of abundance estimators against simulated datasets
 - 5.3.1 Report of the Intersessional Working Group on Abundance Estimation
 - 5.4 Work plan
6. RMP – Preparations for implementation
 - 6.1 North Pacific minke whale Implementation
 - 6.1.1 Report of Implementation Simulation Trials group
 - 6.1.2 Consider relative plausibility of trials
 - 6.1.3 Consider Implementation options
 - 6.1.4 Specify intersessional work to permit completion of Implementations
 - 6.2 Procedures and scheduling of Implementations (Implementation Reviews)
 - 6.3 North Atlantic minke whale Implementation Review
 - 6.3.1 Report of steering group
 - 6.3.2 Implementation Review
 - 6.3.3 Specify intersessional work to permit completion of Implementation Review
 - 6.4 Western North Pacific Bryde's whales
 - 6.4.1 Report of Implementation Simulation Trials group
 - 6.4.2 Sightings surveys
 - 6.5 Other
 - 6.5.1 Sightings surveys plans for North Pacific minke whales
 - 6.5.2 Initial planning for an in-depth assessment of North Pacific minke whales
 - 6.5.3 Revision of RMP annotations
 - 6.5.4 Data availability
 - 6.5.6 Comparison between CLAs and SLAs
 - 6.6 Work plan
7. Estimation of Bycatch and Other Human-Induced Mortality
 - 7.1 Estimation of bycatch based on fisheries data and observer programmes
 - 7.1.1 Collation of information from fisheries
 - 7.1.2 Fatality rates of large whales entangled in fishing gear
 - 7.1.3 Other
 - 7.1.4 Recommendations to the Commission
 - 7.2 Estimation of bycatch based on genetic data
 - 7.2.1 Report of Bycatch Workshop Feasibility Steering Group
 - 7.2.2 Analytical tests for assignment to stocks and/or areas
 - 7.2.3 Other methodological advances
 - 7.3 Further review of information and methods to estimate mortality from ship strikes
 - 7.4 Methods for estimating additional human-induced mortalities
 - 7.5 Work plan
8. Aboriginal Subsistence Whaling Management procedure (AWMP)
 - 8.1 Review intersessional progress
 - 8.2 Bering-Chukchi-Beaufort Seas stock of bowhead whales

- 8.2.1 Selection of SLA
 - 8.2.1.1 Modification to candidate SLAs since the fourth workshop
 - 8.2.1.2 Review of results
 - 8.2.1.3 Comparison with the RMP
- 8.3 Gray whale trial structure
 - 8.3.1 Model-related issues
 - 8.3.2 Trial specifications
- 8.4 Greenlandic fisheries and the Greenlandic Research Programme
 - 8.4.1 Stock structure, range and movement
 - 8.4.2 Abundance and trends
 - 8.4.3 Biological data
 - 8.4.4 Preliminary consideration of management procedures
 - 8.4.5 Conclusion
- 8.5 Scientific aspects of an Aboriginal Subsistence Whaling Scheme
 - 8.5.1 Carryover
 - 8.5.2 Grace period and survey interval
 - 8.5.3 Implementation Reviews
 - 8.5.3.1 Regular Implementation Reviews
 - 8.5.3.2 Unscheduled implementation reviews
 - 8.5.4 Guidelines for surveys
 - 8.5.4.1 Survey/census methodology and design
 - 8.5.4.2 Committee oversight
 - 8.5.4.3 Data analysis and availability
- 8.6 Presentation of results to the Commission
 - 8.6.1 General presentation
 - 8.6.2 Management advice and incorporation into the Schedule
- 8.7 Work plan
- 9. Aboriginal subsistence whaling stock assessments
 - 9.1 Annual review of catches and catch limits
 - 9.1.1 Bering-Chukchi-Beaufort Seas stock of bowhead whales
 - 9.1.1.1 New scientific information
 - 9.1.1.2 Catch information
 - 9.1.1.3 Management advice
 - 9.1.2 In-depth assessment of eastern North Pacific gray whales
 - 9.1.2.1 Catch and stranding information
 - 9.1.2.2 New scientific information
 - 9.1.2.3 Assessment model results
 - 9.1.2.4 Management advice
 - 9.1.3 Minke and fin whales off West Greenland
 - 9.1.4 Humpback whales off St Vincent and the Grenadines
 - 9.2 Catches by non-member nations
 - 9.3 Contaminated gray whales from the eastern North Pacific stock
 - 9.4 Work plan
- 10. Whale stocks
 - 10.1 Matters relevant to more than one
 - 10.1.1 DESS: Progress with data entry and analysis options
 - 10.1.2 SOWER Circumpolar cruises
 - 10.1.2.1 SOWER 2001/02
 - 10.1.2.2 Plans for future Cruises
 - 10.1.3 NASS cruises
 - 10.2 Antarctic minke whales – abundance estimates
 - 10.2.1 Review of new data
 - 10.2.2 Updated estimates by area
 - 10.2.3 Inter-year comparisons and trend
 - 10.2.3.1 Methodological issues that may influence abundance estimates and their trends
 - 10.2.3.2 Timing of the surveys
 - 10.2.3.3 Using JSV data to extrapolate to unsurveyed regions
 - 10.2.3.4 Comparing JARPA data to IDCR/SOWER data
 - 10.2.3.5 Animals within the pack ice
 - 10.2.3.6 Work plan
 - 10.2.3.7 Trends in abundance using population dynamic models
 - 10.2.4 Other
 - 10.2.4.1 Update on mtDNA analyses
 - 10.2.4.2 Response to Resolution 2001-7
 - 10.2.5 Plans for completion of the Antarctic minke whale review
 - 10.3 Southern Hemisphere blue whales – plans for assessment
 - 10.3.1 Abundance estimation
 - 10.3.2 Progress on sub-species differentiation
 - 10.3.2.1 Behaviour and morphology
 - 10.3.2.2 Acoustics
 - 10.3.3 Other
 - 10.4.5 Work plan
 - 10.4 Southern Hemisphere humpback whales
 - 10.4.1 New information on distribution, stock structure, abundance and trends
 - 10.4.2 Further population dynamics modelling
 - 10.4.3 Antarctic humpback whale catalogue
 - 10.4.4 Work required to complete assessment
 - 10.4.6 Work plan
 - 10.5 North Atlantic humpback whales – completion of Comprehensive Assessment
 - 10.5.1 Review of assessment model developments
 - 10.5.2 Review of catch data
 - 10.5.3 Additional analysis and data collection
 - 10.5.3.1 Population structure and stock identity
 - 10.5.3.2 Abundance and trends
 - 10.5.3.3 Biological parameters
 - 10.5.4 Assessment
 - 10.5.5 Future work
 - 10.6 Other small stocks – bowhead, right and gray whales
 - 10.6.1 Small stocks of bowhead whales
 - 10.6.1.1 Davis Strait/Baffin Bay and Hudson Bay/Foxe Basin stocks of bowhead whales
 - 10.6.6.2 Other stocks
 - 10.6.2 North Atlantic right whales
 - 10.6.3 Southern Hemisphere right whales
 - 10.6.4 Other small stocks of right whales
 - 10.6.5 Western North Pacific stock of gray whales
 - 10.6.6 Work plan
 - 10.7 Other
 - 10.7.1 Fin whales in the North Atlantic

- 10.7.2 Sperm whales
 - 10.7.2.1 North Atlantic
 - 10.7.2.2 Worldwide
- 10.7.3 Status of abundance estimates
- 11. Stock Definition
 - 11.1 Further review of terminology
 - 11.2 Review of historical responses of cetacean sub-stocks to severe depletion
 - 11.3 Statistical and genetic issues pertaining to stock definition
 - 11.4 Simulation testing
 - 11.5 Work plan
- 12. Environmental Concerns
 - 12.1 Cooperative research in the Antarctic
 - 12.1.1 Results from SOWER 2000 cruise (cooperation with CCAMLR)
 - 12.1.2 Progress on development of joint research programme with SO-GLOBEC
 - 12.2 Steering group report on POLLUTION 2000+
 - 12.3 Habitat related issues
 - 12.3.1 State of Cetacean Environment Report – consider form of SOCER
 - 12.3.2 Review results from workshop on habitat degradation
 - 12.3.3 Review information regarding whalewatching activities and noise impacts
 - 12.3.4 Interactions between cetaceans and fisheries
 - 12.3.5 Mitigation of incidental capture of large cetaceans in fishing gear
 - 12.4 Other
 - 12.5 Work plan
- 13. Small Cetaceans
 - 13.1 Status of humpback dolphins
 - 13.1.1 Review of information
 - 13.1.2 Conclusions
 - 13.2 Progress on previous recommendations
 - 13.2.1 Status of the baiji
 - 13.2.2 Status of the vaquita
 - 13.2.3 Harbour porpoise
 - 13.2.4 Survey methodology for freshwater cetaceans
 - 13.2.5 Bycatch mitigation
 - 13.2.6 Dall's porpoises
 - 13.2.7 Other recommendations
 - 13.3 Takes of small cetaceans
 - 13.4 Work plan
- 14. Whalewatching
 - 14.1 Report of the intersessional working groups
 - 14.1.1 Data Collection Correspondence Group
 - 14.1.2 Whalewatching Management Correspondence Group
 - 14.2 Whalewatching activities and noise impacts
 - 14.3 Review of research on effectiveness of and compliance with whalewatching guidelines and regulations
 - 14.4 New information on previously discussed topics
 - 14.4.1 Dolphin feeding programmes
 - 14.4.2 'Swim-with' whale and dolphin programmes
 - 14.4.3 National guidelines and regulations
 - 14.4.4 Other
 - 14.5 Other
- 14.6 Work plan
- 15. DNA testing
 - 15.1 Progress on genetic methods for species, stock, individual identification
 - 15.2 Progress on collection and archiving of samples from catches and bycatches
 - 15.3 Reference databases and standards for a diagnostic register of DNA profiles
 - 15.4 Work plan
- 16. Scientific Permits
 - 16.1 Advice on effects of scientific permit catches
 - 16.2 Suggestions for improving review procedures
 - 16.3 Review of results from existing permits
 - 16.3.1 Japan – Southern Hemisphere minke whales
 - 16.3.2 Review of results from existing permit for feasibility study
 - 16.3.2.1 Results reported by Japan
 - 16.3.2.2 Comments and discussion by the Scientific Committee
 - 16.4 Review of new or revised proposals
 - 16.4.1 JARPA
 - 16.4.2 JARPN II
- 17. Whale Sanctuaries
 - 17.1 Review of the Indian Ocean Sanctuary
 - 17.2 Other
 - 17.3 Suggestions for improving the review process
- 18. Research and workshop proposals and results
 - 18.1 Review results from previously funded research proposals
 - 18.2 Review proposals for 2002/2003
 - 18.3 Workshop on Methods for Whale Research
- 19. Committee priorities and initial agenda for the 2003 meeting
- 20. Data processing and computing needs for 2002/2003
- 21. Funding requirements for 2002/2003
- 22. Committee working methods
 - 22.1 Increasing participation of scientists from developing countries
 - 22.2 Participation by member nations in the Committee's work
 - 22.3 General methods of improving the Committee's efficiency and effectiveness
 - 22.3.1 Late arrivals
 - 22.3.2 Citation and restrictions on citation of documents and working papers
 - 22.3.3 Reducing the amount of wasted papers
 - 22.3.4 Observers on surveys
- 23. Election of Officers
- 24. Publications
- 25. Other business
- 26. Adoption of report

Annex B2

Relationship Between the Commission and Scientific Committee Agendas

Agenda Item		Commission Instruction	
Commission	Scientific Committee	Chairman's Report; Item	Resolution
4. WHALEWATCHING		2002a; 4	
4.1 Report of the Scientific Committee	14; Annex L	2002a; 4	1994g; 1995b; 1997b
5. WHALE STOCKS	10	2002a; 6	
5.1 Southern Hemisphere minke whales			
5.1.1 Report of the Scientific Committee	10.2; Annex G	2002a; 6.1	2001b; 2002b
5.2 Southern Hemisphere blue whales			
5.2.1 Report of the Scientific Committee	10.3; Annex G	2002a; 6.2	1994e; 1995a
5.3 Southern Hemisphere humpback whales			
5.3.1 Report of the Scientific Committee	10.4; Annex H	2002a; 6.3	
5.4 North Atlantic humpback whales			
5.4.1 Report of the Scientific Committee	10.5; Annex H	2002a; 6.5	
5.5 Other stocks – bowhead, right and gray whales			
5.5.1 Report of the Scientific Committee	10.6; Annex F	2002a; 6.6	2000d; 2001b; 2002b
5.6 Other	10.7; Annex G	2002a; 6.7	
6. ABORIGINAL SUBSISTENCE WHALING		2002a; 8	
6.1 Aboriginal subsistence whaling scheme	8; Annex E	2002a; 8.1	1995c
6.2 Inedible gray whales from the North Pacific eastern stock	9.3; Annex F	2002a; 8.4	
6.3 Aboriginal subsistence whaling catch limits	9.1; Annexes E, F, H	2002a; 8.2	
7. CATCHES BY NON-MEMBER NATIONS	9.2; Annex F	2002a; 8.3	
9. REVISED MANAGEMENT SCHEME (RMS)			
9.1 Revised Management Procedure (RMP)		2002a; 9.1	
9.1.1 Report of the Scientific Committee		2002a; 9.1	1992a
• General issues	5; Annex D		
• Preparation for implementation (North Pacific minke, North Atlantic minke, and western North Pacific Bryde's whales)	6; Annex D		
• Bycatch	7; Annex M		1999c; 2002b
10. SANCTUARIES	17; Annex N	2002a; 7, Annex E	1993b; 1994f; 1999d
10.1 Reviews of sanctuaries			
10.1.1 Improvements to the review process	17.3	2002a; 7.1	
10.1.2 Review of the Indian Ocean Sanctuary	17.1	2002a; 7.1	
10.2 South Pacific Sanctuary	17.2	2002a; 7.4	
12. SCIENTIFIC PERMITS	16	2002a; 11	2002b
12.1 Report of the Scientific Committee	16	2002a; 11	1987; 1996a; 2000b
12.1.1 Advice on effects of scientific permit catches	16.1	2002a; 11	
12.1.2 Improvements to review procedures	16.2	2002a; 11	
12.1.3 Review of results from existing permits	6; 10.2,4,6; 11; 12; 16.3	2002a; 11	
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REFERENCES

- International Whaling Commission. 1987. Chairman's Report of the Thirty-Eighth Annual Meeting, Appendix 2. Resolution on special permits for scientific research. *Rep. int. Whal. Commn* 37:25.
- International Whaling Commission. 1992a. Chairman's Report of the Forty-Third Meeting, Appendix 4. Resolution on the Revised Management Procedure. *Rep. int. Whal. Commn* 42:47-8.
- International Whaling Commission. 1992b. Chairman's Report of the Forty-Third Meeting, Appendix 5. Resolution on small cetaceans. *Rep. int. Whal. Commn* 42:48.
- International Whaling Commission. 1993a. Chairman's Report of the Forty-Fourth Meeting, Appendix 2. Resolution on the need for research on the environment and whale stocks in the Antarctic region. *Rep. int. Whal. Commn* 43:39-40.
- International Whaling Commission. 1993b. Chairman's Report of the Forty-Fourth Meeting, Appendix 4. Resolution on a Sanctuary in the Southern Hemisphere. *Rep. int. Whal. Commn* 43:41-8.
- International Whaling Commission. 1993c. Chairman's Report of the Forty-Fourth Meeting, Appendix 9. Resolution on small cetaceans. *Rep. int. Whal. Commn* 43:51.
- International Whaling Commission. 1994a. Chairman's Report of the Forty-Fifth Annual Meeting, Appendix 11. Resolution on harbour porpoise in the North Atlantic and the Baltic Sea. *Rep. int. Whal. Commn* 44:34-5.
- International Whaling Commission. 1994b. Chairman's Report of the Forty-Fifth Annual Meeting, Appendix 12. Resolution on research on the environment and whale stocks. *Rep. int. Whal. Commn* 44:35.
- International Whaling Commission. 1994c. Chairman's Report of the Forty-Fifth Annual Meeting, Appendix 13. Resolution on the preservation of the marine environment. *Rep. int. Whal. Commn* 44:36.
- International Whaling Commission. 1994d. Chairman's Report of the Forty-Fifth Annual Meeting, Appendix 4. Resolution on addressing small cetaceans in the IWC. *Rep. int. Whal. Commn* 44:31-2.
- International Whaling Commission. 1994e. Chairman's Report of the Forty-Fifth Annual Meeting, Appendix 5. Resolution on research related to conservation of large baleen whales in the southern oceans. *Rep. int. Whal. Commn* 44:32.
- International Whaling Commission. 1994f. Chairman's Report of the Forty-Fifth Annual Meeting, Appendix 6. Resolution on a sanctuary in the southern ocean. *Rep. int. Whal. Commn* 44:32.
- International Whaling Commission. 1994g. Chairman's Report of the Forty-Fifth Annual Meeting, Appendix 9. IWC resolution on whalewatching. *Rep. int. Whal. Commn* 44:33-4.
- International Whaling Commission. 1995a. Chairman's Report of the Forty-Sixth Annual Meeting, Appendix 13. IWC Resolution 1994-12. Resolution on promotion of research related to conservation of large baleen whales in the Southern Oceans. *Rep. int. Whal. Commn* 45:48.
- International Whaling Commission. 1995b. Chairman's Report of the Forty-Sixth Annual Meeting, Appendix 15. IWC Resolution 1994-14. Resolution on whalewatching. *Rep. int. Whal. Commn* 45:49-50.
- International Whaling Commission. 1995c. Chairman's Report of the Forty-Sixth Annual Meeting, Appendix 4. IWC Resolution 1994-4. Resolution on a Review of Aboriginal Subsistence Management Procedures. *Rep. int. Whal. Commn* 45:42-3.
- International Whaling Commission. 1995d. Chairman's Report of the Forty-Sixth Annual Meeting, Appendix 5. IWC Resolution 1994-5. Resolution on the Revised Management Scheme. *Rep. int. Whal. Commn* 45:43-4.
- International Whaling Commission. 1995e. Chairman's Report of the Forty-Sixth Annual Meeting, Appendix 9. IWC Resolution 1994-8. Resolution on scientific permits. *Rep. int. Whal. Commn* 45:46.
- International Whaling Commission. 1996a. Chairman's Report of the Forty-Seventh Annual Meeting, Appendix 10. IWC Resolution 1995-9. Resolution on whaling under special permit. *Rep. int. Whal. Commn* 46:46-7.
- International Whaling Commission. 1996b. Chairman's Report of the Forty-Seventh Annual Meeting, Appendix 8. IWC Resolution 1995-7. Resolution on surveys intended to provide abundance estimates for the implementation of the revised management scheme. *Rep. int. Whal. Commn* 46:45-6.
- International Whaling Commission. 1996c. Chairman's Report on the Forty-Seventh Annual Meeting, Appendix 5. IWC Resolution 1995-4. Resolution on small cetaceans. *Rep. int. Whal. Commn* 46:44.
- International Whaling Commission. 1997a. Chairman's Report of the Forty-Eighth Annual Meeting, Appendix 11. Amendments to the Commission's Rules of Procedure. *Rep. int. Whal. Commn* 47:55.
- International Whaling Commission. 1997b. Chairman's Report of the Forty-Eighth Annual Meeting, Appendix 2. IWC Resolution 1996-2. Resolution on whalewatching. *Rep. int. Whal. Commn* 47:48.
- International Whaling Commission. 1997c. Chairman's Report of the Forty-Eighth Annual Meeting, Appendix 4. IWC Resolution 1996-4. Resolution on small cetaceans. *Rep. int. Whal. Commn* 47:49-50.
- International Whaling Commission. 1997d. Chairman's Report of the Forty-Eighth Annual Meeting, Appendix 6. IWC Resolution 1996-6. Resolution of provisions for completing the revised management scheme. *Rep. int. Whal. Commn* 47:51.

- International Whaling Commission. 1997e. Chairman's Report of the Forty-Eighth Annual Meeting, Appendix 8. IWC Resolution 1996-8. Resolution on environmental change and cetaceans. *Rep. int. Whal. Commn* 47:52.
- International Whaling Commission. 1998a. Chairman's Report of the Forty-Ninth Annual Meeting, Appendix 5. IWC Resolution 1997-5. Resolution on special permit catches in the Southern Ocean by Japan. *Rep. int. Whal. Commn* 48:47.
- International Whaling Commission. 1998b. Chairman's Report of the Forty-Ninth Annual Meeting, Appendix 7. IWC Resolution 1997-7. Resolution on environmental change and cetaceans. *Rep. int. Whal. Commn* 48:48-9.
- International Whaling Commission. 1998c. Chairman's Report of the Forty-Ninth Annual Meeting, Appendix 8. IWC Resolution 1997-8. Resolution on small cetaceans. *Rep. int. Whal. Commn* 48:49.
- International Whaling Commission. 1999a. Chairman's Report of the Fiftieth Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 1998:3-61.
- International Whaling Commission. 1999b. Chairman's Report of the Fiftieth Annual Meeting, Appendix 11. IWC Resolution 1998-10. Resolution to consider establishment of a mechanism to improve communications between the Commission and its Scientific Committee. *Ann. Rep. Int. Whaling Comm.* 1998:46.
- International Whaling Commission. 1999c. Chairman's Report of the Fiftieth Annual Meeting, Appendix 3. IWC Resolution 1998-2. Resolution on total catches over time. *Ann. Rep. Int. Whaling Comm.* 1998:42.
- International Whaling Commission. 1999d. Chairman's Report of the Fiftieth Annual Meeting, Appendix 4. IWC Resolution 1998-3. Resolution on the Southern Ocean Sanctuary. *Ann. Rep. Int. Whaling Comm.* 1998:42-3.
- International Whaling Commission. 1999e. Chairman's Report of the Fiftieth Annual Meeting, Appendix 6. IWC Resolution 1998-5. Resolution on environmental changes and cetaceans. *Ann. Rep. Int. Whaling Comm.* 1998:43-4.
- International Whaling Commission. 1999f. Chairman's Report of the Fiftieth Annual Meeting, Appendix 7. IWC Resolution 1998-6. Resolution for the funding of work on environmental concerns. *Ann. Rep. Int. Whaling Comm.* 1998:44-5.
- International Whaling Commission. 2000a. Chairman's Report of the Fifty-First Annual Meeting, Appendix 10. IWC Resolution 1999-9. Resolution on Dall's porpoise. *Ann. Rep. Int. Whaling Comm.* 1999:55-6.
- International Whaling Commission. 2000b. Chairman's Report of the Fifty-First Annual Meeting, Appendix 3. IWC Resolution 1999-2. Resolution on Special Permits for Scientific Research. *Ann. Rep. Int. Whaling Comm.* 1999:52.
- International Whaling Commission. 2000c. Chairman's Report of the Fifty-First Annual Meeting, Appendix 5. IWC Resolution 1999-4. Resolution on health effects from the consumption of cetaceans. *Ann. Rep. Int. Whaling Comm.* 1999:53.
- International Whaling Commission. 2000d. Chairman's Report of the Fifty-First Annual Meeting, Appendix 8. IWC Resolution 1999-7. Resolution on small populations of highly endangered whales. *Ann. Rep. Int. Whaling Comm.* 1999:55.
- International Whaling Commission. 2000e. Chairman's Report of the Fifty-First Annual Meeting, Appendix 9. IWC Resolution 1999-8. Resolution on DNA testing. *Ann. Rep. Int. Whaling Comm.* 1999:55.
- International Whaling Commission. 2001a. Chairman's Report of the Fifty-Second Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2000:11-63.
- International Whaling Commission. 2001b. Chairman's Report of the Fifty-Second Annual Meeting, Appendix 1. Resolutions adopted during the 52nd Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2000:55-8.
- International Whaling Commission. 2002a. Chairman's Report of the Fifty-Third Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2001:5-105.
- International Whaling Commission. 2002b. Chairman's Report of the Fifty-Third Annual Meeting, Annex C. Resolutions adopted during the 53rd Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2001:54-60.
-

Annex C

List of Scientific Committee Papers

SC/54/RMP

- 1 ØIEN, N. Report of the Norwegian 2001 sighting survey for minke whales.
- 2 ØIEN, N., BØTHUN, G. AND KLEIVANE, L. A review of available data on surfacing rates of northeastern Atlantic minke whales.
- 3 ALDRIN, M. AND TVETE, I.F. Measurement error models for the Norwegian minke whale surveys 1996-2001.
- 4 ALDRIN, M., HOLDEN, M. AND SCHWEDER, T. Spatial distribution of northeastern Atlantic minke whales 1996-2001.
- 5 SKAUG, H.J., ØIEN, N., BØTHUN, G. AND SCHWEDER, T. Abundance of northeastern Atlantic minke whales for the survey period 1996-2001.
- 6 SKAUG, H.J., HAUG, T. AND ØIEN, N. Spatial genetic structure in North Atlantic minke whales.
- 7 OLSEN, E. AND ØIEN, N. A comparison of age determination methods when applied to North Atlantic minke whales.
- 8 LAVERY, S., DALEBOUT, M.L., FUNAHASHI, N., CIPRIANO, F., ROBERTON, K.M., BROWNELL, R.L., Jr. AND BAKER, C.S. Census of North Pacific minke whales on the Japanese and Korean markets by DNA profiling: implications for plausibility of Implementation Simulation Trials.
- 9 MIYASHITA, T., KATO, H. AND VLADIMIROV, V.A. Plan for the North Pacific minke whale sighting surveys in the Sea of Okhotsk in 2002.
- 10 MIYASHITA, T., OKAMURA, H. AND MINAMIKAWA, S. Report of the longitudinal sighting surveys for Bryde's whales in the North Pacific, 2001.
- 11 MIYASHITA, T., MATSUOKA, K., NISHIWAKI, S. AND HAKAMADA, T. Information on track line and sightings of common minke whales during the recent JARPN/JARPN II.
- 12 MIYASHITA, T. AND YOSHIDA, H. Plan for the Japanese 2002 sighting survey under Japan/Korea joint cetacean research project.
- 13 SHIMADA, H. Report of a sighting survey on western North Pacific Bryde's whale conducted in August-September 2001.
- 14 SHIMADA, H. AND MIYASHITA, T. Research plan for Bryde's whale sighting cruise in the western North Pacific in 2002.
- 15 GOTO, M., KANDA, N. AND PASTENE, L.A. An additional genetic analysis to investigate the plausibility of different stock scenarios in North Pacific common minke whale IST.
- 16 TAYLOR, B.L. AND MARTIEN, K. Consideration of stock archetypes for North Pacific minke whales.
- 17 TAYLOR, B.L. A permutation test for trends in P-values: a measure of population structure between sub-areas 7 and 8 for North Pacific minke whales.

- 18 POLACHECK, T. Some issues and problems in the development of the North Pacific minke whale implementation trials: Why the process has taken so long and may continue to do so?
- 19 KIM, Z.G., SOHN, H. AND MIYASHITA, T. Plan for whale sighting survey in the Western waters of Korea, summer 2002.
- 20 KIM, Z.G., SOHN, H. AND MIYASHITA, T. Cruise report of the Korean whale sighting survey in the Yellow Sea, September 2001.
- 21 KIM, Z.G., SOHN, H. AND MIYASHITA, T. Revised plan of whale sighting survey in the eastern waters of Korea, Spring 2002.

SC/54/AWMP

- 1 WITTING, L., HOLLEBEEK, P., HEIDE-JØRGENSEN, M.P. AND KINGSLEY, M. West Greenland photo survey 2002.
- 2 WITTING, L. On model uncertainty and the selection of management procedures.
- 3 GIVENS, G.H. Empirical estimation of safe aboriginal whaling limits for bowhead whales.
- 4 GIVENS, G.H. Performance comparison of aboriginal whaling management procedures for bowhead whales.
- 5 DEREKSDÓTTIR, E.H. AND MAGNÚSSON, K.G. A strike limit algorithm based on adaptive Kalman filtering with an application to aboriginal whaling of bowhead whales.

SC/54/IA

- 1 COOKE, J.G. Progress report on analysis of IDCR/SOWER data.
- 2 ENSOR, P., SEKIGUCHI, K., COTTON, J., HUCKE-GAETE, R., KARIYA, T., KOMIYA, H., LJUNGBLAD, D., NARITA, H., OLSON, P. AND RANKIN, S. 2001-2002 International Whaling Commission-Southern Ocean Whale and Ecosystem Research (IWC-SOWER) circumpolar cruise, Area V.
- 3 BURT, M.L. AND HUGHES, M.S. Minke whale abundance estimation from the 1999/2000 IWC-SOWER Antarctic cruise in Area I.
- 4 BURT, M.L. Minke whale abundance estimation from the 2000/01 IWC-SOWER circumpolar cruise in Area I and VI.
- 5 BURT, M.L. AND HUGHES, M.S. A note on using different analysis options on abundance estimates using IWC-SOWER 1998/99 survey as an example.
- 6 THIELE, D., CHESTER, E. AND FRIEDLAENDER, A. Antarctic sea-ice habitat for minke whales (*Balaenoptera acutorostrata* sp.). Results of a line transect survey in East Antarctica.

- 7 TYNAN, C.T. Need for updated evaluation of climate change and impacts on cetaceans; decrease in Antarctic minke whale abundance, case in point.
- 8 KATO, H., HONNO, Y., YOSHIDA, H., KOJIMA, E., NOMURA, A. AND OKAMURA, H. Further developments on morphological and behavioural key for sub-species discrimination in southern blue whales, analyses from data through 1995/96 to 2001/02 SOWER cruises.
- 9 PASTENE, L.A. AND GOTO, M. An update of the mitochondrial DNA RFLP analysis in the Antarctic minke whales from Areas V and VI.
- 10 OKAMURA, H., KITAKADO, T., HIRAMATSU, K. AND MORI, M. A new variant of hazard probability model for abundance estimation of minke whales in the Antarctic.
- 11 MATSUDA, H., MURASE, H. AND MORISHITA, J. Comprehensive re-evaluation of the IWC's standard Antarctic minke whale abundance estimation approach.
- 12 MINAMIKAWA, S., MIYASHITA, T. AND OKAMURA, H. Further analyses on the JSV data of the Antarctic minke whale using the GLMs.
- 13 HAKAMADA, T. AND MATSUOKA, K. An examination of the effect of alternative pooling strata in the estimation of abundance in the Antarctic minke whale.
- 14 HAKAMADA, T. Comparative analyses on abundance trend for Antarctic minke whales between JARPA and IWC/IDCR-SOWER in Areas IV and V.
- 15 MATSUOKA, K. AND HAKAMADA, T. Applying alternative approach to Antarctic minke whale abundance estimation with an example for the part of Area IV using IWC/SOWER – 1998/99 data.
- 16 MORI, M., BUTTERWORTH, D. AND MATSUDA, H. Comparison of duplicate sighting rate for Southern Hemisphere whales between the 2nd and 3rd circumpolar surveys of IWC/IDCR-SOWER.
- 17 MURASE, H., MATSUOKA, K., NISHIWAKI, S., HAKAMADA, T. AND MORI, M. Some considerations on key factors affecting sighting conditions on Antarctic minke whale abundance estimation parameters in the IWC/IDCR-SOWER surveys.
- 18 SHIMADA, H. AND MURASE, H. Some analyses on sea ice condition in relation to changes in the Antarctic minke whale distribution pattern in the Antarctic Area IV.
- 19 SHIMADA, H., SEGAWA, K. AND MURASE, H. A preliminary trial: estimation of the Antarctic minke whale abundance within the sea ice area incorporating IDCR/SOWER data with meteorological satellites data.
- 20 SHIMADA, H., MATSUOKA, K., NISHIWAKI, S. AND KATO, H. Proposed for revised plan of the IWC/SOWER/Antarctic cruise in Area V, in 2002/2003 and 2003/2004.
- 21 BRAVINGTON, M.V. Spatial analyses of Southern Hemisphere minke whale data, allowing for size bias and sightability.
- 22 GILL, P. Blue whale research in the Bonney Coast upwelling region of south-east Australia: current status.
- 23 BORCHERS, D. AND BURT, L. Generalised regression methods for estimating school size from line transect data.
- 24 MIKHALEV, Y.A. AND GILL, P. Biological characteristics of pygmy blue whales taken in the Great Australian Bight during 1964/65 Antarctic whaling season.
- 25 BUTTERWORTH, D.S., PUNT, A.E., BRANCH, T.A., FUJISE, Y., ZENITANI, R. AND KATO, H. Updated ADAPT VPA recruitment and abundance trend estimates for Southern Hemisphere minke whales in Areas IV and V.
- 26 BRANDÃO, A. AND BUTTERWORTH, D.S. Further results concerning the closing:IO mode density ratio, R, for the IDCR-SOWER surveys.
- 27 RADEMEYER, R.A. AND BUTTERWORTH, D.S. Could a DISTANCE 4 approach improve the estimation of effective search half-width for blue whales for the IDCR-SOWER surveys?
- 28 BRANDÃO, A., BUTTERWORTH, D.S. AND RADEMEYER, R.A. Searching for evidence of minke whale migration patterns in the IDCR-SOWER survey data.
- 29 RADEMEYER, R.A. AND BUTTERWORTH, D.S. Miscellaneous aspects of minke whale abundance estimation for the IDCR-SOWER surveys.
- 30 TANAKA, E., MATSUOKA, K. AND HAKAMADA, T. A calculation of extent of discrepancy of cetacean stock abundance under assumption that $g(0) = 1$.
- 31 HUCKE-GAETE, R. Blue whale (*Balaenoptera musculus*) habitat selection in coastal waters off Chile.
- 32 BRANCH, T.A. AND BUTTERWORTH, D.S. Comparison of AIC values for different pooling options for minke whales from the IDCR/SOWER Circumpolar surveys and suggested pooling rules.

SC/54/H

- 1 FRIDAY, N.A., PUNT, A.E. AND SMITH, T.D. An expanded framework for the assessment of North Atlantic humpback whales, with illustrative examples.
- 2 PIKE, D.G., GUNNLAUGSSON, T. AND VÍKINGSSON, G.A. Estimate of the abundance of humpback whales (*Megaptera novaeangliae*) from the NASS-2001 Icelandic aerial survey.
- 3 MINTON, G., COLLINS, T., FINDLAY, K., BALDWIN, R., ROSENBAUM, H., KENNEDY, F. AND COCKCROFT, V. Preliminary investigations of humpback whale (*Megaptera novaeangliae*) distribution and habitat use off the coast of Oman.
- 4 ROSENBAUM, H.C., COLLINS, T., MINTON, G., BALDWIN, R., GLABERMAN, S., FINDLAY, K.P. AND BEST, P. Preliminary analysis of mtDNA variation among humpback whales off the coast of Oman and their relationship to whales from wintering grounds in the southwestern Indian Ocean.
- 5 ANDRIOLO, A., MARTINS, C.C.A., ENGEL, M.H., PIZZORNO, J.L., MÁRS-ROSA, S., FREITAS, A., MORETE, M.E., PETTA, C.B. AND KINAS, P.G. Aerial survey of humpback whale (*Megaptera novaeangliae*) to estimate abundance in the breeding ground, Brazil: preliminary results.
- 6 GUNNLAUGSSON, T. AND VÍKINGSSON, G.A. Trends in humpback whale (*Megaptera novaeangliae*) sightings rates from aerial surveys in Icelandic waters during 1986-2001.
- 7 PATON, D. AND CLAPHAM, P. Preliminary analysis of humpback whale sighting survey data collected in Fiji, 1956-1958.
- 8 [NO PAPER]
- 9 GARRIGUE, C., BAKER, C.S., DODEMONT, R. AND STEEL, D. Estimating the abundance of humpback whales in New Caledonia using DNA genotyping and photo-identification.
- 10 PIKE, D.G., GUNNLAUGSSON, T. AND VÍKINGSSON, G.A. Estimates of humpback whale (*Megaptera*

- novaeangliae*) abundance in the North Atlantic, from NASS-95 shipboard survey data.
- 11 FREITAS, A.C., KINAS, P.G., MARTINS, C.C.A. AND ENGEL, M.H. Population estimate for humpback whales from Abrolhos Bank, Brazil wintering ground in the southwestern Atlantic Ocean.
 - 12 SECCHI, E.R., DALLA ROSA, L., BASSOI, M., SANTOS, M.C.O., DANILEWICZ, D., FLORES, P.A., MORENO, I.B. AND KINAS, P.G. Intra and interannual trends in density of humpback whales, *Megaptera novaeangliae*, in the Gerlache strait: summers 1997/98 to 2001/2002.
 - 13 ALLEN, J.M., CARLSON, C. AND ROCK, J. Interim report: IWC research contract 16, Antarctic humpback whale catalogue.
 - 14 POOLE, M.M. Occurrence of humpback whale (*Megaptera novaeangliae*) in French Polynesia 1988-2001.
 - 15 SMITH, T.D. AND REEVES, R.R. Estimating American 19th century whaling catches of humpbacks in the West Indies and Cape Verde Islands.
 - 16 REEVES, R.R., SMITH, T.D., WEBB, R.L., ROBBINS, J. AND CLAPHAM, P.J. Humpback and fin whaling in the Gulf of Maine, 1800 to 1918.
 - 17 JOHNSTON, S.J. AND BUTTERWORTH, D.S. An assessment of the west and east Australian breeding stocks of Southern Hemisphere humpback whales using a model that allows for mixing in the feeding grounds.
 - 18 AVOLIO, M., ERSTS, P., POMILLA, C., VELY, M., BASTID, J.J., WENDLING, B., SEITRE, R., SEITRE, J., DARMMANGEAT, P., COLLIN-OMNES, V., RAZAFINDRAKOTO, Y., FINDLAY, K. AND ROSENBAUM, H.C. Humpback whale distribution and marine mammal diversity in the waters of Mayotte, (Comores Archipelago) in the Mozambique Channel.
 - 19 [NO PAPER]
 - 20 ROSENBAUM, H.C., ERSTS, P.J., RAZAFINDRAKOTO, Y., SOUNGUET, G., POMILLA, C., NGOUESSONO, S., RASOAMAMPINANINA, V. AND WHITE, L. Population characteristics, distribution, and relative abundance of humpback whales off the coasts of Madagascar and Gabon: an update on recent and planned research.
 - 21 BARENDSE, J., THORNTON, M., ELWEN, S. AND BEST, P.B. Migrations of humpback whales on the west coast of South Africa: preliminary results.
 - 22 REEVES, R., SMITH, T. AND CLAPHAM, P. Incidental observations of humpback whales in the North Atlantic Ocean by American whalers in the 19th century.
 - 23 ROBBINS, J. AND MATTILA, D.K. Further investigation of reproductive parameters among female humpback whales (*Megaptera novaeangliae*) in the Gulf of Maine.
- distribution and causes of mortality of beach cast cetaceans in the Sultanate of Oman, January 1999 to February 2002.
- 5 DE BOER, M.N., BALDWIN, R., BURTON, C.L.K., EYRE, E.L., JENNER, K.C.S., JENNER, M.-N.M., KEITH, S.G., MCCABE, K.A., PARSONS, E.C.M., PEDDEMORS, V.M., ROSENBAUM, H.C., RUDOLPH, P. AND SIMMONDS, M. Cetaceans in the Indian Ocean Sanctuary: A review.
 - 6 WHITEHEAD, H. Estimates of the current global population size and historical trajectory for sperm whales.
 - 7 GALES, N.J. AND JARMAN, S.N. A non-lethal genetic method of identifying whale prey.
 - 8 GUNNLAUGSSON, T., VÍKINGSSON, G.A., PIKE, D.G., DESPORTES, G., MIKKELSEN, B. AND BLOCH, D. Combined line-transect and cue-count estimate of sperm whale abundance in the North Atlantic, from Icelandic and Faroese NASS-2001 shipboard surveys.
 - 9 GUNNLAUGSSON, T., VÍKINGSSON, G.A., PIKE, D.G., DESPORTES, G., MIKKELSEN, B. AND BLOCH, D. Fin whale abundance in the North Atlantic, estimated from Icelandic and Faroese NASS-2001 shipboard surveys.
 - 10 VÍKINGSSON, G.A., GUNNLAUGSSON, T., HALLDÓRSSON, S.D. AND OLAFSDÓTTIR, D. NASS 2001 Icelandic shipboard survey report.
 - 11 HAUSER, N. AND CLAPHAM, P. The Cook Islands whale sanctuary.
 - 12 PIKE, D.G., GUNNLAUGSSON, T. AND VÍKINGSSON, G.A. North Atlantic sightings survey 2001 (NASS-2001): aerial survey in coastal Icelandic waters.
 - 13 KONDO, I. AND KASUYA, T. True catch statistics for a Japanese coastal whaling company in 1965-1978.
 - 14 SPWRC. Report of the annual meeting of the South Pacific whale research consortium.
 - 15 THOMPSON, K.F., O'CALLAGHAN, T.M., DALEBOUT, M.L. AND BAKER, C.S. Population ecology of Bryde's whales (*Balaenoptera edeni* sp.) in the Hauraki Gulf, New Zealand: preliminary observations.
 - 16 FUJISE, Y., TAMURA, T., BANDO, T., WATANABE, H., KIWADA, H., OTANI, S., KANDA, N., YASUNAGA, G., MOGOE, T., KONISHI, K., INAMORI, M., SHIGEMUNE, H. AND TOHYAMA, D. Cruise report of the feasibility study of the Japanese whales research program under special permit in the western North Pacific — phase II (JARPN II) in 2001.
 - 17 FUJISE, Y., KAWAHARA, S., PASTENE, L.A. AND HATANAKA, H. Report of 2000 and 2001 feasibility study of the Japanese whale research program under special permit in the western North Pacific — phase II (JARPN II).
 - 18 ISHIKAWA, H., OTANI, S., MOGOE, T., KIWADA, H., TOHYAMA, D., YOSHIDA, T., HAYASHI, T., NAGAMINE, M., FUKUTOME, K., KOYANAGI, T., FUJIHARA, T., SASAKI, T., ISHIHARA, T. AND MORI, M. Cruise report of the Japanese whale research program under special permit in the Antarctic (JARPA) Area IV and eastern part of Area III in 2001/2002.
 - 19 INSTITUTE OF CETACEAN RESEARCH. Research activities of the Institute of Cetacean Research (RAICR) July 2001-April 2002.
 - 20 MORISHITA, J. AND HATANAKA, H. Review of the scientific aspects of Indian Ocean Sanctuary.
 - 21 HEIDE-JØRGENSEN, M.P. AND VÍKINGSSON, G.A. Satellite tracking of baleen whales in the North Atlantic in 2000 and 2001.
 - 22 PEDDEMORS, V.M., BEST, P.B., COCKCROFT, V.G. AND OOSTHUIZEN, W.H. Report on the recent categorization

SC/54/O

- 1 GOVERNMENT OF JAPAN The 2002/2003 research plan for the Japanese whale research program under special permit in the Antarctic (JARPA).
- 2 GOVERNMENT OF JAPAN Research plan for cetacean studies in the western North Pacific under special permit (JARPN II).
- 3 MOORE, S.E. Passive acoustic detection of mysticete whales in Alaskan and Antarctic Seas: a provisional summary of ongoing research and suggestions for future applications.
- 4 COLLINS, T., MINTON, G., BALDWIN, R., VAN WAEREBEEK, K., HYWEL-DAVIES, A. AND COCKCROFT, V. A preliminary assessment of the frequency,

of South African cetaceans according to the 2001 IUCN red list criteria (Ver. 3.1).

- 23 KOZLOV, A.I. Whaling products as an essential element of indigenous diet in Chukotka.
- 24 UNEP. UNEP's plans for a world digital atlas on marine mammals.
- 25 LEAPER, R. Some developments in the last ten years that may be relevant to discussions of the Indian Ocean Sanctuary.
- 26 CLAPHAM, P.J., BERGGREN, P., FRIDAY, N.A., KELL, L.T., KOCH, K.-H., MANZANILLA, S., PERRIN, W.F., READ, A., ROGAN, E., ROJAS-BRACHO, L., SMITH, T.D., STACHOWITSCH, M., TAYLOR, B.L., THIELE, D., WADE, P.R. AND BROWNELL, R.L., Jr. The JARPN II program: a critique.

SC/54/BRG

- 1 WILLETTO, C., O'HARA, T. AND ROWLES, T. Bowhead whale health and physiology workshop 2001: Summary for the International Whaling Commission (IWC) Scientific Committee.
- 2 [NO PAPER]
- 3 PERRYMAN, W.L. AND ROWLETT, R.A. Preliminary results of a shore-based survey of northbound gray whale calves in 2001.
- 4 PERRYMAN, W.L., WATERS, G.M. AND SCHWARZ, L.K. Examination of the relationship between seasonal ice and calf production in the eastern Pacific population of gray whales.
- 5 GEORGE, J.C., ZEH, J., SUYDAM, R. AND CLARK, C. Population size of the Bering-Chukchi-Beaufort Seas stock of bowhead whales, *Balaena mysticetus*, based on the 2001 census off Point Barrow, Alaska.
- 6 RUGH, D.J., BREIWK, J.M., HOBBS, R.C. AND LERCZAK, J.A. A preliminary estimate of abundance of the eastern North Pacific stock of gray whales in 2000/01 and 2001/02.
- 7 WADE, P.R. AND PERRYMAN, W. An assessment of the eastern gray whale population in 2002.
- 8 BEST, P.B., MATE, B., BARENDSE, J., ELWEN, S., THORNTON, M. AND VERHEYE, H. Evidence for a summer feeding ground for right whales on the west coast of South Africa.
- 9 BRADFORD, A.L., BURDIN, A.M., WADE, P.R., IVASHCHENKO, Y.V., TSIDULKO, G.A., VANBLARICOM, G.R. AND WELLER, D.W. Survival estimates of western gray whales (*Eschrichtius robustus*).
- 10 PUNT, A.E., ALLISON, C. AND FAY, G. An examination of assessment models for the eastern North Pacific gray whale based on inertial dynamics.
- 11 FLEISCHER, L.A. AND SCHWEDER, T. Gray whales on their winter grounds in Baja California Sur, México (1980-1998).
- 12 BROWNELL, R.L., Jr. AND WELLER, D.W. Prolonged calving intervals in western gray whales: nutritional stress and pregnancy.
- 13 WELLER, D.W., BRADFORD, A.L., BURDIN, A.M., MIYASHITA, T., KARIYA, T., TRUKHIN, A.M., MACLEAN, S.A., VLADIMIROV, V.A. AND DOROSHENKO, N.V. Photographic recaptures of western gray whales in the Okhotsk Sea.
- 14 WELLER, D.W., IVASHCHENKO, Y.V., TSIDULKO, G.A., BURDIN, A.M. AND BROWNELL, R.L., Jr. Influence of seismic surveys on western gray whales off Sakhalin Island, Russia in 2001.
- 15 MELNIKOV, V.V., LITOVKA, D.I., ZAGREBIN, I.A., ZELENSKY, G.M. AND AINANA, L.I. Results of

shore-based counts of bowhead whales in Chukotka: at the western Bering Strait, and the eastern Gulf of Anadyr; in May and June 1999 to 2001.

- 16 URBÁN R, J., ROJAS-BRACHO, L., PERÉZ-CORTÉS, H., GÓMEZ-GALLARDO, A., SWARTZ, S. AND BROWNELL, R.L. A review of gray whales in their wintering grounds in Mexican waters.
- 17 CLAPHAM, P. Progress on recommendations relating to North Atlantic right whales.
- 18 CLARK, C.W., COLBY, J.A., FOWLER, M.C., TESSAGLIA-HYMES, C., FRISTRUP, K.M., DUNSMORE, K.J. AND GEORGE, J.C. Passive acoustic locations and offshore distribution of bowhead whales (*Balaena mysticetus*) during the Spring 2001 census off Pt. Barrow, Alaska.
- 19 ROONEY, A.P., GEORGE, J.C. AND TARPLEY, R.J. Phylogenetic and morphometric analyses of the *ingutuk*, a morphological variant of the bowhead whale (*Balaena mysticetus*).
- 20 SUYDAM, R.S., O'HARA, T.M., GEORGE, J.C., WOSHNER, V.M. AND SHEFFIELD, G. Subsistence harvest of bowhead whales by Alaskan eskimos during 2001.
- 21 BORODIN, R.G. AND SHEVCHENKO, N. The 2001 aboriginal whale harvest in the waters of the Bering Sea and the Chukchi Sea adjacent to Chukotka, Russia.
- 22 BROWNELL, R.L., Jr., PITMAN, R.L., LEDUC, R.G., CLAPHAM, P.J. AND ROSENBAUM, H.C. Right whales in the North Pacific are poor bellwethers of large ecosystem shifts.
- 23 GULLAND, F.M.D., PEREZ-CORTES, H., URBAN R, J., ROJAS-BRACHO, L., YLITALO, G., KREUDER, C. AND ROWLES, T. Eastern North Pacific gray whale (*Eschrichtius robustus*) unusual mortality event, 1999-2000: a compilation.
- 24 PEREZ-CORTES, H.M., URBAN R, J. AND VELASQUEZ, G.C. Gray whales (*Eschrichtius robustus*) at Magdalena Bay Complex during 1997 winter season.
- 25 MATE, B.R. AND URBÁN R, J. The route and speed of a gray whale on its northern migration from Mexico to central California, tracked by satellite-monitored radio tag.
- 26 MATE, B.R., LAGERQUIST, B.A. AND URBÁN R, J. The use of San Ignacio lagoon by breeding and calving gray whales.
- 27 BORODIN, R.G., BLOKHIN, S.A. AND LITOVKA, D. Historical and present information about the aboriginal whale harvest of gray whales in Chukotka, Russia.

SC/54/E

- 1 FRIDAY, N., AYDIN, K. AND HARKNESS, S. Update on the eastern Bering Sea ecopath/ecosim model.
- 2 BURROWS, D.G., BOLTON, J. AND KRAHN, M.M. Procedures for submission of data on chemical contaminants in cetacean products to the World Health Organisation/Global Environment Monitoring System (WHO/GEMS) database.
- 3 MOORE, S., ASHJIAN, C., MASLOWSKI, W., CAMPBELL, R., SPITZ, Y., OKKONEN, S., SHERR, E., SHERR, B. AND GEORGE, J.C. Biocomplexity in the Arctic: a summary of proposed research.
- 4 CLARK, E.D. The state of the ozone layer and the progress of the Montreal Protocol: consequences for the cetacean environment.
- 5 CLARK, E.D., PERRY, C.S. AND ELLIOTT, W.J. Examples of organic and heavy metal contaminants in cetaceans from coastal waters.

- 6 LINDSTRØM, U. AND HAUG, T. On the whale-fisheries issue: A review of Norwegian studies of the feeding ecology of northeast Atlantic minke whales (*Balaenoptera acutorostrata*) during the past decade.
 - 7 DOLMAN, S.J., PARSONS, E.C.M. AND SIMMONDS, M.P. Noise sources in the cetacean environment.
 - 8 SIMMONDS, M.P. Ocean noise and the law.
 - 9 TORNERO, V., BORRELL, A. AND AGUILAR, A. Body compartmentation and blubber topographical variation of retinoids in common dolphins.
 - 10 TAYLOR, M. Habitat degradation: contribution to extinction risk for southern resident killer whales.
 - 11 TAYLOR, M. Limits to recovery of Bering-Chukchi-Beaufort Seas bowhead whale: habitat degradation and environmental variability.
 - 12 THIELE, D., MOORE, S., HILDEBRAND, J., FRIEDLAENDER, A., SIROVIC, A., PIRZL, R., McDONALD, M., WIGGINS, S., HOFMANN, E. AND KLINCK, J. Second annual report on IWC collaborative research in the SO GLOBEC western Antarctic peninsula study area.
 - 13 CLARKE, R., FÉLIX, F., PALIZA, O. AND BRITNIK, P. Why sperm whales have disappeared from Ecuadorian and northern Peruvian seas.
 - 14 REIJNDERS, P., WELLS, R., ROWLES, T., AGUILAR, A., BJØRGE, A., DONOVAN, G. AND O'HARA, T. Progress report on POLLUTION 2000+: 2001-2002.
 - 15 CHIVERS, S.J., ROBERTSON, K.M. AND DANIL, K. Life history characteristics of the incidental kill of cetaceans in the California drift and set gillnet fisheries during 2001.
 - 16 KARCZMARSKI, L. Population ecology of humpback dolphins in South Africa: implications for conservation and management.
 - 17 KARCZMARSKI, L., GUISSAMULO, A.T. AND COCKCROFT, V.G. Bazaruto Archipelago: an area of high importance in humpback dolphin and dugong conservation.
 - 18 PORTER, L.J. Epimeletic behaviour in *Sousa chinensis*: implications for management.
 - 19 JARAMILLO-LEGORRETA, A., ROJAS-BRACHO, L., GORDON, J. AND GILLESPIE, D. Progress report of vaquita acoustic surveys.
 - 20 BARRERA, J.C. AND ROJAS-BRACHO, L. Progress report vaquita recovery strategy.
 - 21 ROJAS-BRACHO, L., JARAMILLO-LEGORRETA, A. AND GERRODETTE, T. Are aggregation behavior and local movements of vaquita adversely influenced by fishing vessels?
 - 22 SMITH-GOODWIN, J. AND COCKCROFT, V.G. Genetic diversity and phylogeny of humpback dolphins (*Sousa chinensis*) from the south east coast of southern Africa.
 - 23 [NO PAPER]
 - 24 COCKCROFT, V.G. Natural history of Indopacific humpback dolphins (*Sousa chinensis*) off southern Africa.
 - 25 COCKCROFT, V.G. AND SMITH-GOODWIN, J. The phylogeny of humpback dolphins Genus *Sousa*.
 - 26 COCKCROFT, V.G. Conservation biology of humpback dolphins in south & eastern Africa.
 - 27 ATKINS, S. AND ATKINS, B.L. Abundance and site fidelity of Indo Pacific hump-backed dolphins (*Sousa chinensis*) at Richards Bay, South Africa.
 - 28 KEITH, S.G. Recent observations of *Sousa* in the Persian Gulf.
 - 29 PARRA, G.J., CORKERON, P.J. AND MARSH, H. The Indo-Pacific humpback dolphin, *Sousa chinensis* (Osbeck, 1765) in Australian waters: a summary of current knowledge and recommendations for their conservation.
 - 30 GUISSAMULO, A. AND COCKCROFT, V.G. Ecology and population estimates of the Indo-Pacific humpback dolphins (*Sousa chinensis*) in Maputo Bay, Mozambique.
 - 31 CORKERON, P.J. AND VAN PARIJS, S.M. Pacific humpback dolphins, sound and management: a review.
 - 32 LARSEN, F., RITZAU EIGAARD, O. AND TOUGAARD, J. Reduction of harbour porpoise by-catch in the North Sea by high-density gillnets.
 - 33 VINTHER, M. AND LARSEN, F. Updated estimates of harbour porpoise by-catch in the Danish bottom set gillnet fishery.
 - 34 LARSEN, F., VINTHER, M. AND KROG, C. Use of pingers in the Danish North Sea wreck net fishery.
 - 35 RAZAFINDRAKOTO, Y., ANDRIANARIVELO, N. AND ROSENBAUM, H.C. Status of Indo-Pacific humpback dolphins in the coastal waters of Madagascar.
 - 36 ROSENBAUM, H.C., GLABERMAN, S., JEFFERSON, T., COLLINS, T., MINTON, G., PEDDEMORS, V. AND BALDWIN, R. Phylogenetic relationships and population structure among humpback dolphins based on mtDNA variation.
 - 37 SUTARIA, D. Status of Indo-Pacific humpback dolphins (*Sousa chinensis*) along the coast of India.
- SC/54/SM**
- 1 [NO PAPER]
 - 2 BERGGREN, P., CARLSTRÖM, J. AND TREGENZA, N. Mitigation of small cetacean by-catch; evaluation of acoustic alarms (MISNET).
 - 3 BERGGREN, P., BROWN, S., GILLESPIE, D., KUKLIK, I., LEWIS, T., MATTHEWS, J., McLANAGHAN, R., MOSCROP, A. AND TREGENZA, N. Passive acoustic and visual survey of harbour porpoises (*Phocoena phocoena*) in Polish coastal waters confirms endangered status of Baltic population.
 - 4 PARSONS, E.C.M. The behaviour and ecology of the Indian humpback dolphin (*Sousa chinensis plumbea*) and the Pacific humpback dolphin (*Sousa chinensis chinensis*).
 - 5 PARSONS, E.C.M. The impacts of pollution on humpback dolphins.
 - 6 BALDWIN, R.M., COLLINS, T., VAN WAEREBEEK, K. AND MINTON, G. The Indian Ocean humpback dolphin, *Sousa plumbea* (G. Cuvier, 1829).
 - 7 JEFFERSON, T.A. AND HUNG, S.K. A review of the status of the Indo-Pacific humpback dolphin in China.
 - 8 JEFFERSON, T.A. A preliminary analysis of geographic variation in skull morphology of humpback dolphins (genus *Sousa*).
 - 9 VAN WAEREBEEK, K., BARNETT, L., CAMARA, A., CHAM, A., DIALLO, M., DJIBA, A., JALLOW, A.O., NDIAYE, E. AND SAMBA OULD BILAL, A.O. Status and biology of the Atlantic humpback dolphin *Sousa teuszii* (Kükenthal, 1892).
 - 10 VAN WAEREBEEK, K., ALFARO-SHIGUETO, J., MONTES, D., ONTON, K., SANTILLAN, L., VAN BRESSEM, M.-F. AND VEGA, D. Fisheries related mortality of small cetaceans in neritic waters of Peru in 1999-2001.
 - 11 GAZO, M. AND AGUILAR, A. Are pingers useful to reduce damage produced by bottlenose dolphins in trammel nets? A test in the Balearic Islands.
 - 12 CARRETTA, J.V. Preliminary estimates of cetacean mortality in California gillnet fisheries for 2001.

- 36 HUNG, S.K. AND JEFFERSON, T.A. Habitat use of Indo-Pacific humpback dolphins in Hong Kong waters: preliminary analysis.
- 37 PEDDEMORS, V.M. The status of Indo-Pacific hump-backed dolphins (*Sousa chinensis*) in South Africa.

SC/54/BC

- 1 LAVERY, S., DALEBOUT, M.L., YONG-WOON, M.A., FUNAHASHI, N. AND BAKER, C.S. Market surveys of whales, dolphins and porpoises in Japan and Korea, 2001-2002.
- 2 CLAPHAM, P., BERGGREN, P., LEAPER, R. AND ROBBINS, J. Report of the intersessional working group on large whale entanglement.
- 3 FUNAHASHI, N., LENTO, G.M., LAVERY, S., DALEBOUT, M.L., CIPRIANO, F. AND BAKER, C.S. Japanese market distribution of North Pacific minke whale products from unregulated takes and scientific whaling.
- 4 TREGENZA, N., AGUILAR, N., CARRILLO, M., DELGADO, I. AND DÍAZ, F. Collisions between fast ferries and whales in the Canary Islands: observational data and theoretical limits.
- 5 CIPRIANO, F. A review of information sources for design of a system to monitor bycatch rates using commercial market surveys.
- 6 READ, A.J. AND ROSENBERG, A.A. Draft international strategy for reducing incidental mortality of cetaceans in fisheries.

SC/54/SD

- 1 DALEBOUT, M.L., LAVERY, S. AND BAKER, C.S. Stock identity of Bryde's whales from New Zealand and origins of Bryde's and sei whale products sold on the Japanese and Korean markets.
- 2 LENTO, G.M., ROSS, H.A., DALEBOUT, M.L., GOODE, M., McLAREN, P., RODRIGO, A.G., LAVERY, S. AND BAKER, C.S. DNA surveillance: a web-based system for molecular identification of whales, dolphins and porpoises.
- 3 KANDA, N., GOTO, M. AND PASTENE, L.A. Considerations on stock structure of minke whales in western North Pacific.
- 4 BRAVINGTON, M.V. Estimating population rates using genetic kinship data.

- 5 MARTIEN, K. AND TAYLOR, B.L. Permutation testing of population structure hypotheses generated by Boundary rank.
- 6 MARTIEN, K. AND TAYLOR, B. Discussion paper to design performance trials for the testing of spatial structure models.

SC/54/WW

- 1 ENGLUND, A. AND BERGGREN, P. The impact of tourism on Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in Menai Bay, Zanzibar.
- 2 SIMMONDS, M.P., DE BOER, M.N. AND SMITH, J.C. Data collection from whale-watching platforms revisited.
- 3 KISHIRO, T., MORI, K. AND KATO, H. A review of whale watching guidelines in Japan, 2002.
- 4 SCHEIDAT, M., WILLIAMS, R., CASTRO, C. AND GONZALEZ, J. Behavioural responses of humpback whales to whalewatching boats near Isla de la Plata, Machalilla National Park, Ecuador.

SUBMITTED REPORTS**SC/54/Rep**

- 1 Report of the Workshop on North Pacific common minke whale (*Balaenoptera acutorostrata*) Implementation Simulation Trials, Seattle, 19-22 January 2002.
- 2 Report of the Fourth Workshop on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP), Seattle, 23-26 January 2002.

PROGRESS REPORTS (see

<http://www.iwcoffice.org/scweb/scprogreps.htm>)

SC/54/ProgRep

Australia	Netherlands
Brazil	New Zealand
Canada	Norway
Denmark	Oman
France	South Africa
Germany	Spain
Iceland	St Vincent and
Ireland	The Grenadines
Italy	Sweden
Japan	UK
Korea	USA
Mexico	

Annex D

Report of the Sub-Committee on the Revised Management Procedure

Members: Allison, Baba, Baker, Bando, Bannister, Berggren, Bjørge, Borodin, Branch, Bravington, Breiwick, Brownell, Burt, Butterworth, Childerhouse, Cipriano, Clark, Collins, Cooke, Dalebout, Diake, Donahue, Donovan, Ensor, Etylina, Fujise, Funahashi, Garrigue, Givens, Goodman, Goto, Grønvik, Guiste, Gunnlaugsson, Hakamada, Hammond, Hatanaka, Haug, Hedley, Hester, Ishikawa, Johnston, Kanda, Kasuya, Kato, Kawahara, Kell, Kim, Kingsley, Leaper, Lens, Martien, Matsuda, Matsuoka, Melnikov, Minton, Miyashita, Mori, Morishita, Murase, Nagahata, Nagatomo, Nishiwaki, Ohizumi, Ohsumi, Øien, Okamura, Palka, Park, Pastene, Perrin, Pike, Polacheck, Punt, Rambally, Rennie, Ridoux, Rogan, Rosenbaum, Rowles, Sadler, Sakamoto, Santamaria, Schweder, Shimada, Simmonds, J., Simmonds, M., Skaug, Smith, Sohn, Tamura, Tanaka, Taylor, B., Taylor, M., Tichotsky, Tomita, Van Waerebeek, Víkingsson, Wade, Wakako, Walløe, Williams, Yamamura, Yasunaga, Yoshida, Zeh, Zelensky, Zenitani, Zerbini.

1. CONVENOR'S OPENING REMARKS

Bannister welcomed the participants.

2. ELECTION OF CHAIR, APPOINTMENT OF RAPPORTEURS

Bannister was elected Chair. Allison, Palka, Butterworth, Cooke, Polacheck, Smith and Taylor acted as rapporteurs.

3. ADOPTION OF AGENDA

The adopted agenda is given in Appendix 1.

4. REVIEW OF DOCUMENTS

Documents available included SC/54/RMP1-21, SC/54/SD6, SC/54/Rep1.

5. REVISED MANAGEMENT PROCEDURE (RMP) – GENERAL ISSUES

5.1 Adjustment of the convergence criteria for the CATCHLIMIT program

Allison reported that lack of time had prevented her from examining the convergence criteria for the CATCHLIMIT program. She suggested that this work was best done in

conjunction with using the program for *Implementation Simulation Trials*. The sub-committee agreed that this item should be carried forward to next year's meeting.

5.2 Population component to which MSYR, MSYL, density-dependence should apply

This issue is related to both the RMP and AWMP. The calculations specified at the 2000 meeting to inform discussions on this issue (IWC, 2001b) had not been conducted owing to time constraints. However, Allison informed the sub-committee that much of the preparatory changes to programs had been done. The sub-committee **recommended** that these calculations be conducted intersessionally and reported to next year's meeting.

5.3 Evaluation of abundance estimators against simulated datasets

5.3.1 Report of the Intersessional Working Group on Abundance Estimation

The terms of reference for the Intersessional Working Group on Abundance Estimation (IWC, 2001a, p.94) agreed to last year were to expand the existing set of simulated datasets to be able to evaluate performance over a wider range of potential survey and biological conditions. Priority areas for future simulation included school size based models; surfacing rates; movement effects; and the following conditions that reflect the Southern Hemisphere IDCR/SOWER minke whale abundance surveys: effects of binoculars, effects of uncertainty in species identity and its interaction with school size and detection function, interactions among school size estimation, double team estimators, and school size effects when using closing mode.

The report of the Working Group is given as Appendix 2. Palka reported that the program used to create simulated line transect abundance data has been expanded to include responsive movement and the models of measurement error used in the analytical methods to estimate abundance of North Atlantic minke whales (SC/54/RMP5). The responsive movement datasets are currently being analysed by Palka. The datasets with measurement error are currently being analysed by Skaug. The sub-committee agreed that evaluating the performance of new methods to estimate abundance has been ongoing for the last few years and it was expected that it would have to continue in the near future because there were new analysis methods being developed to estimate abundance of various whales of concern to the IWC. Because of this, the sub-committee agreed that this agenda item should be a standing agenda item. In addition,

the sub-committee **recommended** that existing simulated datasets and associated documentation should be archived with the Secretariat.

5.3.2 Other

No items were discussed under this agenda item.

5.4 Work plan

The sub-committee agreed to re-establish the Working Group with the priority task to expand the existing set of simulated datasets with the features needed to evaluate the new methods that are being developed to estimate the abundance of Southern Hemisphere minke whales using the IDCR/SOWER data. Specifics are found in the IA sub-committee report (Annex G, appendix 5). In addition, the sub-committee **recommended** that existing simulated datasets and associated documentation should be archived with the Secretariat.

6. RMP – PREPARATIONS FOR IMPLEMENTATION

6.1 North Pacific minke whale *Implementation*

6.1.1 Report of the Intersessional Workshop

The Workshop took place in Seattle from 19-22 January, 2002. The report (SC/54/Rep1) is published in this volume, and was summarised by Donovan, who had chaired the meeting. The Workshop had taken note of the Scientific Committee's strong desire that the *Implementation* be concluded at its 2002 meeting. Donovan outlined decisions made on diagnostics for conditioning of trials and the review of abundance estimates that had been conducted. The question of data availability had been raised and was referred to the Scientific Committee for further consideration. The analysis of genetic data had been discussed at length, including the methods of hypothesis testing, a Bayesian approach and the Boundary Rank method. This had, however, not resulted in complete agreement as to the plausibility of four resultant hypotheses on stock structure involving from two to four stocks. Japan had advised the meeting of its harvest plans, and these had been taken into account in the conceptual specification of a number of revised trials. A number of further issues requiring consideration by the Scientific Committee had been identified, and an ambitious work plan developed to complete the trials in time for the 2002 Scientific Committee meeting.

Thanks were expressed to Donovan and the other participants at the Workshop for their efforts. It was noted that some of the stock-related issues raised at the Workshop would require consideration by the Stock Definition sub-committee (see Annex I).

6.1.2 Report of the Implementation Simulation Trials group

The report is given as Appendix 3. The Steering Group had not been able to secure completion of the work plan to have trial results ready for consideration at this meeting. The primary reason was that further consideration of the genetic analyses in terms of the Group's mandate had led to the necessary development of substantial new hypotheses, which required further trials to be conducted to be able to report that any RMP variant recommended had been tested under trials that adequately spanned the plausible range of uncertainty.

As part of the Group's activities, a small meeting of USA and Japanese genetics experts was held in Tokyo in December 2001, and these persons were thanked for their contributions. Pastene did, however, draw attention to certain problems that had arisen regarding this meeting, which he ascribed to lack of clarity in the Terms of Reference for the meeting.

Taylor commented that overburdening of the Secretariat and inadequate time allotments for meetings were major reasons for the failure to complete the trials by the deadline. Kawahara remarked that the Terms of Reference for the Workshop mentioned only modification of trials, whereas two quite new scenarios had been put forward, whose consideration he felt should have awaited the next *Implementation Review*.

Miyashita was requested to prepare documentation in relation to revised abundance estimates which he had developed intersessionally at the request of the Workshop; this documentation is reproduced in Appendix 4.

6.2 Procedures and scheduling of *Implementations* (*Implementation Reviews*)

6.2.1 Proposals from last year and experience to date

Last year the Committee expressed concern about the length of time taken to complete the RMP *Implementation* for North Pacific minke whales, and made some preliminary proposals for expediting the conduct of future *Implementation* (*Reviews*), noting that they should be considered further this year (IWC, 2002a, pp.12-13).

This year, the sub-committee noted that, once again, its own timetable for the completion of the North Pacific minke whale *Implementation* had not been met (Item 6.1). In view of the fact that the *Implementation* Trial process for North Pacific minke whales has taken longer than envisaged, the sub-committee first heard individual members' comments on the causes for the delays, then went on to draw lessons as a sub-committee from the experience gained, and finally proposed a procedure for ensuring that future *Implementations* be completed on schedule once the pre-requisites are met.

SC/54/RMP18 presented a discussion of why the development of the North Pacific implementation trials had taken considerably longer than initially anticipated. The author identified a number of combinations of factors that have resulted in the implementation trials for the North Pacific minke whale requiring substantially more time than was initially anticipated. He concluded that while some of the details associated with these factors are specific to the North Pacific minke whale situation, many of the factors reflect lack of clarity and unresolved general issues in the *Implementation Trial* development process. They include:

- (1) Determining when decisions about plausibility should be undertaken and defining criteria for assessing whether a specific hypothesis is plausible or implausible.
- (2) Developing a common understanding of the role of hypotheses testing, power analyses and other statistical approaches in developing and evaluating alternative proposed hypotheses.
- (3) Determining the extent that the process of developing a specific implementation trial is intended to represent an evaluation of a particular application of the generic RMP relative to it being the development of a case-specific management procedure.
- (4) Determining the extent to which modifications of the generic RMP procedure should be considered in order to

accommodate desired specific operational objectives of those wanting to undertake whaling in an area.

- (5) Developing criteria for defining *Small Areas* (especially in terms of minimum and maximum sizes), particularly in the absence of informative data on stock structure.
- (6) Developing integrative modelling approaches for incorporating process error within a single trial to avoid the exponential expansion of the potential number of separate trials that need to be considered and to be able to deal with inter-annual variability in the spatial and seasonal dynamics.
- (7) Determining whether there should be minimum information criteria for initiating the development of an *Implementation* and requiring that sufficient data be collected before the process is initiated (in contrast to the development of the *Implementation* in parallel with extensive relevant new data collection programs).

Unless a number of these general issues are resolved, SC/54/RMP18 concluded that the Committee will be unable to complete the North Pacific minke whale *Implementation* by next year's meeting and that future *Implementations* would encounter similar problems.

Smith and Bravington identified the following lessons from the North Pacific minke whale *Implementation* experience:

- (1) The fit of simulation models to the available data should be inspected carefully.
- (2) The generation of hypotheses that include all our uncertainty is very difficult.
- (3) The spatial scale at which the area is divided up to meet the *Small Area* requirement of the RMP needs to be selected carefully at the beginning.
- (4) Methods of addressing aspects of an *Implementation* that were not included within the general RMP development and testing should be identified to the Scientific Committee for development and evaluation.
- (5) Operational difficulties of simulating the implications of large numbers of hypotheses should be avoided or minimised.
- (6) Uncertainty about hypothesised processes beyond that in statistical estimation error (e.g. process error or 'additional variance') should be included in the model formulation itself.
- (7) There is a general concern about the possibility of local depletion being non-reversible over management timescales.
- (8) In the case of North Pacific minke whales, the RMP is being asked to evaluate a harvesting regime that is simultaneously over-specified (insists on harvesting whales both while migrating and feeding) and under-specified (details of how anticipated catches are concentrated in space are not provided).
- (9) The unit of conservation, and the acceptable risk to population sub-divisions at various scales, is unclear.
- (10) *Implementations* are data hungry, and alternate and repeated evaluations of available data often become important in the process.

Butterworth compared the process followed in the North Pacific minke whale case with his experience with the implementation of RMP-like management procedures in contexts outside the IWC. The following conditions seemed important: (1) data finalisation for trial development; (2) assessment using data in (1) as the basis for conditioning of trials; (3) iterative refinement of candidate management

procedure based on results of trials developed under (2). He identified the following potential reasons for the failure to complete the North Pacific minke case in a timely manner:

- (1) Plausibility: this is not settled early enough such that time is wasted developing implausible trials.
- (2) New hypotheses: if new evidence indicates that a new hypothesis is supported, this should be included, or the end product can be criticised on these grounds. He considered that in the North Pacific case, new hypotheses had not been unjustifiably added to the trials, and that this was not the primary reason for the delay in completion.
- (3) Trial complexity: the trials have become enormously complex. Modifications often take more than a year to code, condition and run. He considered this to be the biggest problem and suggested that the solution was to: (i) use simpler trials; and (ii) do the work of specifying them at small intersessional meetings.

Walløe asserted that the main reason why the process had taken so long was that some members of the Committee were opposed to the killing of whales and wanted to spin out the process as long as possible. Smith disagreed, noting, for example, that last year the Japanese delegation had expressed a preference for taking account of new information instead of recommending an *Implementation* on the basis of the results available to date (IWC, 2002b, p.100).

Schweder noted that the Committee in 1991 had opted to recommend a generic RMP rather than go for a case-by-case approach. However, no-one had envisaged that 10 years of trials would be needed for an *Implementation*. He considered that the generic RMP should be used, and then the Committee should re-consider in five years time whether case-specific variants might be needed.

Bravington noted the problem that the abundance estimates do not pertain temporally and spatially to the whaling grounds. Punt questioned whether the spatially generic RMP was sufficient to cover the spatio-temporal structure of the North Pacific minke case.

Kim noted that the *Implementation* for North Pacific minke whales was based on the 1991 Comprehensive Assessment. Although more data needed to be collected from the coastal areas, the RMP *Implementation* should nevertheless be completed on schedule with the current information.

Hatanaka emphasised the robustness of the RMP and considered that it was not reasonable, when dealing with a natural system such as the sea, to demand too much precision with respect to factors such as bycatch, stock structure, etc. Japan and Korea have engaged in coastal whaling for minke whales in the past and the RMP could be applied to coastal whaling.

Pastene considered that if new trials are specified whenever new data is available, the process may never end. A new In-Depth Assessment is already planned for North Pacific minke, and new information from this assessment can be incorporated during the next *Implementation Review*.

Following the above individual comments, the sub-committee noted that expeditious completion of RMP *Implementations* was possible, because this had been achieved in the case of North Atlantic and Southern Hemisphere minke whales in the early 1990s.

Biologically and operationally, North Pacific minke whales were a more difficult case because: (1) coastal whaling was concentrated into limited areas; (2) harvesting

took place on migration routes, as well as on the feeding grounds, so that the temporal as well as the spatial dimension needed to be taken into account in understanding and modelling stock structure; (3) related to the temporal dimension, the clear evidence of stock differentiation, e.g. between J and O stocks, did not automatically make area delineation easy because of the seasonally-dependent overlap proportion in different areas. Past exploitation and potential depletion of some stocks was also an exacerbating factor. However, it was noted that to a greater or lesser extent some of these factors also applied to the Southern Hemisphere case, and more to the North Atlantic.

The reasons why the *Implementation* had proved so difficult to complete were manifold, but the sub-committee identified the following issues:

- (1) Lack of guidance at the outset as to the risk-related management objectives. For example, it was unclear what degree of stock differentiation would be such that the (sub-)stock merited conservation in its own right and thus its depletion should be one of the performance measures.
- (2) Lack of agreement at the outset as to what were the basic data required to embark on an RMP *Implementation* for a region. The Scientific Committee was faced with data that were clearly suboptimal for managing a complex interaction between harvesting and biology.
- (3) Lack of agreement as to what constituted plausible hypotheses and how to weight these. For example, was it 'plausible' to hypothesise the existence of multiple stocks in the absence of direct evidence, or to assume that there was only a single stock? Where could the limit be drawn to prevent an unwieldy number of hypotheses being considered?
- (4) Lack of clear distinction between the process of In-depth Assessment (previously: Comprehensive Assessment) and the RMP *Implementation* process. In the case of the North Pacific minke whale, the last Comprehensive Assessment in 1991 had not been focussed on providing information useful for the RMP *Implementation* process, and the process of improving basic understanding of minke whale stock structure in the region proceeded in parallel with the process of developing *Implementation trials* for the RMP.
- (5) The complexity of the ISTs meant that the turnaround time to specify, formalise, code up and run scenarios and trials was sometimes longer than the time between meetings of the sub-committee. In addition, the results of conditioning, and the results of trials, were presented simultaneously, so the performance of the model was never considered in isolation. By the time trial results were available, the sub-committee had often reviewed new data and formulated new hypotheses which it wanted to implement. Hence the trial results were often not even examined.
- (6) At each stage in the process, new data were being reviewed. A clear time point at which consideration of data would cease, and final ISTs be specified, was either not identified, or not adhered to.
- (7) No Scientific Committee policy on the availability to Committee members on data used for the *Implementation* was available.
- (8) The conditioning of trials is a very complex and time-consuming process if done exactly. It was often not clear to what extent the trials had to mimic closely what was currently known or believed about the stocks in question, or whether more generic trials that broadly

captured the essential feature of the situation might be sufficient, as had been done for the Southern Hemisphere and minke *Implementation*.

- (9) Lack of a clear basis for defining *Small Areas* in the context of whales being harvested on their migration routes.

Some members considered that a hypothesis must be supported by some data to be considered plausible. Other members noted that this left the question of what is the appropriate null hypothesis in the absence of informative data. Assuming a single stock for an entire region may not be a reasonable null hypothesis, given that experience with other species and areas shows that this is rarely the case. The sub-committee agreed that there needed to be minimum level of information to start the *Implementation* process, so that the question of choosing null hypotheses in the total absence of suitable information would not arise (see recommendations below). However, a choice must be made regarding how wide a range of hypotheses to begin with, and whether the intention should be that hypotheses should only be narrowed as the *Implementation* process progresses.

The sub-committee also identified issues that arose after the results of initial ISTs were available, where these suggested problems with the *Implementation*.

Hatanaka noted that in some cases the results implied very small RMP catch limits for stocks from which several hundred animals had been taken annually over several decades without signs of depletion. This would be difficult to explain to those with an interest in harvesting whales in the area.

The sub-committee recognised that this could occur, but noted that the RMP is designed to be conservative in cases where the data are insufficient. The option of basing catch limits on estimates of abundance in *Small Areas* at one time of year, would tend to be the one selected when data are sparse, and could often result in rather low catch limits in areas where the historical harvest had been high. The sub-committee felt that in such cases it was necessary to explain the reasons for this and to identify what improvements to the data could change the outcome (such as more appropriate abundance data, better information on stock structure to enable the more conservative hypotheses to be excluded, etc). It may also be possible to identify changes in harvesting strategy that would solve the problem without the need for additional data. The experience had shown that it would not generally be appropriate to continue postponing completion of the *Implementation* indefinitely until such data were forthcoming.

There was considerable debate over whether an alternative version of the RMP needed to be developed to cover 'difficult' coastal whaling cases such as the North Pacific minke. Zeh reminded the sub-committee that its application to coastal whaling was clearly one of the main interests of the Commission in developing the RMP. It was noted that none of the specific problems associated with the North Pacific minke *Implementation* were caused by specific provisions of the RMP. However, the problem of defining *Small Areas* for whaling on migratory corridors (point (9) above) will be a recurring problem. After considerable discussion of the issues involved, the sub-committee **agreed** that the RMP could be implemented for coastal whaling, taking advantage of the flexibility already provided for in the RMP provisions, and the potential to consider operational measures, such as spreading catches spatially with *Small Areas*.

6.2.2 Proposed process

The sub-committee went on to consider solutions to the problems identified. These could be usefully divided into the following types of issues:

- (1) General policy and scientific issues, e.g:
 - (a) what level of population structure merits conservation;
 - (b) what constitutes plausible hypotheses, and how to rank or weight these;
 - (c) how should *Small Areas* initially be chosen, i.e. how should the RMP definition be converted to a more applicable working definition;
 - (d) how should balance in trials be achieved, in particular to avoid excessive emphasis on scenarios which are more difficult in a conservation context;
 - (e) how to calculate abundance estimates for cascading when the main synoptic survey estimates for the total stock size are not very applicable to the size of a (sub-)stock migrating through a coastal whaling area.
- (2) Process issues, e.g:
 - (a) where and when is the dividing line between an In-Depth Assessment and the start of an *Implementation*;
 - (b) how to ensure that the In-Depth Assessment results in a suitable range of hypotheses about stock structure;
 - (c) how and when to determine whether a sufficient baseline of information exists to begin the *Implementation* process;
 - (d) how and when to select factors of sufficient potential relevance to include in hypotheses for *Implementation Simulation Trials*;
 - (e) when and how to assess plausibility of hypotheses and thus narrow down the range;
 - (f) what arrangements are required to ensure adequate access to the data by Committee members;
 - (g) what data should be used for conditioning and how precise does the conditioning need to be;
 - (h) at what point to determine that new data cannot be considered for the current *Implementation*;
 - (i) how to ensure that final specification and conduct of trials proceed expeditiously after this point;
 - (j) how to ensure that the description and results of the trials are presented in a sufficiently transparent manner to be comprehensible to Committee members;
 - (k) what kind of accompanying advice/information/explanation should be included with the final recommendation for an *Implementation*.

The following suggestions arose for dealing with the above issues:

- (1) A set of stock structure archetypes should be compiled and maintained, which should be considered in all In-depth Assessments. The question to the Assessment should be: which, if any, of these can be excluded? Which are plausible, but require modification/further specification to apply to this species and region?
- (2) The definition of the operating model for *Implementation Simulation Trials* should be part of the In-Depth Assessment.
- (3) A generic checklist of basic data/information/understanding should be developed so that it can be

determined after an In-Depth Assessment whether an *Implementation* can be initiated.

- (4) Scientific judgement can be used to determine which factors may be sufficiently important to include explicitly in ISTs. Some factors can be determined *a priori* or on the basis of experience with other cases, to be either of minor significance, or for other reasons not useful to include in trials.
- (5) The data to be used for developing hypotheses and conditioning *Implementation Simulation Trials* should be identified at the In-Depth Assessment before the *Implementation* process starts. A point in the process after which no new data can be considered should be identified, so that specification and running of final trials can proceed. The availability of these data for analysis by members should be ensured. The question of the availability of the data used for the *Implementation* needs to be resolved.

Butterworth was especially concerned that the process be completed rapidly once 'last orders' had been called on new data, fearing that the credibility of the result could be jeopardised if people could point to new information that had not been taken into account in producing the final recommendations, and that contradicted data or hypotheses which had been included.

The sub-committee acknowledged this was an issue, but considered that it would be reasonable for the Committee to agree a deadline at which the data to be used were finally specified. New data after this point would not be ignored but would be considered at the following *Implementation*. It was felt that the Committee could exercise its scientific judgement as to whether a certain item of data would have significant implications for the recommendations. Furthermore, if the range of plausible hypotheses had been adequately specified, it should be a rare occurrence that a new piece of data would radically change the picture.

Butterworth responded that nevertheless the problem could arise that newer information could radically change the relative plausibility of hypotheses and hence impact recommendations.

The sub-committee agreed that the *Implementation* process should proceed expeditiously once it had been ascertained that the basic requirements to proceed had been met. However, it was emphasised that decisions made in order to complete the *Implementation* should not set an immutable precedent for future *Implementations* and *Implementation Reviews*. To proceed expeditiously with an *Implementation*, it is often necessary to make provisional decisions about certain factors, that should not be taken as final judgements that bind future *Implementations*. Whatever the results of an *Implementation*, they should be presented to the Commission. It may also be appropriate to include recommendations as to how the *Implementation* might be improved in the future, particularly with respect to new information. It was noted that the RMP provides for the following *Implementation Review* to be brought forward in the event of major new data becoming available.

Recommendations

The sub-committee **recommended** that *Implementations* and *Implementation Reviews* be conducted according to the schedule shown in table 2 of the Scientific Committee report (Item 6.2).

The assessment that precedes an *Implementation* is termed *Pre-Implementation Assessment* to distinguish it from the In-Depth Assessments conducted for species on which

whaling is not currently envisaged. The *Pre-Implementation Assessment* should take account of all relevant knowledge on the species in the region. The proposed schedule does not define the length of time required for the *Pre-Implementation Assessment*. As part of this assessment, the Committee would decide whether to proceed with the *Implementation*. Once the decision to proceed is made, the process should be completed according to the schedule in table 2 of the Scientific Committee report.

The sub-committee further agreed that the following general issues require serious consideration:

- (1) Stock-related issues: stock structure archetypes, unit-to-convert, etc. The sub-committee agreed that the issues identified here should be referred to the sub-committee on Stock Definition.
- (2) Plausibility and levels of uncertainty. The sub-committee agreed to convene a small group at this meeting to develop a framework for future consideration of this issue, and to report to the plenary. Their report is attached as Appendix 13.
- (3) Spatio-temporal considerations in the context of application of the RMP. The sub-committee agreed that this topic should be included on the agenda for next year's meeting, and the submission of papers encouraged.
- (4) Data availability and transparency. The sub-committee agreed that this be addressed by a small group during this meeting (see Item 6.6.4).
- (5) Level of information needed for: (a) conducting a *Pre-Implementation Assessment*; and (b) proceeding to an RMP *Implementation*. The sub-committee agreed that this should be addressed next year, and encouraged submissions on this issue.

6.3 North Pacific Minke Whale *Implementation* (continued)

6.3.1 Review of trial structure and consideration of relative plausibility of trials

The Intersessional Implementation Trials group (see Item 6.1.2) reported that a number of tasks identified by the Seattle Workshop as necessary for finalising the specifications of the North Pacific minke whale trials had not been completed prior to the meeting due to lack of time. The sub-committee established three small groups to check conditioning on an initial set of trials and to further specify specific elements of the trials:

- (1) to consider the initial results from conditioning of the baseline A trials (convened by Allison);
- (2) to examine the specifications for the distribution of putative W stock in sub-areas 12SW and 12NE (convened by Allison);
- (3) to work on details of the specification for the baseline D trials (convened by Smith).

A report from small group (2) is presented in Appendix 5. The sub-committee endorsed its conclusions. However, lack of time prevented the other two small groups from completing their work during the time allotted to the sub-committee. The sub-committee therefore **recommended** that these two groups continue their work and provide a report direct to the Plenary.

6.3.1.1 DISCUSSION RELATED TO PLAUSIBILITY OF DIFFERENT STOCK STRUCTURE HYPOTHESES

SC/54/RMP15 presented the results of an AIC (Akaike's Information Criterion)-based evaluation of the plausibility of baseline stock scenarios defined by the Workshop on

western North Pacific common minke whale *Implementation Simulation Trials* (SC/54/Rep1). These were based exclusively on mtDNA data derived from JARPN and JARPN II surveys. The four mtDNA haplotypes that presented the highest frequencies in sub-areas 7, 8 and 9 were used as independent parameters in the AIC. Different combinations of these haplotypes were made to evaluate the baseline scenarios and some of their variants. In addition, five groups of haplotypes, defined by a phylogenetic approach, were used for the AIC-based evaluation. The relative weighting of the model was assessed following the methodology of Burnham and Anderson (1998). Results of the AIC for the different combinations of haplotypes used were consistent, providing the best evaluation for baseline scenario A. This scenario suggests that sub-areas 7, 8 and 9 were composed of a single stock (O) with sporadic occurrence of individuals from a different stock (W) in part of sub-area 9. Although the AIC revealed that baseline scenario A was the most consistent with the available mtDNA data in these areas, the authors noted that a more comprehensive evaluation of stock structure in the western North Pacific was still needed. Such comprehensive evaluation should consider the results of several approaches, both genetic and non genetic.

In response to a question of clarification, the authors indicated that the analyses in SC/54/RMP15 were based on all the genetic samples from sub-areas 7, 8 and 9, including possible J stock animals.

There was extensive discussion on this paper both with respect to the appropriateness or not of using AIC criteria in this situation for assessing relative plausibility, and the implication of the results of the analyses for the North Pacific minke whale trials.

Cooke stated that SC/54/RMP15 was using the AIC in a manner that was inconsistent with its original definition which did not cover the weighting of different models. He noted that if the data are uninformative the AIC will ascribe high weight to the null model and as such is inherently biased towards simple models in such situations. Wade stated that the AIC weighting approach (Burnham and Anderson, 1998) may be appropriate for parameter estimation, but not for weighting different models. He further suggested that weighting of different models in such a manner can only be done in a Bayesian context as Kass and Raftery (1995) had shown that using AIC weights to approximate Bayesian probability led to priors that were not sensible. Butterworth considered that the approach could be used to provide pair-wise weightings of models with the same number of estimable parameters, though naturally care needed to be taken if giving weights to a number of such models not to over-represent certain classes in the set of models considered. He also considered that the approach could be used to exclude under-parameterised models. Some approach needed to be agreed to exclude or under-weight over parameterised models to bound otherwise unlimited speculation, though the associated penalty in the AIC criterion might not be the optimal choice. He also suggested that the question of whether the analysis needed to be done in a Bayesian context was irrelevant for several of the results in SC/54/RMP15. This was because the difference in weights suggested by the AIC criteria was so large that only very highly skewed priors would change the basic results in these instances.

Martien, Wade and Taylor stated their concern that restricting the analyses to the most common haplotypes and collapsing the results into a single 'other' category could result in the loss of important information on stock structure

from haplotypes of moderate to low frequency. As such, they questioned the reliability and the power of the AIC statistics to provide a reliable measure of relative plausibility given both their simulation results and the problem with the AIC statistic when a large number of haplotypes is included in the analysis. They also noted that the four haplotypes could be biased because their frequencies differ among the sub-areas. A haplotype that is at high frequency in a sub-area with low sample size is less likely to be at high frequency overall than a haplotype that is at high frequency in a sub-area with a large sample size.

There was also discussion of the phylogenetic analysis used in one of the AIC analyses in SC/54/RMP15. The aim of the phylogenetic analysis was to define groups of haplotypes that were similar and could be collapsed into a single category for use in the AIC analyses of relative plausibility. Martien, Wade and Taylor were concerned that the phylogenetic analysis did not support the clusters defined in SC/54/RMP15 and thus the results were not relevant for assessing plausibility. They noted that the bootstrap support is below 50% for virtually all of the nodes on the phylogenetic tree, including the nodes used for defining the five haplotype clusters that went into the AIC analyses. They also noted that two of the five clusters are paraphyletic (i.e. haplotypes contained in the cluster are more closely related to haplotypes in other clusters than they are to each other). The authors of SC/54/RMP15 agreed that the clades in trees on which the clusters were defined were not supported by high bootstrap values and noted that this fact was discussed in SC/54/RMP15. Nevertheless, the authors noted that the results using the clusters from the phylogenetic tree were consistent with the scenario that whales in sub-area 9W are different from the others. This is similar to the baseline A scenario in the implementation trials.

Martin, Wade and Taylor presented the results of simulations that they had conducted to test the performance of the AIC approach used in SC/54/RMP15 (Appendix 6). The simulations modelled from 1 to 4 populations and generated four spatial samples of the haplotype frequency from the simulated populations. The results indicated that the use of AIC is very likely to result in the definition of too few stocks if in fact there is more than one stock. For example, in all of the simulation results, the three or four stock hypotheses were never selected as the most likely even in those simulations in which there were in fact three or four stocks, and the hypothesis that there were two stocks was only selected as the most likely 20% of the time in those simulations in which there were two stocks.

Goto, Kanda and Pastene (Appendix 7) questioned the relevance of these simulation results in terms of the original aim of SC/54/RMP15 since the results test the ability of the AIC method to select the 'best' hypotheses and are not presented in terms of 'relative plausibility'. In response, Taylor and Martien noted that even though the results of the simulations were presented in terms of the ability of the AIC to determine the most likely results, it is clear that the AIC was not providing a reliable measure of relative plausibility. Thus, the results indicate that neither the three or four stock hypotheses would have been judged as the most plausible even in the cases when there were three stocks, and the two stock hypotheses would have been considered the most plausible only in 20% of the cases when there were two stocks. Moreover, the AIC values for the three and four stock hypotheses tended to be large relative to the one stock hypothesis in all the simulations, indicating that they would have been considered relatively implausible.

Butterworth suggested that the reason for the poor performance of the AIC in the simulation results was because they included a large number of haplotypes. He noted that once the number of haplotypes increases beyond a certain level the behaviour of the AIC statistic is to heavily favour hypotheses involving fewer stocks. The reason is that the greater the number of haplotypes considered, the penalty contribution to the AIC from the estimable parameters increases much more rapidly than the additional information from the extra haplotypes.

Goto, Kanda and Pastene also noted this problem with the AIC and the increasing number of parameters and stated that this was the reason they had restricted the number of haplotypes considered in SC/54/RMP15. They presented some additional AIC analyses along the lines of those conducted in SC/54/RMP15 but with an increased number of haplotypes (Appendix 7). In these analyses, Baseline A remained the most plausible as the number of haplotypes increased from 4 to 16, and the relative plausibility given to the other hypotheses decreased sequentially. When 27 haplotypes (involving 87% of the total samples in sub-areas 7, 8 and 9) were considered, the null hypothesis of no stock structure (Baseline B) was deemed the most plausible, and all of the other hypotheses were given a weight of less than 0.05 relative to the null hypothesis.

Hatanaka considered that the results in SC/54/RMP15 indicated that the baseline scenarios C and D were highly implausible and consideration should be given to dropping them from the final trial specifications. Butterworth concurred that the results in SC/54/RMP15 indicated that the Baseline D scenario was not very plausible. However, he concluded that the results suggest that while the specific model used for testing Baseline C suggested it was not a very plausible scenario, variants of model C (e.g. model 9) in SC/54/RMP15 did indicate that the basic four stock scenario underlying the Baseline C had a relative weight ranging from 0.085 to 0.287, and thus should not be judged to be implausible based on the results in SC/54/RMP15. Pastene considered that other biological data should also be considered in assessing the relative plausibility of baseline C.

Polacheck, while noting that he shared a number of the general concerns about the appropriateness of the approach in SC/54/RMP15, also expressed concerns about model 10 in the paper (which is based on a linear change in proportion of O and W) constituting a sufficient basis for representing the Baseline D scenario. The latter allows for a wide range of different mixing relationships between the O and putative W stocks and in addition is a model simplification of a hypothesised complex spatial and temporal mixing of two stocks in the area to the east of Japan. It is important to distinguish between the underlying hypothesis and its computer model representation. Polacheck also noted that even if one accepted the results in SC/54/RMP15 as a basis for assessing plausibility, the results (e.g. those for model 9) indicate that the fundamental issue underlying the trials of how coastal the O stock could be would still need to be addressed in the implementation trials.

Butterworth responded that he thought that the results for model 10 in SC/54/RMP15 indicated that any monotonic decline in the proportion of O stock animals to the east of Japan between Areas 7W and 9E would be considered implausible based on the AIC test used in the paper. He also noted that analyses in SC/54/RMP15 included J stock whales in Area 7W. This could be a factor contributing to the relative weight or plausibility given to model 9 in the paper.

In summary, there was general agreement that developing objective measures for evaluating plausibility and assessing relative plausibility or weightings is highly desirable. However, there was substantive disagreement about the general applicability of the AIC approach used in SC/54/RMP15, its application to genetic data with a large number of haplotypes, and its relevance for assessing the plausibility of the different scenarios being considered in the North Pacific minke whale trials. Nevertheless it was agreed that further simulation testing of the other methods was desirable. The sub-committee agreed to retain the basic baseline scenario defined at the Seattle Workshop.

Appendix 8 presents information and analyses on the proportion of immature animals by sex taken in the JARPN and JARPN II surveys from sub-areas 7W, 7E, 8 and 9. The results of the AIC tests comparing the proportion of immature and mature animals by sex indicated the proportions in sub-areas 7E, 8 and 9 are similar, and different from the proportions in sub-area 7W. The main source of the difference in the proportions is the occurrence of a higher proportion of immature males in sub-area 7W than in the other areas. Sub-area 7W was consistent with the inshore waters where many immature animals had been taken by small-type whaling. Therefore it is reasonable to conclude that immature animals are distributed in coastal sub-area 7W and that mature males are distributed in offshore waters from 7E to sub-area 9. Based on these results, the authors of Appendix 8 concluded that the results are consistent with the occurrence of a single stock in sub-areas 7, 8 and 9 which aggregates by sex and reproductive status.

In discussion, Butterworth suggested that the high proportion of immature males within sub-area 7W compared to sub-areas 7E to 9 raised the question of whether there could in fact be many separate stocks to the east of Japan. The most parsimonious interpretation of the data on maturity status and sex is that there are not.

It was pointed out that there was a very low proportion of immature females in all of the samples from areas 7, 8 and 9 and that there was no difference in the proportion of immature females by longitude in the samples. Thus, the lower proportion of immature females in areas to the east of 7W indicates that the sampling is missing a high proportion of the population no matter what stock structure model is assumed. Taylor, Martien and Polacheck considered that while the information provided in Appendix 8 was consistent with the hypothesis of only a single stock in the areas to the east of Japan, it was also not inconsistent with the existence of more than one stock in those areas. They further noted that if there are two or more stocks in the area east of Japan, the habitats for the more coastal and pelagic ones are substantial and very different. In such circumstances, it would not be unexpected that the latitudinal, spatial and temporal distributions of mature and immature animals by sex within each stock might be quite different, even though there may be substantial segregation by maturity state and sex within each stock.

The sub-committee also briefly reviewed Hatanaka and Miyashita (1997) which provided data on the proportion of mature animals by sex taken in the commercial coastal catches along the eastern side of Japan. This found a similar pattern to the pattern found in the JARPN and JARPN II samples. Additionally, it concluded that immature females as well as males were found in the southern part of Area 7 early in the season (April to May) as well as in Area 11 in May and June. Hatanaka considered that these results further confirmed the consistency of the single stock hypothesis. There was limited time for further discussion of this question

but there was no agreement in the sub-committee about whether the available data on the proportion of immature animals by area and time were consistent only with a single stock hypothesis.

SC/54/RMP16 considered stock archetypes for North Pacific minke whales. Five archetypes were depicted: panmixia (corresponding to Baseline B); maternal feeding ground site fidelity (Baseline C); isolation-by-distance (Baseline C); intrusion (Baseline A); and broad mixing (Baseline D). They discussed how these models relate to genetic measures. They emphasised that there were a number of reasons why no signal would be detected using nuclear data when a signal was detected using mitochondrial DNA data, including the fact that the effect size is much smaller for nuclear data resulting in much lower statistical power and male biased dispersal. As long as statistical power remains low, it is not possible to distinguish between maternal feeding ground site fidelity and actual separation of breeding grounds without data from the breeding ground. They also noted that the performance of analytical methods using genetic data to define stock structure has not been tested for any method other than Boundary Rank (Martien and Taylor, 2001).

In discussion, the difficulty of making inferences about breeding stocks simply based on detected differences in mitochondrial DNA frequency on the feeding grounds was further noted. Thus, it is possible to have a single breeding stock but differential feeding stocks. It was noted that when spatial differences are found in samples from the feeding grounds it is not possible to distinguish based on the genetic samples alone whether this also represents a situation with segregation occurring on the feeding ground from a single breeding stock or a situation in which there is more than one breeding stock and the segregation of these stocks on the feeding grounds. In the former case, the question of what is the important unit-to- conserve from the management perspective becomes an important question. Kanda noted that outbreeding between different feeding stocks in the same breeding ground is as important as having site fidelity to feeding ground for whales' long-term persistence. In the context of this discussion, Hatanaka considered that it was dangerous to make conclusions about stock structure based only on analyses of mitochondrial DNA. There was general agreement on the importance and need to obtain data from the breeding grounds in order to make conclusive inferences about stock structure.

SC/54/RMP17 explored using the trend in p -values as sample size increases to assess the probability that the observed trend in p -values for North Pacific minke whale samples taken in sub-areas 7 and 8 came from a panmictic population. The expectation is that if the null hypothesis is true, i.e. that there is no population structure, then the average trend in p -values as sample size increases will be zero. If the alternate hypothesis is true, i.e. that there is population structure, then the expected average trend in p -values as sample size increases will be negative. The distribution for trends under the null hypothesis is generated by sampling from the pooled distribution of haplotypes using the actual number of individuals sampled in JARPN. Trends were estimated by fitting two functions to sample size (the independent variable) and π^2 p -values (dependent variable) using both a linear regression and a power function. The p -value for the trend test is the proportion of time that the estimated slope from the panmictic population is equal to or less than the observed slope. The result comparing samples from sub-area 7 to 8 is $p = 0.065$ for a linear fit and $p = 0.090$ for a power fit.

In discussion, it was noted that there had been changes over time in the criteria used to remove J stock animals from sub-area 7 and 8 samples that had been used to calculate the *p*-values used in SC/54/RMP17. Thus, the first two *p*-values did not exclude any J stock animals, while the final *p*-value was based on data in which J stock animals had been excluded. Taylor suggested that the conclusion in SC/54/RMP17 would be robust to this because removal of J stock animals from the samples from which the first two *p*-values were calculated would be expected to reduce the calculated *p*-values. Therefore, by not having excluded them, the estimated slope values in SC/54/RMP17 would be expected to be closer to zero than if the J stock animals had been removed.

Taylor stated that the analyses in SC/54/RMP17 were done on the dataset which used the procedure described in the Seattle Workshop report for excluding possible J stock animals. Since that procedure was conservative (i.e. it also resulted in the removal of a large number of animals from the samples in areas 8 and 9), Taylor considered the results in SC/54/RMP17 to be conservative. Pastene and Butterworth noted a concern that not all of the J stock animals may have been consistently removed in the results presented in SC/54/RMP17.

Schweder stated that all of the information in terms of the *p*-values in the statistical tests should be contained in the value from the combined samples and that there is nothing to be gained from looking at the resulting *p*-values from individual sub-samples.

Taylor concluded that the results in SC/54/RMP17 provided support for hypotheses which included a potential coastal stock. Further, it was important to consider the power of the statistical tests to distinguish a difference in hypothesis-testing when considering the plausibility of different hypotheses.

6.3.1.2 DISCUSSIONS RELATED TO DETAILS OF THE TRIAL SPECIFICATIONS

In SC/54/RMP18, Polacheck noted that although he had been a participant in the Seattle Workshop (SC/54/Rep1) he had some concerns with some of the conclusions because almost all of the substantive agreement had been reached after he had to leave the meeting at 4:00pm on the last day of the Workshop. SC/54/RMP18 identified four specific areas of concern:

- (1) Inter-annual variability in mixing proportions;
- (2) Assignment of 'W' stock whales between Areas 12NE and 12SW;
- (3) *Small Area* definitions and RMP variants;
- (4) Finality of the specifications.

The issues concerning (3) *Small Area* definitions are discussed under Item 6.3.2.

SC/54/RMP18 noted that at last year's IWC meeting, concerns were raised about the implications for conditioning and the RMP performance of inter-annual variability in the spatial temporal distribution. These concerns arose in part because of temporal inconsistency in the three abundance estimates used in Area 9 and the inability of the conditioning process to simultaneously fit the three estimates. The Seattle Workshop reviewed the abundance estimates for Area 9 and considered that only one of the three abundance estimates used previously for Area 9 was probably appropriate for use in the conditioning. Given this and problems in conditioning the operational model with inter-annual variability, the

Workshop agreed not to model temporal variability in abundance within the operational model. While this provides a pragmatic solution to the previous lack of fit in the conditioning to the Area 9 abundance estimates, this does not mean that substantial inter-annual variability does not exist, only that there is a lack of any data for estimating it and for use in the conditioning. One concern with the lack of ability (given the time constraints) to allow for inter-annual variability is that the results of the conditioning process may underestimate the level of uncertainty about the plausible range of current depletion level for the O stock and the variability in the performance of the RMP.

The sub-committee agreed that the issue of whether inter-annual variability in the spatial distribution should be considered further, particularly within the context of the Baseline D trials. As such, the question was referred to the small group convened by Smith (see Item 6.3.1) with responsibility for finalising the Baseline D trial specifications.

SC/54/RMP18 noted that previous trials considered the whole of the Okhotsk Sea as a single sub-area (Area 12). Because of new information presented at the 2001 Scientific Committee meeting, it was agreed that there was a need to divide this area into two sub-areas to take into account J stock animals entering Area 12 (Areas 12SW and 12NE). This required development of hypotheses for the distribution of 'W' stock animals within Area 12 in those scenarios involving 'W' stock animals in that area. The intersessional Workshop had agreed that in the final trials all of the 'W' stock animals in the old Area 12 would be confined to sub-area 12NE. The Workshop report provided no reason for adopting this as the sole hypothesis to be considered. There would appear to be no *a priori* barrier or reason that would confine 'W' stock whales, if present, only to the northern part of the Okhotsk Sea. As such, either trials should be considered which allow for mixing of 'W' stock whales into Area 12SW or an appropriate justification should be provided for why this is implausible, or at least not worth considering. The issue was referred to the small group convened by Allison with responsibility for finalising the specification of the trials with respect to the distribution of putative W stock animals within Area 12 (see above and Appendix 5).

SC/54/RMP18 also raised the question of the degree to which the trial specifications in SC/54/Rep1 should be considered both a final and a complete set of trials. One issue in particular is whether the set of trials provides a sufficient basis for addressing the three stock issue (i.e. J, W and O stocks). Thus, whether all of the implementation tests with three stocks with mixing in areas 7E, 8 and/or 12 have been collapsed into the baseline gradient model. However, this model had only developed verbally at the Workshop and partially formally specified through e-mail correspondence after the meeting. The gradient model constitutes some major changes to the previous conditioning. It is not clear to what extent problems may be encountered in getting the model working and conditioned, if its behaviour will in fact provide adequate and sufficient basis for representing plausible three stock dynamics. Polacheck was concerned that if substantial problems were encountered with conditioning the gradient model they could result in the Committee having no three stock implementation results to consider when it comes to making a recommendation on the RMP implementation for North Pacific minke whales. At a minimum, it can be anticipated that modification and alternative specifications will be required when the model is actually implemented.

The sub-committee agreed that for all of the trials, and especially for the four stock and gradient models, flexibility needs to be maintained in the specifications to allow for unforeseen problems in the conditioning process. It agreed that, as in the past, an intersessional Steering Group would be required to oversee the finalisation of the trial specifications (see Item 6.3.3). It further agreed that the small group convened by Smith (see above) should further consider various aspects of the Baseline D trial specifications already noted.

6.3.1.3 DISCUSSION RELATED TO THE BY-CATCH LEVELS TO USE IN THE TRIALS

SC/54/RMP8 reported results from market surveys of North Pacific minke whale products conducted in Korea from May 1999 to November 2001, and from market surveys in Japan from February 1999 to January 2002. A total of 315 products were identified as North Pacific minke based on sequencing of the mtDNA control region and by DNA profiling using allelic variation at five microsatellite loci. Eight market surveys in Korea over the period yielded 193 separate North Pacific minke products, which comprised at least 126 individual whales, 95% of which showed the characteristic mtDNA haplotype of the J stock. Over this period in Japan, five market surveys yielded 122 North Pacific minke products, representing at least 97 individuals, 42% of which showed the characteristic mtDNA haplotype of the J stock. Relatively few replicate products were found within each survey indicating that products from many other individuals probably remained unsampled. Replicate samples of a small number of individuals were detected in consecutive survey periods, two to seven months apart, but very few replicate samples of individuals were shared between surveys more than seven months apart. This suggests that products from an individual whale are not stored long-term and are sold in less than seven months. The duration of products from an individual on the Korean market was probably much less. Given the very conservative nature of these censuses, it appeared that the total yearly Korean bycatch of North Pacific minke remains high, as does the Japanese catch of J stock minke (see also SC/54/BC3). This indirect evidence of high bycatch is confirmed by reported bycatch (SC/54/ProgRep Japan and SC/54/ProgRep Korea).

As well as comparing the genotypes of all products within each of the markets sampled, SC/54/RMP8 also compared genotypes of products between markets. Surprisingly, two individual multi-locus genotypes were also shared between the Korean and Japanese market samples. Using the conservative Korean allele frequencies, the probability of these particular genotype matches occurring purely by chance was less than 0.05. Additional data are needed to ascertain with more confidence if these products represent the same individual whales on both markets. However, the small number of potential matches between the two countries indicate that bycatch products from Japan and Korea must be considered additive rather than overlapping.

There was extensive discussion on the possible implications of the information in SC/54/RMP8 and of other new information on what were appropriate values to use for the level of bycatch in the simulation trials.

Pastene cautioned on the use of market genetic data for estimating level of bycatch for the reasons given in SC/54/RMP13. He expressed concern with respect to conclusions about the one case in which samples from Japan

and Korea had the same multi-locus genotype. He considered it was premature to draw any conclusion as the micro-satellite analyses were not complete.

Baker, Dalebout, Cipriano and Funahashi noted that specifications for the RMP *Implementation Simulation Trials* are intended to take into account a range of plausible hypotheses or scenarios for the stocks in question. One of the parameters included in the specification is the level of incidental takes or fisheries-related bycatch. They noted that there has been considerable debate about the plausible range of values to use in the North Pacific minke whale trials. They provided a review of how the specifications have changed over time and of new information available at this meeting, and developed a proposal for the range of plausible values to consider in the North Pacific Minke whale trials (Appendix 9).

Kim queried the averaged yearly bycatch deduced from the genetic analysis of market samples, saying that because he could not find any linear trend and the bycatch of 2001 was abnormally high, the reported number rather than the average should be used. He believed that new information had to be considered later at the time of the in-depth assessment as the RMP reached its almost final stage.

After considerable initial discussion, it was evident that there was not full agreement with the proposal in Appendix 9. There was lack of agreement within the sub-committee on procedural aspects, i.e. whether it was appropriate at this point in the trial specification process to consider revising the values to use for the level of bycatch in the simulation trial. Most members agreed that it was appropriate and considered that such a decision was fully consistent with the general procedures and timeframes recommended by the sub-committee for conducting future implementations (see Item 6.2 and table 2 of the Scientific Committee report). Hatanaka and Kawahara disagreed because of the extensive amount of time spent on this issue in the past and because the trials are in their final stage of specification. The sub-committee was not able to reach consensus on this question and the Chair determined that the sub-committee would consider possible revision to the level of bycatch to be used in the implementation trials.

Discussion of this issue resolved into four specific questions, given the new information available at this meeting:

- (1) Does the new information warrant updating the previously agreed base value (i.e. the K1 option) for the level of the Korean bycatch?
- (2) Should an additional option for the level of the Korean bycatch be considered (i.e. the K2 option) and if so what value should be used?
- (3) What value for the level of Japanese bycatch should be used in the J1 option in simulation trials?
- (4) What value for the level of Japanese bycatch should be used in the J2 option in simulation trials?

With respect to (1), it was noted that the previous basis for determining the base value for the K1 option was to use the average of the reported bycatch from Korean fisheries. The sub-committee agreed that this was an appropriate approach and the value to use for the K1 option would be an average updated from 61 to the average of all the recent Korean bycatch estimates, i.e. 89 whales per year (excluding drifting and stranded animals)¹.

¹ The trial specifications are for a bycatch which varies with population size. The effect of this decision is that 89 replaces 61 in the existing formula for annual future bycatch.

There was extensive discussion on whether it was necessary and appropriate to consider more than one option for the Korean bycatch. Some members thought it was inappropriate to consider additional values at this point and that if a range of values was to be considered then both a maximum and minimum value should be considered. Most members thought that it was necessary to consider a range of values to cover the uncertainty associated with the level of bycatch. This uncertainty included the possibility that similar fisheries to those in South Korea which have bycatch may also occur in the region, but there is no information on such bycatches. Also, reported bycatches are a minimum of the actual bycatch and experience from a number of fisheries suggests that bycatches are generally and frequently under-reported. There was also concern that the range of values selected in the past had subsequently proved to be too small and that it was important that the trial results are robust to uncertainties in the level of bycatch. The sub-committee could not reach agreement on whether a K2 option should be used in the trial, although most members considered that it should. Given that a decision was required, the Chair determined that a K2 option should be included.

It was agreed that the maximum reported value for the Korean bycatch in any year should be used for the K2 option in the trials as a plausible upper bound for the level of bycatch coming from the western parts of the Sea of Japan. There was some discussion on whether the upper bound should also include stranded and dead animals found drifting. It was agreed to use only the maximum of the actual annual reported bycatch, i.e. the figure of 148 from 2001². It was noted that in 2001, 12 animals were also found stranded or drifting in South Korea and that even if all of these animals represented fishery related mortalities the RMP procedure should be robust to an uncertainty of this magnitude.

There was extensive discussion on what value to use for the J1 option. Butterworth noted that two options had been defined in the past, at least in part because there was lack of agreement on what were appropriate values to use for bycatch in the Japanese fishery. The J1 one option represented the views of those members that believed that a low value was the most appropriate. In those circumstances the current value for the J1 option was retained.

There was some disagreement on the values to be used for the J2 option. The Chair determined that as most members considered that a value of 100 was appropriate, with a value of 150 for sensitivity trial 13, those figures should be used.

The sub-committee also considered what combination of the K1 and K2 options should be crossed with the J1 and J2 options. It was agreed to limit the number of options to two and to use the upper and lower range among the four possible combinations (i.e. the K1/J1 and K2/J2 options). It was noted that by using the upper and lower range the performance of the RMP in the simulation trials to intermediate values could be assessed by interpolation.

The full revised specifications of the North Pacific minke whale trials are given as Appendix 10.

Hatanaka and Kawahara opposed the above decisions. Their views are recorded in Appendix 11.

6.3.2 Consider Implementation Options

SC/54/Rep1 included consideration of an RMP variant involving 'partial cascading' (option 6 in Item 10.2 of the Report). In this option, two *Small Areas* are defined (one

comprising sub-area 9 and the other defined as comprising sub-areas 7, 8, 11 and 12). In addition, those two *Small Areas* are defined as a combination area for the purpose of cascading. However, in that option the catch cascades into the *Small Area* 7+8+11+12 are all taken from sub-areas 7W and 11. This form of cascading was referred to as 'partial cascading' and as noted in the report is not in accord with the definition of catch cascading included in the RMP specifications. The Workshop had recommended that the Scientific Committee should review the concept of 'partial cascading' and, if deemed appropriate, should develop any necessary additions to the RMP annotations.

Butterworth stated that 'partial cascading' is not an RMP variant but is a feature related to conducting *Implementation Simulation Trials*. In the trials, it is necessary to specify how catches are allocated among constituent sub-areas of a *Small Area*. Conventional trial practice has been to assume that all catches are taken from the sub-area likely to lead to worst performance in terms of conservation. However, this can in some instances result in unrealistic trials and thus the concept of partial cascading was proposed to spread catches over some (but not all) of the sub-areas within a *Small Area* in a more plausible manner, given likely operations in practice.

In the context of 'partial cascading' and also in relationship to the RMP variants defined in SC/54/Rep1, SC/54/RMP18 raised concerns that most of the proposed *Small Area* definitions (i.e. those in options 2-6) appear to be inconsistent with the basic principle that underlies the approach adopted in the RMP for dealing with multi-stock problems. Under the RMP, a *Small Area* is meant to be an area in which only a single stock occurs or one in which harvesting would be in proportion to the relative abundance of the stocks within it. However, options 2 to 6 combine sub-areas into *Small Areas* that would allow catches within the defined *Small Areas* to be taken not in proportion to their relative abundance. In fact, the agreed trials specifically acknowledged that this is likely to be the case by considering the 'worst case' scenarios in which all of the whales are to be taken from a part of the defined 'small' area (i.e. from only one or a few of the sub-areas comprising the suggested *Small Area*).

SC/54/RMP18 noted that this does not mean that the proposed *Small Area* definition would necessarily result in unacceptable performance in terms of the Commission's management objectives. However, these approaches, if they were to be considered, would seem to require a substantive modification to the current RMP specifications. The modification would require permitting *Small Areas* to be intentionally defined so that harvesting could be substantially disproportional to the relative abundance of different stocks. However, the abundance estimates for coastal areas on the migration route are likely to be small relative to the number of whales actually passing through these migratory areas.

Cooke suggested that the current RMP specifications could in fact adequately deal with this problem by using the synoptic sighting surveys to estimate the total abundance in a combination area and using other abundances for cascading to provide the relative proportion of whales in the various *Small Areas* at the time when whaling on the migration is actually occurring.

Butterworth stated that while this might be a solution in theory he considered it to be highly impractical to implement in practice. From his perspective, a *Small Area* could be defined as any *Small Area* that gives adequate performance based on simulation trials.

² This means 148 replaces 89 in the relevant formula (see footnote 1).

Taylor expressed concern about changing the definition of *Small Areas* without first conducting adequate testing and that adopting the definitions of *Small Areas* in the Workshop Report could be setting a precedent that might be hard to change later. Polacheck also was concerned about *ad hoc* changing or intentionally misapplying the carefully tested and agreed RMP specifications and the precedent that this might set.

Schweder suggested that it may be necessary to consider the development of a 'second' RMP to deal with the situation of coastal whaling and whaling on the migration route, if in fact the current *Small Area* definition can not be adequately applied in these situations. However, it first needs to be determined if in fact this is necessary or whether the current RMP specification can be appropriately applied in such situations.

There was general agreement that the issue of partial cascading and appropriate *Small Area* definitions for situations involving coastal whaling needed further discussion and consideration, and that a solution to this general problem was not possible at the current meeting. The sub-committee recognised that a decision was required in terms of the North Pacific minke implementation trials, in order to allow the trials to proceed. It agreed for this pragmatic reason to use the RMP management variants that were defined in SC/54/Rep1 in the simulation trials. It also emphasised that its decision this year should not be considered a precedent for future trials and that the issue will need to be further considered next year. Acceptable performance could still be achieved (in part relying on some of the conservative features within the CLA). However, this would mean that a solution to the multi-stock problem for any proposed 'RMP' implementation would be highly dependent upon the specific details and set of assumptions about mixing and migration. SC/54/RMP18 considered that such a change would represent a fundamental change in how the RMP was conceived to be implemented and would impose a substantially larger burden upon the implementation trial process.

There was extensive discussion about the partial cascading concept and the concerns raised in SC/54/RMP18 about the appropriateness of the *Small Area* options that would intentionally allow for and probably result in the catches within a *Small Area* being taken not in proportion to the stocks contained within it.

There was general agreement that the concept of partial cascading and the definition of a number of the *Small Area* variants being considered in the North Pacific minke whale implementation trials were not fully in accord with the definition of *Small Areas* in the RMP. There was also agreement that the definition of *Small Areas* within the RMP created problems in the application of the RMP to whaling on the migration route, particularly in the context of coastal whaling and the North Pacific minke whale situation. This is because synoptic abundance estimates used to calculate the catch limits for a *Small Area* are from the feeding and migration areas when a large proportion of the animals are on the feeding grounds, as this is the best time for conducting such surveys.

6.3.3 Specify intersessional work to permit completion of Implementations

The sub-committee recognised that substantial intersessional work was still required if final implementation trial results were to be available at next year's Scientific Committee meeting. While some of the work may be possible to

complete via e-mail, there was general agreement that it was impractical to complete most of the substantial work required in this way and that an intersessional workshop would be necessary. The sub-committee noted that two of the small groups concerned with substantive issues related to the implementation trials were still working and would report on progress directly to the plenary. As such, the sub-committee was not in a position to provide detailed terms of reference at this point for an intersessional Workshop or for a Steering Group for the trials. Nevertheless, it **recommended** that a Workshop be held and that the Scientific Committee develop terms of reference during plenary for the Workshop and the Steering Group, taking into account the progress made by these small groups in the interim.

With respect to the small group looking into the conditioning of the Baseline A trials (under Allison, see Item 6.3.3), it was reported that technical problems were being encountered in conditioning. There were indications of minimisation problems in the estimation of the parameters as well as concerns about lack of fit to some of the abundance estimates. It was not clear whether these technical problems could be resolved before the completion of the current meeting, and the sub-committee **recommended** that if not, then Punt and Allison would be asked to collaborate to find what they considered to be an acceptable solution to the problems. Once this was achieved the results would be circulated to the small group reviewing the conditioning results (under Allison, see Item 6.3.1) for comments and suggestions. A final review and agreement on the conditioning would take place at the intersessional Workshop.

Concerns were expressed about the problems being encountered with the conditioning of the Baseline A trials and possible implications for completion of the simulation trials. The structure of the Baseline A trial is substantially less complex than the C and D baseline trials and at this point the coding has not been completed for either of these baselines. It was agreed that the same procedure as outlined in the preceding paragraph be followed to complete the conditioning of Baseline C and D trials and the sensitivity trials to each of these baselines.

6.4 North Atlantic minke whale Implementation Review

6.4.1 Report of Steering Group

An e-mail correspondence group (Smith (Chair), Palka, Skaug, Walløe, Øien, Kawahara, Cooke) was established last year (IWC, 2002a, p.12). The group identified data sources and analysis steps required for preparing for conducting an *Implementation Review*. Several sources of data and their analyses were identified that would be required to conduct such a review. The timing requirements for data and analysis availability under the RMP were noted.

6.4.1.1 NEW DATA

Sighting survey data for the period 1996-2001 were made available in late 2001 for use in the *Implementation Review*. MtDNA and microsatellite determinations have been made for data from 1997-2001. The data have been provided to the Secretariat incrementally as they have become available, with the 2000 and 2001 data made available in late March 2002, all for use in the *Review*. Dive time data were collected in 2001 for two whales, and made available in December 2001.

6.4.1.2 NEW ABUNDANCE ESTIMATES

Methods for handling multi-year data were reviewed previously by the Scientific Committee (Skaug, 2000; 2001). These have been incorporated directly into new abundance estimates in SC/54/RMP5. Analyses of measurement error models (SC/54/RMP3) and spatial distribution patterns (SC/54/RMP4) were incorporated into SC/54/RMP5. Analyses of surfacing rates are given in SC/54/RMP2.

SC/54/RMP5 described new abundance estimates and was made available to the Steering Group on 25 March 2002. Simulation testing of the abundance estimation methods (including treatment of multi-year data) using datasets prepared by the intersessional Working Group on Abundance Estimation was planned to be initiated after final abundance estimates were tabled. Some simulation testing has been conducted, but not for the treatment of multi-year data. Additional testing is likely to be needed.

6.4.1.3 SMALL AREAS

An analysis of DNA data for stock structure using data from 1997-1999 was circulated to the Steering Group in late 2001. An updated analysis including also the 2000-2001 data is given in SC/54/RMP6.

6.4.1.4 BIOLOGICAL PARAMETERS

Few new biological papers were identified after the *Implementation* was initially completed (e.g. SC/54/RMP7). Potentially relevant ecological information has been developed in SC/54/E6.

The group noted that the availability of new estimates of abundance did not meet the three months' lead-time required under the RMP. The delay in making estimates from the new data available was necessitated by the need for 'quality control of the analyses'.

6.4.2 Implementation Review

6.4.2.1 STOCK STRUCTURE

SC/54/RMP6 presented an analysis of genetic data from the Norwegian commercial minke whale catches from the period 1997-2001. The data contained 10 microsatellites loci and mtDNA from 2,676 animals. Differences were found in mtDNA haplotype frequencies between the Central and Eastern *Medium Areas*, while no sub-structure was found within the Eastern *Medium Area*. The microsatellites showed no evidence of sub-structure, neither between the Central and Eastern *Medium Areas*, nor within the Eastern *Medium Area*. However, the authors noted that the analysis to some extent was preliminary.

Skaug mentioned that he had already followed suggestions to combine loci and this preliminary analysis suggested significant results for some areas not being in Hardy-Weinberg equilibrium, which can mean multiple stocks present within the strata. He intends to do more work along these lines as well as employ some new techniques, including Boundary Rank (see discussions in Annex I, Stock Definition). In response to a question about whether he had investigated interannual variability, Skaug reported that he had tried using a new technique by Pritchard but did not find evidence for interannual variability. He had not yet looked into seasonal differences within a strata as has been shown for minke whales in the Antarctic. It was suggested that in addition to p -values, it would help members interpret the data if estimated levels of genetic differentiation (such as F_{st}) were reported. The use of the Bonferroni correction was also noted to be conservative and it was suggested that

presenting uncorrected p -values would allow a more full examination of results, and that the Stock Definition Working Group had made specific recommendations at the 1999 meeting. Baker noted that the results suggested a potential Wahlund effect in the Central *Medium Area*.

Cooke suggested four stock structure hypotheses for consideration in an *Implementation Review* (Appendix 12). The first hypothesis is that there is no stock structure. The second hypothesis is that there is site fidelity without inheritance whereby individuals choose a feeding area and always return to that area but without the choice having a basis in inheritance. The third hypothesis is site fidelity with partial inheritance where some individuals choose to feed where their mothers fed while the remainder behave as whales in the second hypothesis.

Schweder asked how Cooke's hypotheses could account for the interannual variability in distribution observed in North Atlantic minke whales. Cooke responded that such variability could be accounted for in variable distributions between *Small Areas* using the estimate of additional variance given in SC/54/RMP5.

6.4.2.2 ABUNDANCE

SC/54/RMP1 reported on the sightings survey conducted in summer 2001 as part of the six-year survey programme over the period 1996-2001 to obtain an abundance estimate of minke whales for the northeastern Atlantic. After encountering problems with access to the Russian EEZ in the southeastern Barents Sea in previous years, permit for access was given for 2001. Thus, one vessel covered the blocks off the Kola coast and Novaya Zemlya. Another vessel was scheduled for a repeated survey of the North Sea area which was also intended as a contribution towards the NASS-2001 survey. As the Norwegian vessel dedicated for the North Sea area was denied access to the UK EEZ, a last minute change had to be made for an allocation of this survey effort northwards into the Norwegian Sea. In addition, this vessel was dedicated to collecting dive time data by VHF tagging.

The survey was conducted over the period 27 June to 7 August 2001. Approximately 570 n.miles were conducted on primary effort in the Norwegian Sea. There were primary sightings of 30 minke; 28 fin; 6 killer; 3 northern bottlenose and 24 sperm whales. Bad weather hampered the latter half of the survey period in that area, but efforts were then used on radio and satellite tagging and biopsy sampling. Two minke whales were instrumented with VHF tags but the tags sent few signals. One humpback whale and one fin whale were instrumented with satellite tags in the Vestfjord and in the Norwegian Sea, respectively, but signals were not received.

In the southeastern Barents Sea the waters off Kola and the banks west of Novaya Zemlya were surveyed with approximately 1,000 n.miles of primary effort; and 88 primary sightings of minke whales were made. The latter half of the survey period was hampered by bad weather.

During the 2001 survey, biopsies were collected from six white-beaked dolphins and four humpback whales within the Norwegian Sea, and four minke whales and one fin whale within the southeastern Barents Sea. In addition, fluke photos from four humpback whales were collected from the Norwegian Sea.

SC/54/RMP2 reported on results from two VHF radio tracking experiments conducted in Norwegian waters in August/September 2001 to collect data on dive patterns of minke whales. The mean inter-surfacing intervals for the two

sampled whales were 66.85s (SD=5.5) and 99.21s (SD=2.09) corresponding to blow rates of 53.85 and 36.29 blows/hour, respectively. These are comparable to blow rates recorded earlier in the northeast Atlantic by VHF radio tracking as well as visually-collected surfacing data. No significant differences were found between day and night dive times for the one new whale sampled over approximately 2.5 days. Mean inter-surfacing interval based on data from 10 VHF tracked animals is 76.98 (SD = 13.26), which is equivalent to a blow rate of 46.8 blows/whale/hour.

The sub-committee noted with disappointment that so few new data on dive time patterns had been collected since they last considered the abundance of minke whales in the northeast Atlantic. They recalled that this had been a major concern about the previous estimate (IWC, 1997, p.273), and that the estimates in SC/54/RMP2 were also conditional of observations on a relatively few whales made over a limited latitudinal range. The available data did not include observations, for example, in the northern part of the study area where minke whales are known to feed on euphausiids rather than herring in the south. The dive patterns may differ with prey species.

Øien explained that one reason there were few new data is that researchers had pursued satellite tagging methods as a way of collecting substantial additional data, but that attachment problems had not been solved. Those attempts were made in Spitsbergen and the North Sea. Thus this past year they reverted to radio tagging, and are continuing those types of studies this year in the Norwegian Sea.

M. Taylor queried if the activity of the whales would be representative of normal activity given that the animals were being pursued by the vessel tracking them. It was explained that the vessel follows the animal at a distance and does not pursue it, and it was not thought that this affected behaviour.

Some members queried why the results given differed from those in Stockin *et al.* (2001). Øien pointed out that the methods used in that study were different, and that animals were sampled primarily in shallower waters. M. Taylor noted that the samples in Stockin *et al.* (2001) were not restricted to shallow waters, having been collected in waters from 50 up to 250m depth. He suggested that small sample size in SC/54/RMP2 may explain the difference, in light of great variation in dive time among individuals.

It was suggested that it might be possible to model differences in diving behaviour by comparing patterns in different habitats in existing data, if there is enough contrast. Another approach to improving our understanding of diving patterns, and possibly to correct for any effects of heterogeneity in habitat, would be to apply the method described in SC/54/IA10, which utilises information from the survey data on sequential sightings of the same group. Even more simply, the sighting duplicates could be examined for latitudinal changes in surfacing patterns using the survey data.

SC/54/RMP3 described buoy sighting experiments and data used to estimate bias and variability in radial distance estimates (made by the naked eye without further means) and angle estimates obtained by pointing an arrow and reading from an angle board. Two buoys with radar reflectors were used, and the vessel approached the buoys at survey speed. At signal the observer in the barrel was asked to make estimates, to be compared to distance and angle measured by radar. By fitting regression models, it was found that a model with a fixed relative bias in radial distances and with a variance in the logarithmic variance to relate linearly to true

distance does fit the data. Similarly, a simple model for errors in angle measurement was found. By comparing to pair wise differences in duplicate sightings in the survey, the variability for radial distances was found to be similar in the survey and the buoy sighting experiment. For angle measurements, errors were found to be larger in the survey.

In discussion, members commented on the lack of differences in the errors for angles and sighting distances between the duplicate sightings data and for the buoy experiments. It was queried if the extent of rounding was similar in the two types of data. It was reported that there was no difference for radial distances. Cooke noted that in his analysis of the 1995 survey data there was substantially more rounding in the survey data than in the experiments (Cooke and Leaper, 1996).

The lack of difference for angle measurements might be expected because it was noted that the measurements to animals were made to the persistent water disturbances caused by the surfacing animals.

Cooke reported his experience during calibration experiments that, because the buoys used present a rather tall vertical profile, they tend to become suddenly visible at a fixed distance. Thus the observers may be judging relative distance to that point of visibility rather than distance directly. Thus the error might be expected to decline with distance for buoys, but only as an artefact of the shape of the buoy.

Members noted the desirability of obtaining better methods of testing the ability to estimate distances at sea, and ultimately to apply methods to measure distance at sea and thus avoid reliance on subjective distance estimation.

In SC/54/RMP4, to estimate over-dispersion in counts over survey legs and to obtain a model for local clustering to be used in the simulation model for bias correction of hazard probability parameters, spatial point process models of the Neyman-Scott type were fitted to the one-dimensional data of sighting locations along the survey transect legs. The method is to construct an empirical K-function to which the corresponding theoretical K-function depending on the Neyman-Scott parameters and the detection function parameters is fitted. Since artificial clusters in the one-dimensional data can arise as the effective strip width varies over transect legs due to variability in sighting conditions and observer efficiency, and also to come around edge-effects due to stops in the survey due to bad weather or darkness, a simulation approach was taken to remove potential bias. The individual Neyman-Scott parameters are not precisely estimated within survey blocks. For the North Sea the model did not fit well due to the apparent existence of only one large cluster off Scotland.

A question was raised about the sensitivity of Neyman-Scott models to the definition of initial clusters and a suggestion was made to use transect variance as an alternative and then compare the results of the approaches. Schweder replied that this had not yet been done in this instance, but that the alternative approach had not previously been tried in the North Sea.

SC/54/RMP5 provided an analysis of data from the Norwegian annual minke whale surveys conducted in the period 1996-2001. The series of surveys has covered different parts of the northeastern Atlantic each year in the period. To account for additional variance that arises in multi-year surveys, a random effects model had been developed. Except for this, the method of analysis was to a large extent the same as that used in the analysis of data from the 1995-survey (Schweder *et al.*, 1997). The abundance

estimate for the Eastern *Medium Area* was 79,719 minke whales ($CV = 0.19$), while the estimate for the total survey area (including *Small Area CM*) was 109,298 minke whales ($CV = 0.16$).

Discussion focused on the aspects of the estimation methods that were different from those used for the 1995 survey. The use of the maximum pod size to convert pod number into whale number was questioned because that might over estimate abundance. It was noted that the maximum pod size estimate is the more representative because surfacing is not synchronous. Also, relative to concerns raised in the discussion of SC/54/RMP2, it was noted that abundance estimates would likely be upwardly biased if dive time estimates were biased upward.

It was also noted that the Bernoulli trial data in fig. 4 of SC/54/RMP2 suggested an increasing probability of duplicate sightings being made at greater distances in one instance. This may suggest heterogeneity in some whales being visible at greater distances. It was explained that this cell actually contains a small number of samples so this may not be a reliable estimate in that case.

The automatic duplicate identification rule used did not perform very well in both high density and low density areas. While this might be expected in the former case, one would expect better performance when the density was lower. It was noted that rules that performed better had been explored for the 1995 survey. Skaug responded that there might be a need to retune the rule to reduce the proportion missed, although that increases the probability of a false identification.

It was also queried why one set of parameters for the Neyman-Scott spatial clustering process had been used in the bias correction process, when in fact the spatial model parameters differ spatially. The response was that a single set of parameters was used, as in the 1995 survey analysis; however it would be possible to use parameter values that varied spatially.

6.4.2.3 CONCLUSIONS

The results of the analyses presented on stock structure suggest that animals in the North Sea *Small Area* may be differentiated from animals in other areas. Further, there is the possibility that the distinction made between *Medium Areas E* and *C* may need to be reconsidered. The sub-committee was interested in seeing further application of the Boundary Rank method to the genetic samples collected from catches since the last *Implementation* was completed. Further, Walløe indicated that Norway was interested in removing the Lofoten Island *Small Area* distinction to combine that area with surrounding areas.

Examination of the previous *Implementation Simulation Trials* indicated that these possibilities had not been completely considered then. Further, the RMP specification suggests that *Implementation Simulation Trials* may be required when *Small Area* definitions are changed.

Given the limited time available, further consideration of this item was left to a small group under Cooke (Butterworth, Smith, Taylor, B. Walløe) to report to Plenary (see Appendix 14).

6.4.3 Specify intersessional work to permit completion of *Implementation*

Given the limited time available, further consideration of this item was left to the small group appointed under Item 6.4.2.3 above.

6.5 Western North Pacific Bryde's Whales

6.5.1 Report of Implementation Simulation Trials group

Allison reported that because of other priorities there had not been time to code and run any trials as recommended last year.

Allison noted that she planned to establish a process for examining catch data beforehand, prior to trials taking place. The data would be tabled by areas small enough such that any future trials would only use combinations of the prepared datasets and not require any further disaggregation.

In considering the above, the Committee noted its discussions below, concerning the need to reconstruct the past catches. It agreed that Allison's proposals for examining catch data should be held over until that reconstruction had been completed.

6.5.1.1 CATCH DATA TO BE USED IN THE TRIALS

The sub-committee considered the catch data available for use in the trials. Last year the Committee had been provided with information on unreported catches of large whales, including Bryde's whales, in Japanese coastal whaling operations, and had encouraged further investigation of the issue. This year SC/54/O13 had been prepared in response to the Committee's request for preparation of a paper to be considered at this year's meeting. It contained further information on such catches by species, region and month for limited operations by one whaling company between 1965-78, and compared them with official statistics. Information was now available from at least three large-type whaling companies and four small-type whaling companies operating in Japanese coastal waters. The senior author of SC/54/O13 was Mr I. Kondo, whose book on the subject had been drawn to the Committee's attention last year.

SC/54/O13 described major under-reporting of sperm, sei and Bryde's whales taken off the Pacific coast of northern Japan, often over twice the officially reported catch. There were problems with species identity: some fin whales taken in the Sea of Japan and the Okhotsk Sea, for example, had been recorded as sei whales. Sei and Bryde's whales were not completely separated in the record.

The information in SC/54/O13 had been derived from operation summary charts of one company, covering monthly whaling operations by geographical region, giving positions of whales taken, monthly catches by species and cumulative catches by season. Figures derived from those charts differed in some minor aspects from those given in Kondo (2001), but were regarded as true figures. Kondo (2001) recorded under-reporting of Bryde's whales off the Bonin Islands in 1981-1987 but the original records have been lost.

In discussion, Sakamoto noted that verification of information is essential before the Committee uses it since the accuracy is unknown.

It was agreed that further work was needed to reconstruct past catches in more detail. An intersessional Working Group under Brownell (members Kasuya, Smith) was given the task of investigating the quality and nature of data provided in the past, including requesting data from additional whaling companies, and suggesting methods of dealing with it, for use in the *Implementation Trials*. Given that unreported catches are experienced in finfish fisheries investigations, the group was authorised to seek advice from, and as necessary co-opt, someone outside the Committee with relevant expertise. It was also authorised to co-opt Committee members with relevant expertise, as appropriate.

It was agreed that copies of the operation summary charts should be lodged with the Secretariat.

Komatsu stated that Mr Kondo had refused to make contact with Japanese Government officials who had requested to see him to provide the information on the past whaling data. Therefore the Government of Japan was unable to check and verify the information and it maintains its position at this time that the statistics already provided are still the official data. Komatsu also indicated that Japanese scientists would not serve on the intersessional group.

Kasuya responded that Mr Kondo saw no reason to meet with the Government of Japan because he had already made details of the statistics available in his book, and because he was making these details available to the IWC in the paper written with Kasuya (SC/54/O13).

Smith expressed his considerable regret at the lack of response from Japanese scientists in assisting with the work of the intersessional group.

6.5.1.2 STOCK STRUCTURE

Pastene presented appendix 10 of SC/54/O17. Mitochondrial DNA control region sequencing and microsatellite analyses were conducted on samples of ordinary form Bryde's whales from different localities of the western North Pacific (WNP). The mtDNA analysis involved the following samples from this oceanic region: JARPN II (surveys conducted in 2000 and 2001, $n=85$); Ogasawara (former coastal whaling in 1983, 1984, $n=103$) and central western North Pacific (CWNP, former pelagic whaling in 1979, $n=95$). As out-groups, Bryde's whales from the western South Pacific (WSP, $n=24$), eastern South Pacific (ESP, $n=33$) and eastern Indian Ocean (EIO, $n=23$) were used. A total of 58 unique mtDNA sequences (haplotypes) were discriminated in the total samples. The analysis of molecular variance using PHist and Fst statistics revealed no significant differences among the three localities in the North Pacific. In contrast, striking mtDNA differences were found among oceanic regions. Additional analyses using a randomised chi-square test found some degree of heterogeneity between historical samples from Ogasawara and recent JARPN II samples but the same test found no significant heterogeneity between JARPN II and CWNP or between Ogasawara and CWNP. The microsatellite analysis with five loci involved the same localities in the WNP: JARPN II ($n=85$), Ogasawara ($n=50$) and CWNP ($n=50$). The following out-groups were used: WSP ($n=25$) and EIO ($n=10$). No significant deviation from the Hardy-Weinberg equilibrium was observed in the three WNP localities and no significant differences in allele frequencies were found among these localities. In contrast, striking nuclear DNA differences were found among WNP, WSP and EIO. The analysis confirmed the occurrence of different genetic populations in the western North Pacific, western and eastern South Pacific and in the eastern Indian Ocean. Overall the results provided support for the stock structure scenario defined by the Scientific Committee in the North Pacific during the Comprehensive Assessment. The authors noted that the mtDNA heterogeneity found by the chi-square test between Ogasawara and JARPN II is difficult to interpret at this stage and that other information (apart from genetics) should be considered in the future to provide a better interpretation and conclusion.

The sub-committee noted that sample sizes in the above remain small, and it was suggested that genetic and pollutant analyses (see SC/54/O17, appendix 13) might be coupled to provide useful information.

It was agreed that the results reported in SC/54/O17, appendix 10, gave no reason to change the stock structure in the existing trials, but that as much work as possible should be undertaken before the next meeting, to allow a full and detailed discussion next year.

In discussion of the *Implementation Schedule* (i.e. table 2 of the Scientific Committee report) in this context, it was noted that activities so far were still within the *Pre-Implementation Review* in 'Box 1'; it would be necessary to review progress at next year's meeting to determine exactly what point had been reached on the Schedule. Hopefully by then meeting the criteria in Box 1 would be well advanced.

The sub-committee noted that it may be in a position at the next meeting to complete the *Pre-Implementation*. If so, any new data after that meeting that might indicate additional hypotheses would only be considered in the subsequent *Implementation Review*.

Coding of the trials (as specified in IWC, 2000) would accordingly be suspended until next year's meeting.

6.5.2 Sightings surveys

SC/54/RMP10 described a survey to confirm the longitudinal distribution pattern of western North Pacific Bryde's whales conducted by two vessels, in two blocks, 21°N-39°N, 145°E-175°E and 21°N-39°N, from 23 July to 20 August 2001. A total of 86 primary sightings (130 animals) was recorded. While distributed throughout the range of the survey, fewer animals were found in the eastern part of the area.

SC/54/RMP13 reported a survey over 41 days in August and September 2001, using one vessel. The survey area was divided into two blocks: PL(10°00'N-25°00'N) and PM (25°00'N-35°00'N). Two schools (two animals) were recorded as primary sightings in block PL, and none in block PM.

SC/54/RMP14 described plans for a Bryde's whale survey in the western North Pacific (in 25°00'N-42°00'N, 155°00'W-180°00'W) in August-September 2002. It would take place only if the planned minke whale survey in the Russian EEZ (see SC/54/RMP9) could not be undertaken. Closing and passing modes would be used.

The sub-committee endorsed the proposal in SC/54/RMP14 and asked Shimada to provide Committee oversight for the survey.

6.5.3 Future work

The sub-committee agreed that this had been covered in its discussions under Item 6.5.1:

- (1) Investigate the quality and nature of past Japanese coastal catch data, including requesting data from additional whaling companies, and suggesting methods of dealing with it for use in the *Implementation Trials*; to be overseen by a small group under Brownell (members Kasuya, Smith).
- (2) Undertake intersessionally as much analysis as possible, including genetics, to allow a full and detailed discussion of stock structure at the next meeting.

6.6 Other

6.6.1 Sightings survey plans for North Pacific minke whales

SC/54/RMP9 detailed plans for a sightings survey for minke whales in the Sea of Okhotsk in summer 2002. It will take place from 23 July to 20 September, using two vessels, with the objective of estimating abundance using IO passing

mode. Biopsy samples for assessing stock structure will be collected opportunistically. Training and experiments in distance and angle estimation will be conducted.

The sub-committee endorsed the proposal, and **recommends** that the Commission requests the relevant authorities of the Russian Federation to grant permission in timely fashion for the Japanese vessels to undertake surveys in its EEZ.

SC/54/RMP12 described joint Japan/Korea sighting surveys in the Sea of Japan in 2002. Using two vessels, the main objective is to obtain information on distribution and density of the East China Sea-Yellow Sea-Sea of Japan minke whale stock, using normal closing mode. One vessel will conduct opportunistic biopsy sampling. One survey has already been undertaken (10 April-9 May 2002) and the other will take place from 13 May to 1 July 2002. Kim reported that one Korean scientist will be participating. The sub-committee **endorsed** the proposal, and asked Miyashita to provide Committee oversight for the surveys.

SC/54/RMP19 provided information on plans to conduct a sightings survey in the period 20 August-19 September 2002 in western Korean waters. It has the objective to estimate minke whale abundance in terms of the RMP, in both closing and passing mode, and to obtain general information on seasonal cetacean distribution.

SC/54/RMP20 gave details of a Korean sighting survey in the Yellow Sea, undertaken last year, i.e. 6-26 September 2001. Because of bad weather only 49.5% (621.6 out of 1,255.7 n.miles) could be undertaken on effort. Nine minke whale schools (10 animals) were observed as primary sighting under Beaufort scale 3-4. It reported that minke whales were aggregated in the southern part of the offshore area. Water surface temperature in the survey area ranged from 19.0°C off the northern coast to 27.4°C in the southern area offshore.

SC/54/RMP21 described a revised plan for a sightings survey in eastern Korean waters. It had been revised in accordance with discussions at last year's meeting, particularly in terms of coverage probability and randomness of start points. One vessel will operate from 14 May to 18 June. The survey area is divided into seven rectangular blocks taking account of land shapes, with a total predetermined transect distance of 1,370 n.miles (see also Kim, 2001).

The sub-committee **endorsed** the proposals in SC/54/RMP19 and 21 in terms of the RMP and asked Miyashita to provide Committee oversight for the surveys. It **recommends** that the survey report and plans be elevated to full paper status to ensure they are entered into the record (SC/54/RMP19, 20, 21).

6.6.2 Initial planning for in-depth assessment of North Pacific minke whales

The sub-committee judged that work on this comprehensive assessment should be delayed until the North Pacific minke whale *Implementation* is complete. However, members noted with concern the information it had received about higher levels of bycatch in the region of J stock (see Item 6.3.1). The sub-committee agreed that there was a need to address the assessment of North Pacific minke whales as a matter of urgency, but it noted that the *Implementation Simulation Trials* would provide some information on this issue.

6.6.3 Revision of RMP annotations

The sub-committee agreed that there were no matters in this context requiring attention at this time.

6.6.4 Data availability

The intersessional Workshop had encountered difficulties over access to genetics data important to the development of trials (SC/54/Rep1). It had noted that the matter of data availability is complex and sensitive, involving the need to strike a balance between the Committee's needs and the rights of scientists who had collected the data, and the great importance of the issue to the Committee's work in the context both of the development of *Implementation Simulation Trials* and in discussions of their relative plausibility. It had strongly recommended that the question of data availability should be considered at this meeting.

Points referred to in discussion in the sub-committee included:

- (1) Transparency and openness are essential in any process adopted.
- (2) Sufficient safeguards must be in place; there should be some system of enforcement, with sanctions available against those who break the rules.
- (3) Owners of data must have enforceable intellectual property rights to their data.
- (4) In addition to the primary researchers, all collaborating scientists should be required to seek permission to use the data in question.
- (5) Members of the Scientific Committee would normally have the status of 'accredited' scientists.
- (6) Requests for use of data under the RMP should be routed via the Secretariat and not direct to the owners.
- (7) It is essential that the data used in management, e. g. in *Implementation Trials*, are made available; they are as important as the abundance data for which protocols already exist.

The sub-committee came to no conclusions on the matter, and referred it to a Working Group under Donovan (Baker, Cooke, Hammond, Hatanaka, Perrin, Smith, Walløe), to report direct to Plenary. The Working Group would have the task of reviewing the question further and recommending possible courses of action, for agreement by the Commission.

6.7 Work plan

The sub-committee agreed that the following tasks should be completed before the next meeting:

- (1) Adjust the convergence criteria for the CATCHLIMIT program, in conjunction with using the program for *Implementation Simulation Trials* (see Item 5.1).
- (2) Conduct calculations on the population component to which MSYR, MSYL, density dependence should apply (Item 5.2).
- (3) Hold an intersessional Workshop to permit completion of the North Pacific minke whale *Implementation Simulation Trials* (Item 6.3.3).
- (4) Undertake work towards the North Atlantic minke whale *Implementation Review* (report from Plenary on recommendations from Cooke's small group) (Item 6.4.2.3).
- (5) For the *Pre-Implementation* assessment of western North Pacific Bryde's whales (Item 6.5.1):
 - (a) submit all available data and associated stock structure analyses for discussion at the next meeting;
 - (b) develop scenarios for possible levels of historic catches (through the intersessional Working Group under Brownell).

In this context high priority must be given to (b) above.

In addition, the sub-committee agreed that the following items should be included in next year's agenda:

- (1) Evaluation of abundance estimators against simulated datasets (Item 5.3.1).
- (2) Spatio-temporal considerations in the context of the application of the RMP (papers on the subject are encouraged) (Item 6.2.2).
- (3) The level of information needed for:
 - (a) conducting a *Pre-Implementation Assessment*; and
 - (b) proceeding to an *RMP Implementation* (submissions on the subject are encouraged) (Item 6.2.2).
- (4) Initial planning for an in-depth assessment of North Pacific minke whales (Item 6.6.2).

7. ADOPTION OF REPORT

Items 1-6.4 and 6.6.1-6.6.3 were adopted at ca 18:00 on 6 May 2002. Items 6.5 and 6.7 were adopted at 13:00 on 8 May 2002. The sub-committee expressed its appreciation for the work of the rapporteurs and the Chair.

REFERENCES

- Burnham, K.P. and Anderson, D.R. 1998. *Model Selection and Inference. A Practical Information-Theoretic Approach*. Springer-Verlag, New York. 353pp.
- Cooke, J. and Leaper, R. 1996. Analysis of angle and distance estimation from NILS95. Paper SC/A96/AE34 presented to the Abundance Estimation Working Group in Oslo, April 1996 (unpublished). [Paper available from the Office of this Journal].
- Hatanaka, H. and Miyashita, T. 1997. On the feeding migration of Okhotsk Sea-West Pacific stock minke whales, estimates based on length composition data. *Rep. int. Whal. Commn* 47:557-64.
- International Whaling Commission. 1997. Report of the Abundance Estimation Working Group. *Rep. int. Whal. Commn* 47:261-90.
- International Whaling Commission. 2000. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 7. Initial trial specifications for western North Pacific Bryde's whales. *J. Cetacean Res. Manage. (Suppl.)* 2:118-23.
- International Whaling Commission. 2001a. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 3:90-125.
- International Whaling Commission. 2001b. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 3. Report of the Working Group on *MSYL*, *MSYR* and density-dependence trials. *J. Cetacean Res. Manage. (Suppl.)* 3:106.
- International Whaling Commission. 2002a. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 4:1-78.
- International Whaling Commission. 2002b. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 4:93-147.
- Kass, R.E. and Raftery, A.E. 1995. Bayes factors. *J. Am. Stat. Assoc.* 90:773-95.
- Kim, Z.G. 2001. Plan for whale sighting survey in the eastern waters of Korea, Spring 2002. Paper SC/53/RMP27 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Kondo, I. 2001. *Rise and Fall of Japanese Coastal Whaling*. Sanyo-sha, Tokyo. 449pp. [In Japanese].
- Martien, K.K. and Taylor, B.L. 2001. A new method of generating hypothesized population structures for continuously distributed species using genetic data. Paper SC/53/SD7 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Schweder, T., Skaug, H.J., Dimakos, X.K., Langaas, M. and Oien, N. 1997. Abundance of northeastern Atlantic minke whales, estimates for 1989 and 1995. *Rep. int. Whal. Commn* 47:453-84.
- Skaug, H.J. 2000. Combination of multiyear surveys for Northeastern Atlantic minke whales. Paper SC/52/RMP12 presented to the IWC Scientific Committee, June 2000, Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- Skaug, H.J. 2001. Plans for next year's analysis of the NILS 1996-2001 data. Paper SC/53/RMP2 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Stockin, K.A., Fairbairns, R.S., Parsons, E.C.M. and Sims, D.W. 2001. Effects of diel and seasonal cycles on the dive duration of the minke whale (*Balaenoptera acutorostrata*). *J. Mar. Biol. Assoc. UK* 81:189-90.

Appendix 1 AGENDA

1. Convenor's opening remarks
2. Election of Chair, appointment of rapporteurs
3. Adoption of agenda
4. Review of documents
5. Revised Management Procedure (RMP) – general issues
 - 5.1 Adjustment of the convergence criteria for the CATCHLIMIT program
 - 5.2 Population component to which *MSYR*, *MSYL*, density-dependence should apply
 - 5.3 Evaluation of abundance estimators against simulated datasets
 - 5.3.1 Report of the Intersessional Working Group on Abundance Estimation
 - 5.3.2 Other
 - 5.4 Work plan
6. RMP – preparations for implementation
 - 6.1 North Pacific minke whale *Implementation*
 - 6.1.1 Report of the Intersessional Workshop
 - 6.1.2 Report of *Implementation Simulation Trials* group
 - 6.2 Procedures and scheduling of *Implementations (Implementation Reviews)*
 - 6.2.1 Proposals from last year and experience to date
 - 6.2.2 Proposed process
 - 6.3 North Pacific minke whale *Implementation* (continued)
 - 6.3.1 Review of trial structure and consideration of relative plausibility of trials
 - 6.3.1.1 Discussion related to plausibility of different stock structure hypotheses
 - 6.3.1.2 Discussions related to details of the trial specifications
 - 6.3.1.3 Discussion related to the bycatch levels to use in the trials
 - 6.3.2 Consider *Implementation* options
 - 6.3.3 Specify intersessional work to permit completion of *Implementation*
 - 6.4 North Atlantic minke whale *Implementation Review*
 - 6.4.1 Report of Steering Group
 - 6.4.1.1 New data

6.4.1.2	New abundance estimates	6.5.1.2	Stock structure
6.4.1.3	Small Areas	6.5.2	Sightings surveys
6.4.1.4	Biological parameters	6.5.3	Future work
6.4.2	<i>Implementation Review</i>	6.6	Other
6.4.2.1	Stock structure	6.6.1	Sightings survey plans for North Pacific minke whales
6.4.2.2	Abundance	6.6.2	Initial planning for in-depth assessment of North Pacific minke whales
6.4.2.3	Conclusions	6.6.3	Revision of RMP annotations
6.4.3	Specify intersessional work to permit completion of <i>Implementation</i>	6.6.4	Data availability
6.5	Western North Pacific Bryde's whales	6.7	Work plan
6.5.1	Report of <i>Implementation Simulation Trials</i> group	7.	Adoption of report
6.5.1.1	Catch data to be used in the trials		

Appendix 2

REPORT OF THE WORKING GROUP ON ISSUES RELATED TO ABUNDANCE ESTIMATION

Members: Palka (Chair), Borchers, Bravington, Butterworth, Cooke, Hakamada, Hammond, Hedley, Kingsley, Okamura, Polacheck, Schweder, Skaug, Smith.

Last year the Committee re-established this intersessional Working Group with the priority task to expand the existing set of simulated datasets to be able to evaluate performance over a wider range of potential survey and biological conditions. Priority areas for future simulation included: school size based models; surfacing rates; movement effects; effects of binoculars; effects of uncertainty in species identity and its interaction with school size and detection function; interactions among school size estimation; double team estimators; and school size effects when using closing mode.

The original set of 100 replicates of 32 simulated scenarios described in Polacheck *et al.* (2000) were sent to Okamura to possibly be used to investigate a new variant of the hazard probability model for abundance of Antarctic minke whales (SC/54/IA10), knowing that these data do not exactly simulate the survey design and procedures used in the IDCR/SOWER cruises.

To expand the types of simulated datasets, a programmer (D. Smith), working with Palka, has become familiar with the program used to create the simulated datasets. Presently he has modified the program to include reactive movements, and different models that incorporate uncertainty in measurement error.

When the reactive movement code is invoked, a whale enters into a reactive region (a user-defined distance from the

ship), reacts by changes in dive time, speed, and/or direction, and then alters its position for the next surfacing. The amount of reaction is a function of the distance between the whale and ship and the user-defined reactive distance. Palka is presently analysing different simulated scenarios of avoidance using the methods developed in Palka and Hammond (2001).

When the new measurement error code is invoked, errors are added to the angle, radial distance and/or time using the models described in appendix C in SC/54/RMP5. In addition, tracks can be permanently lost with a pre-set probability, and values of angle and/or radial distance can be set to missing with a pre-set probability. Using this new code it is possible to produce a data set without errors and that same dataset with errors. Skaug is presently analysing different simulated scenarios with and without measurement errors using the methods developed in SC/54/RMP5.

REFERENCES

- Palka, D.L. and Hammond, P.S. 2001. Accounting for responsive movement in line transect estimates of abundance. *Can. J. Fish. Aquat. Sci.* 58:777-87.
- Polacheck, T., Palka, D., Borchers, D., Cooke, J.G., Skaug, H.J. and Dixon, C. 2000. Simulation comparison of different methods for estimating whale density from double-team line transect data. Paper SC/52/RMP18 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].

Appendix 3

REPORT OF THE NORTH PACIFIC MINKE RMP TRIALS STEERING GROUP

Members: Butterworth (Chair), Allison, Cooke, Goto, Hatanaka, Kawahara, Kim, Martien, Okamura, Pastene, Polacheck, Punt, Smith, Taylor, Wade, Walløe.

Terms of Reference

The terms of reference given to this Steering Group at the last meeting (IWC, 2002, p.9) in 2001 were as follows:

- (1) facilitate the conduct of analyses of genetic data for sub-areas 7, 8 and 9 in time to advise the intersessional meeting;
- (2) facilitate the specification and running of an initial set of trials to facilitate choices of final trials at the intersessional meeting.

In addition, the Steering Group took note of the agreement of the Scientific Committee at its 2001 meeting that the results of these North Pacific minke whale *Implementation Simulation Trials* would be examined at the Committee's 2002 meeting with the goal of recommending to the Commission one variant of the RMP irrespective of any further data forthcoming in the interim, and that this would constitute the end of the *Implementation* (IWC, 2002, p.8).

Genetics

Pursuant to (1) above, in December 2001 a collaborative meeting was held in Tokyo between Pastene, Goto, Kanda, Taylor and Martien to discuss available genetics techniques and analyses, and to apply some of these further. Their deliberations are recorded in Pastene *et al.* (2002), and contributed to the discussions on genetic analyses that took place during the intersessional Workshop on the North Pacific minke *ISTs* held in Seattle, January 2002 (SC/54/Rep1).

Intersessional workshop

A planned intersessional workshop was hosted by the US National Marine Mammal Laboratory in Seattle from 19-22 January 2002, with 15 participants. The deliberations of this meeting are given in SC/54/Rep1. The Terms of Reference were as follows.

- (1) Review results of further analyses of genetic data for sub-areas 7, 8 and 9 to decide what trial modifications may be necessary in consequence, and re-estimation of mixing proportion between 'J' and 'O' stocks in sub-areas 7 and 11.
- (2) Specify final trials in the light of discussions at the 2001 Scientific Committee meeting and the results of trials run intersessionally, and decide upon which combinations of *Small Area* definitions and RMP variants to run the final trials.
- (3) Initiate discussion on approaches to advise on the relative plausibility of trials and their application in this instance, to facilitate discussion of this matter at the 2002 Scientific Committee meeting.
- (4) Specify Terms of Reference for continued work under the intersessional e-mail group until the 2002 meeting. This Workshop was able to address (1) and (4) above, and make substantial progress on (2), but did not have sufficient time to address (3).

Progress since intersessional Workshop

SC/54/Rep1 (item 12.1) identified a schedule of eight tasks necessary for completion prior to the 2002 Scientific Committee meeting to be able to run *ISTs* for report there. Experience subsequently showed this schedule to have been overly ambitious, and it was not completed. Progress by the start of the 2002 Scientific Committee meeting has been as follows.

- (1) Finalise abundance estimates for sub-divisions of sub-areas 7, 8 and 9 – Completed.
- (2) Finalise adaptations of existing mixing matrices for these sub-divisions – Almost completed for the Baseline A scenario, except for a few of the sensitivity trials, and well advanced for Baseline C.

- (3) Check conditioning on an initial set of trials – Availability of the information required for this exercise is imminent.
- (4) Specify dispersal rates for four-stock trials – Initial model runs necessary to provide input information for this process have yet to be completed.
- (5) Completion of specification of the three stocks with mixing trials – This work is conceptually complete (see Annex G of SC/54/Rep1), but still requires technical development into the detailed format for trial specifications of Annex H of that report.
- (6) Develop a format for reporting results – In the absence to date of further trial results for consideration, this process has not developed further than the format used during the 2001 Scientific Committee Meeting.
- (7) Prepare code for potential $MSYR_{1+}$ trials – Work has yet to commence.
- (8) Run final trials – Work has yet to commence, completion of task (3) above being a pre-requisite for its initiation.

Concluding remarks

The Steering Group proved unable in the time available to address all of its terms of reference and to have the results of final *ISTs* available for the 2002 Scientific Committee meeting upon which the Committee might have been able to agree upon a recommendation of an RMP variant to the Commission for implementation.

The primary reason for this situation was that the further consideration of genetic analyses for the Steering Group led to the development of substantial new hypotheses. Though there is a wide range of opinions within the Group concerning the plausibility of these hypotheses, the Group considered that these hypotheses were necessary to examine further. Because these new hypotheses were not subsets of those examined earlier, this has given rise to a process of expanding rather than contracting uncertainty. Without further examination of these hypotheses, it would not have been possible to inform the Commission that the *ISTs* conducted as the basis to recommend an RMP variant had adequately spanned the plausible range of uncertainty.

In the process of the Group's deliberations (including those at the Seattle Workshop), the following issues were identified as requiring further consideration by the Scientific Committee (references are to items in SC/54/Rep1).

- (1) Data availability for the *Implementation* process (item 6.2).
- (2) Review of the concept of 'partial cascading' and, if deemed appropriate, the development of any necessary additions to the explanatory notes of the RMP (item 10.2).
- (3) Plausibility of trials (item 11).
- (4) Appropriate procedures for scheduling and conduction any future RMP *Implementation (Reviews)* (item 13).

REFERENCES

- International Whaling Commission. 2002. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 4:1-78.
- Pastene, L., Kanda, N., Goto, M., Taylor, B. and Martien, K. 2002. Report of the 'Small Drafting Group'. Paper SC/J02/NP13 presented to the Scientific Committee Workshop on North Pacific common minke (*Balaenoptera acutorostrata*) *Implementation Simulation Trials* held in Seattle, USA, 19-22 January, 2002 (unpublished). [Paper available from the Office of this Journal].

Appendix 4

SPLIT OF ABUNDANCE ESTIMATES IN THE NEW SUB-AREAS FOR THE WESTERN NORTH PACIFIC COMMON MINKE WHALE

Tomio Miyashita

The Seattle Workshop (SC/54/Rep1) concluded that the old sub-areas 7, 8 and 9 should be divided into the smaller sub-areas. These were 7W, 7E, 8W, 8E, 9W, 9E and 9N. Because there was no sighting effort in the last area, the split was conducted in the former six sub-areas. The Workshop requested the work to be conducted via e-mail communication between Miyashita, Butterworth and Taylor. Because of the necessity for quick work, a simpler but reasonable method was adopted.

1. Split of abundance

Abundance was allocated from the old sub-area into the new one in proportion to the area surveyed (nm^2). For the sub-area 7W, the abundance was estimated by the inverse-variance weighted average of 1990, 1991 and 1992 estimates after splitting from the old sub-area. For other sub-areas, it was easier because the data was in a single year.

2. CV estimation

Three factors: mean school size (s); effective search width (esw); and encounter rate (n/L), were considered for the total CV of abundance (p). For the first two factors, these were assumed to be the same values as those in the old sub-areas. For the last one, the effort and number of sightings were re-allocated from the original data and estimated by the usual estimator for CV (n/L). The CV (P) was calculated by:

$$CV^2(P) = CV^2(s) + CV^2(\text{esw}) + CV^2(n/L)$$

The results are shown in Table 1.

Table 1
Split of abundance in sub-areas 7, 8 and 9

Sub-area	Timing	Estimate	CV
7W	Aug-Sept 1991	1,164	0.183
7E	Aug-Sept 1990	791	1.848
8W	Aug-Sept 1990	472	0.855
8E	Aug-Sept 1990	585	1.071
9W	Aug-Sept 1990	3,226	0.538
9E	Aug-Sept 1990	5,038	0.405

Appendix 5

REPORT OF THE SMALL GROUP TO EXAMINE THE DISTRIBUTION OF PUTATIVE W STOCK IN SUB-AREAS 12SW AND 12NE

Members: Allison (Chair), Martien, Polacheck, Punt, Taylor.

SC/54/Rep1 indicates that in all North Pacific minke whale *Implementation Simulation Trials* that include a W stock, the W stock is present only in the Northeastern portion of sub-area 12. The group first discussed the rationale for this specification. All of the historical catch in sub-area 12 came from the Southwestern portion. Specifying that there are no W-stock animals present in sub-area 12SW ensures that the trials are precautionary in that all historical catches come out of O stock(s). Because the relative representation of O and W stocks in sub-area 12 as a whole is specified independently, the specification on their distributions within sub-area 12

will not impact the abundances of the stocks. The participants agreed that this was an appropriate specification and that it did not conflict with any of the mixing matrices specified during the intersessional meeting.

The group also briefly discussed the general issue of introducing an element of stochasticity into some of the mixing matrices to account for interannual variability in migration and spatial distributions. However, the participants concluded that this issue could be most appropriately examined within the context of base-case D trials. As such, the participants agreed that this issue was best referred to the small group chaired by Smith, which will be finalising the specifications for that base-case.

Appendix 6

THE UTILITY OF AIC IN CHOOSING BETWEEN ALTERNATE MODELS OF STOCK STRUCTURE

Karen K. Martien, Paul Wade and Barbara L. Taylor

SC/54/RMP15 proposed the use of Akaike's Information Criterion (AIC; Akaike, 1974) in weighing the relative plausibilities of the stock structure models that have been proposed for North Pacific minke whales. Here, the utility of the analyses presented in SC/54/RMP15 is evaluated.

Results are presented of some general performance analyses recently begun (see also SC/54/SD6) to examine the ability of AIC to choose the correct population structure model from a suite of hypothesised models. While these are general performance analyses not tuned specifically to the

abundance and life history of North Pacific minke whales, they do raise concerns regarding the level of performance that can be expected in the minke whale case. Some specific comments on SC/54/RMP15 follow.

Performance analyses

The equation used here for calculating AIC differs slightly from that given in SC/54/RMP15. AIC is determined by calculating the likelihood (L) of a model given the data and then adjusting for the number of parameters in the model (k). A second-order variant of AIC (AIC_c) was used, which includes a correction to increase the penalty assessed to more complicated models (i.e. those that include more parameters) when the sample size (n) is low relative to the number of parameters:

$$AIC_c = -2\ln(L) + 2k \left(\frac{n}{n-k-1} \right)$$

Burnham and Anderson (1998) recommend the use of this sample size correction whenever n/k is less than 40, as is typical in studies of population structure.

To test the performance of AIC at accurately choosing among alternate models of population structure, we used the simulation model described by Taylor *et al.* (2000) was used to generate datasets for which the actual population structure was known. The simulation tracked the evolution of mitochondrial haplotypes in a set of populations. Because the model simulates mitochondrial evolution, only adult females were included in the simulations.

Datasets were generated comprised of one, two, three or four populations. In each dataset, the total effective size (N_{eT}) of all populations combined was 4,000 adult females. This is approximately one-third the estimated effective female abundance for North Pacific minke whales ($N_e \sim 12,000$). In the dataset consisting of a single population, there was no dispersal. In the datasets comprised of more than one population, all populations had the same effective abundance (totalling 4,000) and were arranged in a linear stepping-stone with dispersal occurring only between adjacent populations at the rate of 20 dispersers per generation (N_{eM}). The generation time in the model used to generate the simulated datasets was four years. Thus, this value of N_{eM} corresponds to the demographically trivial movement rate of five individuals per year. These four datasets allowed evaluation of the performance of AIC as a function of the number of populations actually present in a region, while holding the total effective abundance (N_{eT}) and the degree of differentiation between populations (determined by N_{eM}) constant.

Each simulation ran for 200,000 years. The complete haplotype profile (the sequence of each haplotype and its frequency in each population) was recorded every 500 years for the last 50,000 years of the simulation, resulting in 100 independent haplotype profiles for each dataset. For each haplotype profile, we drew 90 samples in each of four sampling locations for a total of 360 samples. For datasets comprised of one, two or four populations there were an equal number of sampling locations from each population. For the dataset comprised of three populations, there were two sampling locations in the central population and one from each of the end populations. For each dataset, population structure models consisting of 1, 2, 3 and 4 populations were examined. There were three possible two-population models and three possible three-population models, resulting in a total of eight models. The AIC associated with each of these models was calculated and the

model that resulted in the lowest AIC was accepted. This sampling and model selection procedure was repeated 10 times for each of the 100 haplotype profiles, and how often AIC would favour the correct model of population structure was noted. By repeating this procedure for all four datasets it was possible to determine the performance of AIC as a function of the number of populations actually represented in a sample.

The results show that the use of AIC in evaluating stock structure models is very likely to result in the definition of too few stocks (Table 1). The one-stock model is chosen with high probability regardless of the actual number of populations present in the sample. When the sample is actually derived from three or four populations the probability of choosing the stock structure model that accurately reflects the underlying population structure is zero.

Table 1

Probability of defining a given number of stocks as a function of the number of populations actually present in a sample. The probability of defining the correct number of stocks for each simulated dataset is in bold.

Actual number of populations	Number of stocks defined			
	1	2	3	4
1	1	0	0	0
2	0.798	0.202	0	0
3	0.918	0.082	0	0
4	0.47	0.53	0	0

These results show that AIC is not a good method to use in evaluating the plausibility of stock structure models as it is very likely to result in the under-estimation of the number of populations present in a region. AIC never resulted in the definition of more populations than were actually present. The analyses presented here were initiated as part of a general evaluation of AIC and differ in several important details from the North Pacific minke whale case. For instance, the sample size in SC/54/RMP15 is larger than the sample size used in this analysis, which could result in improved performance. On the other hand, the effective abundance of North Pacific minke whales is three times that of the simulated populations used in this study and their generation time is considerably longer. Consequently, the expected level of genetic differentiation between populations of North Pacific minke whales is lower. This will likely make them much more difficult to distinguish genetically and increase the probability of under-estimating the number of populations. Further performance analyses that are tuned specifically to the biology of minke whales and their abundance and sampling in the western North Pacific should be conducted before a final decision is made regarding the utility of AIC in evaluating the plausibility of the stock structure models that have been proposed for North Pacific minke whales. Nonetheless, it is unlikely that the ability of AIC to choose the correct stock structure model in the case of North Pacific minke whales will be substantially higher than that found in these analyses.

REFERENCES

- Akaike, H. 1974. A new look at the statistical model identification. *IEEE Transactions on Automatic Control* 19(6):716-23.
- Burnham, K.P. and Anderson, D.R. 1998. *Model Selection and Inference. A Practical Information-Theoretic Approach*. Springer-Verlag, New York. 353pp.
- Taylor, B.L., Chivers, S.J., Sexton, S. and Dizon, A.E. 2000. Evaluating dispersal estimates using mtDNA data: comparing analytical and simulation approaches. *Conserv. Biol.* 14:1287-97.

Appendix 7

A QUICK RESPONSE TO APPENDIX 6

M. Goto, N. Kanda and L.A. Pastene

In response to Appendix 6, additional AIC analysis was conducted using a larger number of haplotypes. Nine (and 'other'), 16 (and 'other') and 27 (and 'other') haplotypes were considered as independent variables. These haplotypes have the highest frequencies in sub-areas 7, 8 and 9. The maximum number of haplotypes used in SC/54/RMP15 was 4 (and 'other'). Results are presented in Table 1(a-d). Table 1a corresponds to tables 2-4 in SC/54/RMP15. In the case of Table 1b and 1c the most plausible model corresponds to model 1 (Baseline A). This result is the same as in SC/54/RMP15. In these two cases the second most plausible model is model 3. In the case of using 27 haplotypes and

'other' (Table 1d), the most plausible model is model 6 (Baseline B) followed by model 1 (Baseline A). The calculation for model 10 (corresponding to Baseline D) could not be made given the available time. In general, once the number of haplotypes considered increases beyond a certain level, the behaviour of the AIC statistics is to heavily favour hypotheses involving fewer stocks. The reason for this is that for a greater number of haplotypes considered, the penalty contribution to AIC from extra estimable parameters gets unreasonably large compared to the extra information being considered. Suspicions that this would be the case led the data groupings in SC/54/RMP15.

Table 1

AIC values for different models related to stock scenarios and for different combinations of haplotypes. Relative weight of these values is also shown.

Models	No. of group		Δ AIC	wt	Remark
(a): 4 haplotypes comprising 34.6% of total samples (from SC/54/RMP15)					
		4 individual Haps + other			
1 7W=7E=8W=9E(94+97)=9W(94+97) $\neq$ 9W(95+00+01)	2	1229.66	0	1	Baseline A
2 7W=7E=8W=8E $\neq$ 9W=9E	2	1234.30	4.64	0.0983	
3 7W=7E=8W=8E=9E $\neq$ 9W	2	1230.52	0.86	0.6505	
4 7W=7E=8W=8E=9E(94+97) $\neq$ 9W(94+97) $\neq$ 9W(95+00+01)	3	1235.18	5.52	0.0633	
5 7W=7E=8W=8E $\neq$ 9E(94+97) $\neq$ 9W(94+97) $\neq$ 9W(95+00+01)	4	1237.71	8.05	0.0179	
6 7W=7E=8W=8E=9W=9E	1	1238.91	9.25	0.0098	Baseline B
7 7W $\neq$ 7E=8W=8E $\neq$ 9W=9E	3	1239.33	9.67	0.0079	Baseline C
8 7W=7E=8W $\neq$ 8E $\neq$ 9W=9E	3	1236.47	6.81	0.0332	
9 7W $\neq$ 7E=8W=8E=9E $\neq$ 9W	3	1234.25	4.59	0.1008	
10 7W $\neq$ 9E(7E. 8W. 8E. 9W: gradient)	2	1237.99	8.33	0.0155	Baseline D
(b): 9 haplotypes comprising 57.2% of total samples					
		9 individual Haps + other			
1 7W=7E=8W=8E=9E(94+97)=9W(94+97) $\neq$ 9W(95+00+01)	2	2112.52	0	1	Baseline A
2 7W=7E=8W=8E $\neq$ 9W=9E	2	2117.73	5.21	0.0739	
3 7W=7E=8W=8E=9E $\neq$ 9W	2	2115.07	2.55	0.2794	
4 7W=7E=8W=8E=9E(94+97) $\neq$ 9W(94+97) $\neq$ 9W(95+00+01)	3	2121.47	8.95	0.0114	
5 7W=7E=8W=8E $\neq$ 9E(94+97) $\neq$ 9W(94+97) $\neq$ 9W(95+00+01)	4	2128.62	16.1	0.0003	
6 7W=7E=8W=8E=9W=9E	1	2123.16	10.64	0.0049	Baseline B
7 7W $\neq$ 7E=8W=8E $\neq$ 9W=9E	3	2127.06	14.54	0.0007	Baseline C
8 7W=7E=8W $\neq$ 8E $\neq$ 9W=9E	3	2126.19	13.67	0.001	
9 7W $\neq$ 7E=8W=8E=9E $\neq$ 9W	3	2124.21	11.69	0.0029	
10 7W $\neq$ 9E(7E. 8W. 8E. 9W: gradient)	2	-	-	-	Baseline D
(c): 16 haplotypes comprising 74.4% of total samples					
		16 individual Haps + other			
1 7W=7E=8W=8E=9E=(94+97)=9W(94+97) $\neq$ 9W(95+00+01)	2	2821.62	0	1	Baseline A
2 7W=7E=8W=8E $\neq$ 9W=9E	2	2833.11	11.49	0.0032	
3 7W=7E=8W=8E=9E $\neq$ 9W	2	2824.71	3.09	0.2133	
4 7W=7E=8W=8E=9E(94+97) $\neq$ 9W(94+97) $\neq$ 9W(95+00+01)	3	2840.08	18.46	1E-04	
5 7W=7E=8W=8E $\neq$ 9E(94+97) $\neq$ 9W(94+97) $\neq$ 9W(95+00+01)	4	2855.24	33.62	5E-08	
6 7W=7E=8W=8E=9W=9E	1	2829.13	7.51	0.0234	Baseline B
7 7W $\neq$ 7E=8W=8E $\neq$ 9W=9E	3	2846.26	24.64	4E-06	Baseline C
8 7W=7E=8W $\neq$ 8E $\neq$ 9W=9E	3	2850.52	28.9	5E-07	
9 7W $\neq$ 7E=8W=8E=9E $\neq$ 9W	3	2840.36	18.74	9E-05	
10 7W $\neq$ 9E(7E. 8W. 8E. 9W: gradient)	2	-	-	-	Baseline D
(d): 27 haplotypes comprising 86.6% of total samples					
		27 individual Haps + other			
1 7W=7E=8W=8E=9E(94+97)-9W(94=97) $\neq$ 9W(95+00+01)	2	3379.33	6.07	0.0481	Baseline A
2 7W=7E=8W=8E $\neq$ 9W=9E	2	3380.49	7.23	0.0269	
3 7W=7E=8W=8E=9E $\neq$ 9W	2	3380.1	6.84	0.0327	
4 7W=7E=8W=8E=9E(94+97) $\neq$ 9W(94+97+) $\neq$ 9W(95+00+01)	3	3412.01	38.75	4E-09	
5 7W=7E=8W=8E $\neq$ 9E(94+97) $\neq$ 9W(94+97+) $\neq$ 9W(95+00+01)	4	3431.08	57.82	3E-13	
6 7W=7E=8W=8E=9W=9E	1	3373.26	0	1	Baseline B
7 7W $\neq$ 7E=8W=8E $\neq$ 9W=9E	3	3402.05	28.79	6E-07	Baseline C
8 7W=7E=8W $\neq$ 8E $\neq$ 9W=9E	3	3407.25	33.99	4E-08	
9 7W $\neq$ 7E=8W=8E=9E $\neq$ 9W	3	3534.31	161.05	1E-35	
10 7W $\neq$ 9E(7E. 8W. 8E. 9W: gradient)	2	-	-	-	Baseline D

Appendix 8

EXAMINATION OF THE PROPORTION OF IMMATURE MINKE WHALES DISTRIBUTED IN SUB-AREAS 7, 8 AND 9

Ryoko Zenitani, Yoshihiro Fujise, Hiroshi Okamura and Shigeyuki Kawahara

At the Workshop on North Pacific minke whale *Implementation Simulation Trials* (SC/54/Rep1) the following results, derived from examination of the body length and maturity status compositions of minke whales collected during JARPN and JARPN II, were presented in Zenitani *et al.* (2002): (1) incomplete composition of sex and maturity status (mature male dominance with few mature females and few immature animals) of minke whales found in sub-areas 7, 8 and 9; (2) relatively more immature animals were found in the coastal sub-area 7 compared with the offshore sub-areas 8 and 9; (3) incomplete maturity status composition found in sub-areas 7, 8 and 9 provide no support for the existence of independent stocks in each sub-area. The Workshop recommended that a statistical analysis be conducted to test whether or not these immature proportions did differ.

The present study examines the proportion of immature animals collected during JARPN and JARPN II using AIC (Akaike Information Criterion).

Table 1 provides the number of samples collected during JARPN and JARPN II surveys from 1994-2001 by sex, maturity status and sub-area (sub-area 7 was divided into W and E at 147°E). The present study used data obtained from 558 individuals (64 immature males, 27 immature females, 436 mature males and 31 mature females) in sub-areas 7W, 7E, 8 and 9.

In order to examine the difference in proportion of immature males, immature females, mature males and mature females (maturity status composition) among sub-areas, AIC was used.

The log likelihood function is given by:

$$\ln L = \sum_{s,m} n_{s,m} \ln p_{s,m}$$

where:

m (maturity status): maturity status (immature male, immature female, mature male and mature female);

$n_{s,m}$: sample size of animals with maturity status m in sub-area s ;

$p_{s,m}$: expected proportion of animals with maturity status m in sub-area s ; and

the AIC is given by:

$$AIC = -2 \ln L + 2ks(km-1)$$

where:

L is the maximised likelihood function;

ks is the number of sub-areas; and

km is the number of maturity status ($km = 4$).

The following models were evaluated by the AIC.

- (1) sub-area 7W = 7E = 8 = 9 (namely, sub-area 7 = 8 = 9)
- (2) sub-area 7W ≠ 7E = 8 = 9
- (3) sub-area 7W = 7E ≠ 8 = 9 (sub-area 7 and 8 = 9)
- (4) sub-area 7W = 7E = 8 ≠ 9 (sub-area 7 = 8 and 9)
- (5) sub-area 7W ≠ 7E = 8 ≠ 9
- (6) sub-area 7W ≠ 7E ≠ 8 = 9
- (7) sub-area 7W = 7E ≠ 8 ≠ 9 (sub-area 7, 8, 9)
- (8) sub-area 7W ≠ 7E ≠ 8 ≠ 9

Table 2 provides the values of AIC for the above models. The smallest AIC value was obtained for model (2) (AIC = 817.11). The AIC value is different from other models to the significant degree. These results suggested that maturity status composition in sub-area 7W differs from that in sub-areas 7E, 8 and 9.

Table 2
Results of AIC.

	Models	AIC
(2)	7W ≠ 7E = 8 = 9	817.11
(5)	7W ≠ 7E ≠ 8 ≠ 9	820.07
(6)	7W ≠ 7E ≠ 8 = 9	820.16
(8)	7W ≠ 7E ≠ 8 ≠ 9	822.18
(3)	7W = 7E ≠ 8 = 9	827.15
(7)	7W = 7E ≠ 8 ≠ 9	829.17
(4)	7W = 7E = 8 ≠ 9	837.98
(1)	7W = 7E = 8 = 9	841.06

The proportions of immature males, immature females, mature males and mature females were calculated for sub-area 7W and for sub-area 7E, 8 and 9 combined (Table 3). In sub-area 7W, the proportion of mature males is the highest (0.655) followed by the proportion of immature males (0.224). Proportions of immature and mature females are low.

The mature male proportion in sub-area 7E, 8 and 9 combined is the highest (0.839). Proportions of immature animals and mature females are low. Results of AIC suggest

Table 1
Number of samples by sex, maturity status and sub-area collected during JARPN and JARPN II from 1994 - 2001.

	Sub-area 7W		Sub-area 7E		Sub-area 8		Sub-area 9		Total	
Maturity status	n	Proportion	n	Proportion	n	Proportion	n	Proportion	n	Proportion
Immature male	39	(0.224)	1	(0.026)	8	(0.071)	16	(0.069)	64	(0.115)
Immature female	10	(0.057)	3	(0.077)	2	(0.018)	12	(0.052)	27	(0.049)
Mature male	114	(0.655)	34	(0.872)	98	(0.875)	19	(0.815)	438	(0.786)
Mature female	11	(0.063)	1	(0.026)	4	(0.036)	15	(0.064)	31	(0.056)
Total	174		39		112		233		558	

Table 3
Proportion of maturity status, by sex in sub-area 7W and sub-area 7E=8=9.

	7W			7E=8=9		
	<i>n</i>	Proportion	SE	<i>n</i>	Proportion	SE
Immature male	39	0.224	0.032	25	0.065	0.013
Immature female	10	0.057	0.018	17	0.044	0.010
Mature male	114	0.655	0.036	322	0.839	0.019
Mature female	11	0.063	0.018	20	0.052	0.011
Total	174			384		

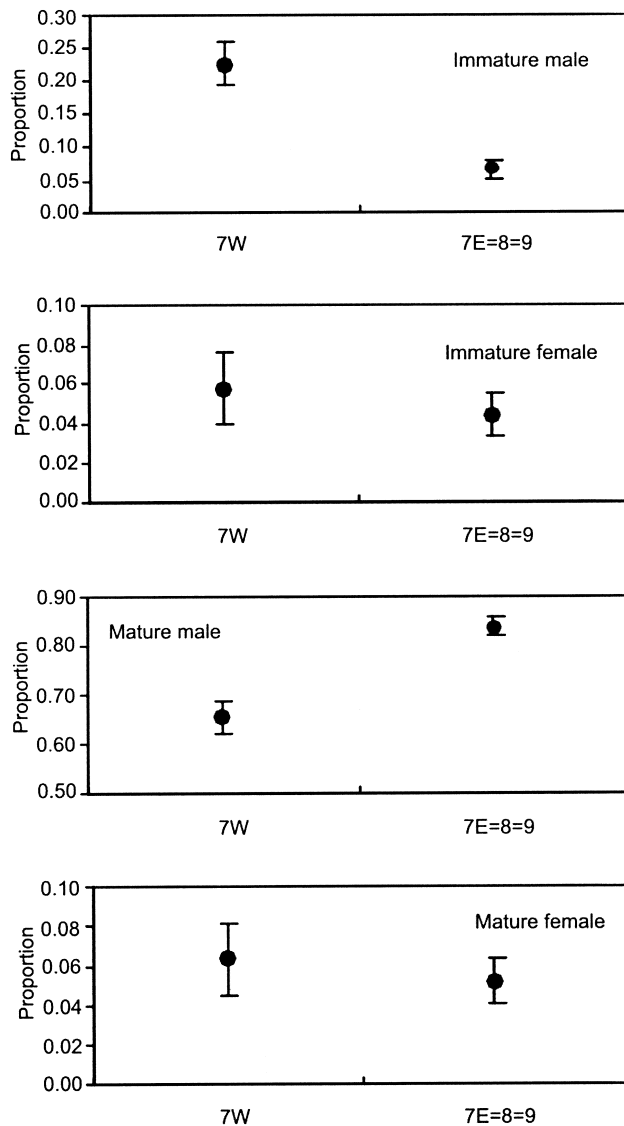


Fig. 1. Proportion of immature and mature animals, by sex in sub-area 7W and sub-area 7E = 8 = 9. Standard error is shown.

that maturity composition is similar in sub-areas 7E, 8 and 9 and different from sub-area 7W. These differences are shown graphically in Figs 1 and 2. Relatively more immature

animals were found in sub-area 7W, which is consistent with the past catches by the small-type whaling catcher boats that operated in the inshore waters of sub-area 7W (Zenitani *et al.*, 2002).

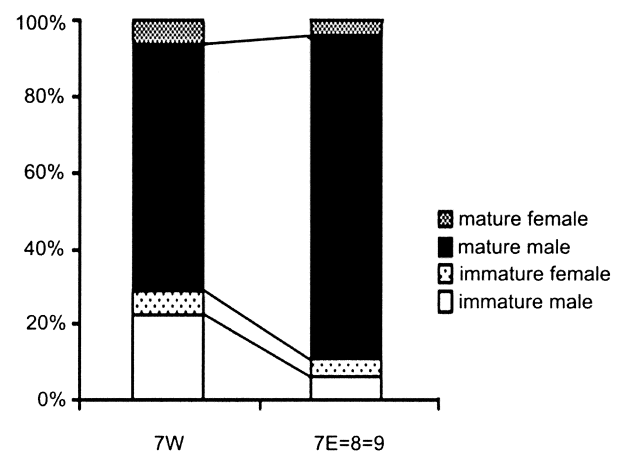


Fig. 2. Maturity status composition in sub-areas 7W and 7E = 8 = 9.

Therefore, it is reasonable to conclude that immature animals are distributed in coastal sub-area 7W and mature males are distributed in the offshore area from sub-area 7E to sub-area 9. These results are consistent with the occurrence of a single stock in sub-area 7, 8 and 9, which segregate by sex and reproductive status.

REFERENCE

- Zenitani, R., Fujise, Y., Kawahara, S. and Kato, H. 2002. Examination of the distribution and reproductive status of western North Pacific minke whales collected in sub-areas 7, 8 and 9 during JARPN and JARPN II from 1994 to 2001. Paper SC/J02/NP12 presented to the Scientific Committee Workshop on North Pacific common minke (*Balaenoptera acutorostrata*) Implementation Simulation Trials held in Seattle, USA, 19-22 January 2002 (unpublished). [Paper available from the Office of this Journal].

Appendix 9

A PLAUSIBLE RANGE OF INCIDENTAL TAKES FOR RMP IMPLEMENTATION SIMULATION TRIALS OF NORTH PACIFIC MINKE WHALES

C.S. Baker, M. Dalebout, F. Cipriano and N. Funahashi

Specifications for the RMP *ISTs* are intended to take into account a range of plausible hypotheses or scenarios for the stocks in question. One of the parameters included in the specification is the level of incidental takes or fisheries related bycatch. There has been considerable debate about the plausible range of values for this parameter in the North Pacific minke whale *ISTs* and the specified values have changed several times in recent years.

At the 1998 meeting, specifications considered two levels of catch for Korea and two options for Japan (IWC, 1999, p.92):

Incidental catch off Korea

Option Ki in which incidental catches were assumed to be 0 in 1988, after which they scaled up linearly until 1995, then set to reported catch in 1996 (129) and 1997 (78). After this they are assumed to be density-dependent and scaled using a value of 78 from 1998.

Option Kii in which incidental catch is assumed to be 150 from 1988 and is not density-dependent.

Incidental catch off Japan

Option Ji in which only reported incidental catches are used, averaging 7.6/year for 1979 to 1997. The 1996-97 average of 27/year to be used for future years.

Option Jii in which an incidental catch of 93 is assumed (based on Tobayama *et al.*, 1992).

At the 1999 meeting, specifications were modified as follows (IWC, 2000, pp.110-111):

Incidental catch off Korea

Option K in which future catches are as above and scaled using a value of 61 from 1997-98.

Incidental catch off Japan

Option Ji as above, except future catches are assumed to be density-dependent and scaled using a value of 25 from 1996-98.

Option Jii in which an incidental catch of 75 is assumed from 1900 to present and assumed to be density-dependent in the future.

At the 2001 meeting, specifications remained unchanged despite direct and indirect evidence that these values were implausibly low (Baker, 2002). Following a change in regulations by the Government of Japan announced at the 2001 meeting, reported bycatch in that country increased substantially. As a result, the intersessional Working Group of the RMP, at its meeting in early 2002, agreed to consider an additional set of trials with bycatch at levels of 50 and 100 for Japan.

At the 2002 meeting, new information indicated high levels of bycatch in both countries.

SC/54/ProgRep Korea reported the entanglement of 148 minke whales and the recovery of 12 from drift or stranding for a total of 160 possible incidental takes. The majority of this bycatch was from sub-area 6 and a smaller proportion from sub-area 5. Korean annual bycatch of minke whales reported under new regulations began in 1996 with a report

of 129 animals, 78 in 1997, 45 in 1998, 56 in 1999 and 77 in 2000. Across the six years of records (including 2001), bycatch has averaged 91 whales/year and seems to be increasing.

Following the changes in regulations in Japan, a total of 54 minke whales were reported as bycatch in the second half of 2001 (SC/54/Rep1) for a total of 79 entanglements and 10 strandings in 2001 as reported in SC/54/ProgRep Japan. Most of this bycatch was from sub-areas 6, 2 and 7. It seems reasonable to extrapolate from the second half of 2001 to a total annual bycatch of approximately 100. This is close to the values suggested previously by Tobayama *et al.* (1992) and Baker *et al.* (2000).

Genetic surveys of markets confirmed high levels of J-stock products in both countries and the proportion of J-stock products seems to be increasing in Japan (SC/54/RMP8; SC/54/BC1).

The geographic distribution of J-stock products is widespread around Japan and J-stock products are found in a high proportion in prefectures bordering sub-areas 2 and 7 (SC/54/BC3; Dalebout *et al.*, 2002). If these products originate primarily from local bycatch, as required under previous government guidelines, this indicates a greater degree of mixing of these stock in coastal waters of these sub-areas than previously considered.

From this new information, we suggest the following plausible range of bycatch for future *ISTs*:

For Korea, a minimum of 91 (based on the six-year average) and an upper plausible range of 160 to account for the possibility of continued catches at the 2001 level.

For Japan, a minimum of 100 and an upper plausible range of 150 to account for possible continued under-reporting or further increases in reported bycatch under new regulations allowing sale of bycatch.

REFERENCES

- Baker, C.S. 2002. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 13. Uncertainty and (im)plausibility of incidental takes for RMP *Implementation Simulation Trials* for North Pacific minke whales. *J. Cetacean Res. Manage. (Suppl.)* 4:138-9.
- Baker, C.S., Lento, G.M., Cipriano, F. and Palumbi, S.R. 2000. Predicted decline of protected whales based on molecular genetic monitoring of Japanese and Korean markets. *Proc. R. Soc. Lond. Ser. B* 267:1191-9.
- Dalebout, M.L., Lento, G.M., Cipriano, F., Funahashi, N. and Baker, C.S. 2002. How many protected minke whales are sold in Japan and Korea? A census by microsatellite DNA profiling. *Animal Conservation* 5:143-152.
- International Whaling Commission. 1999. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 1:61-116.
- International Whaling Commission. 2000. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 5. Specifications of the North Pacific minke whaling trials. *J. Cetacean Res. Manage. (Suppl.)* 2:105-17.
- Tobayama, T., Yanagisawa, F. and Kasuya, T. 1992. Incidental take of minke whales in Japanese trap nets. *Rep. int. Whal. Commn* 42:433-6.

Appendix 10

SPECIFICATIONS OF THE NORTH PACIFIC MINKE WHALING TRIALS

These specifications were revised following the Scientific Committee meeting, in consultation with the Steering Group

A. Basic concepts and stock structure

The objective of these 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 and age) 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 18 sub-areas (see Fig. 1). Future surveys are unlikely to cover sub-areas 1, 2, 3, 4, 5, 6, 9N, 10 and 13 (see Table 1) so for these trials, these sub-areas are taken to be *Residual Areas* (although allowance is made for future incidental catches from some of these sub-areas – see section D). The term ‘stock’ refers to a group of whales from the same breeding ground. The model assumes there is a ‘J’ stock (‘home’ area – Sea of Japan and perhaps also the Yellow Sea and East China Sea) and considers three classes of hypothesis in regard to the stock(s) whose ‘home’ area is to the east of Japan:

- (1) those based on the results of hypothesis testing, which primarily imply the possibility of some ‘W’ stock animals in sub-area 9¹ but no additional stock structure (‘J’ stock apart) to the east of Japan (henceforth referred to as ‘3 stocks with 2 in sub-area 9’);
- (2) those based on the results of the boundary rank method, which suggest that there are three stocks (‘O_W’, ‘O_E’ and ‘W’) in addition to the ‘J’ stock to the east of Japan (henceforth referred to as ‘4 stocks’); and
- (3) those based on two stocks to the east of Japan (excluding the ‘J’ stock), which allow mixing of these stocks across most of sub-areas 7-9 during April-September (henceforth referred to as ‘3 stocks with mixing gradient’).

¹ Some of the sub-areas identified in earlier versions of these trials have since been sub-divided. For ease of presentation, the original sub-areas (e.g. 9) have been retained in some of the specifications and refer to all of their sub-components (e.g. 9W, 9E and 9N in the case of sub-area 9).

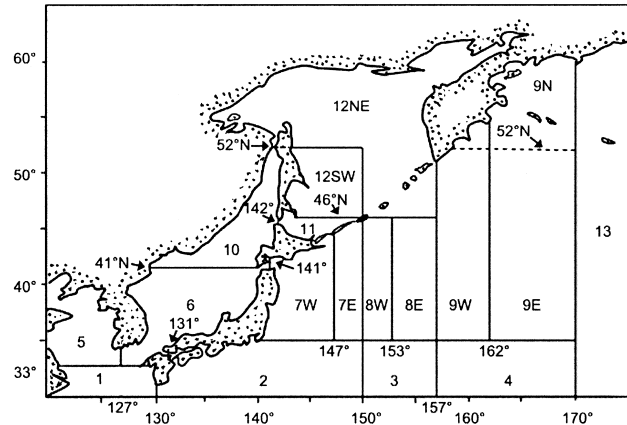


Fig. 1. The 18 sub-areas used for the *Implementation Simulation Trials* for North Pacific minke whales. (Note: sub-area 9N is only used in Baseline D).

Four baseline trials are considered to account for patterns observed in the results from the genetic analyses. The four ‘baseline’ trials and their key features are:

Baseline-A: ‘W’ stock in sub-area 9 each year with 60% probability. In a year when the ‘W’ stock is in sub-area 9, 50% of the animals in sub-area 9W are from the ‘W’ stock (see section F(e)). The fraction of 1+ non-‘J’ stock animals in sub-area 12 in August-September in a pristine state that are from the ‘W’ stock is determined from the relative abundance of such animals in sub-areas 7, 8, 9W and 9E at that time (see section F(d)). As a sensitivity test to allow for the concern that sample sizes may have been too small for genetic tests to distinguish further stock structure, a trial is to be conducted for this scenario which includes some ‘W’ stock animals in sub-area 8 (sensitivity trial 14: in years when the ‘W’ stock is in sub-area 9, 25% of the animals in sub-area 8 are from the ‘W’ stock – see section F(i)).

Baseline-B: A 2-stock trial (no ‘W’ stock) reflects a limiting case of the baseline A trial with no ‘W’ stock whales present in sub-areas 8, 9 or 12.

Baseline-C: 4 stock model of which three non-‘J’ stocks (‘O_W’, ‘O_E’ and ‘W’) occur to the east of Japan. The divisions between the ‘O_W’ and ‘O_E’ and ‘W’ stocks occur at

Table 1

Plan for future sighting surveys of minke whales in the western North Pacific in August/September.

Season	Sub-area								
	7W	7E	8W	8E	9W	9E	11	12SW	12NE
2000							(Yes) ¹	Yes	Yes
2001							Yes	Yes	Yes
2002					Yes	Yes			
2003	Yes	Yes	Yes	Yes					
2004							Yes	Yes	Yes
2005					Yes	Yes			
2006	Yes	Yes	Yes	Yes					
continuing in this pattern									

¹ Abundance estimate already available. See Table 6a.

147°E and 157°E respectively. These boundaries are ‘hard’ (no mixing across them). The fraction of 1+ non-‘J’ stock animals in sub-area 12 in August-September in a pristine state that are from the ‘W’ stock is determined from the relative abundance of such animals in sub-areas 7, 8, 9W and 9E at that time (see section F(d)). Variants of this hypothesis first place the ‘O_W’/‘O_E’ boundary at 153°E (see sensitivity trial 17), then allow ‘O_W’ and ‘O_E’ mixing between 147°E and 153°E (sensitivity trial 18), further allow intrusion of the ‘O_E’ stock into sub-area 9E (sensitivity trial 19), and finally allow for some mixing of the ‘O_W’ and ‘O_E’ stocks throughout sub-areas 7 and 8 (sensitivity trial 20).

Baseline-D: 2 stocks (‘O’ and ‘W’) to the east of Japan that mix across the area 147°E to 162°E. The highest densities of ‘O’ stock animals occur in sub-area 7W and decline to the east, while the highest densities of ‘W’ stock animals occur in sub-area 9E and decline to the west. This baseline assumes an additional sub-area, 9N, (see Fig 1) which is defined by a line of latitude at 52°N, this being the northernmost point of any strata used for survey abundance estimates in sub-areas 9W and 9E. The relative proportion of the ‘W’ and ‘O’ stock animals in sub-areas 12SW+12NE and 9N is computed using the same model which provides the relative proportion of ‘W’ and ‘O’ animals in sub-areas 7W, 7E, 8W, 8E, 9W and 9E.

B. Basic dynamics

Further details of the underlying age-structured model and its parameters can be found in IWC (1991, p.112), except that the model has been extended to take sex-structure and dispersal into account. The 1+ population of a stock is governed by Equations B.1(a) for the ‘J’ stock for which there is no dispersal (permanent movement between stocks) and by Equations B.1(b) for the ‘O’ and ‘W’ stocks (‘O_W’ and ‘O_E’ stocks for the ‘4 stocks’ case).

$$\begin{aligned} R_{t+1,a+1}^{m/f,s} &= \tilde{R}_{t,a}^{m/f,s} + \tilde{U}_{t,a}^{m/f,s} \delta_{a+1} & 0 \leq a \leq x-2 \\ R_{t+1,x}^{m/f,s} &= \tilde{R}_{t,x}^{m/f,s} + \tilde{R}_{t,x-1}^{m/f,s} & (B.1a) \\ U_{t+1,a+1}^{m/f,s} &= \tilde{U}_{t,a}^{m/f,s} (1 - \delta_{a+1}) & 0 \leq a \leq x-2 \end{aligned}$$

$$\begin{aligned} R_{t+1,a+1}^{m/f,s} &= (1 - D^{s,s'}) \tilde{R}_{t,a}^{m/f,s} + D^{s',s} \tilde{R}_{t,a}^{m/f,s'} \\ &+ \left((1 - D^{s,s'}) \tilde{U}_{t,a}^{m/f,s} + D^{s',s} \tilde{U}_{t,a}^{m/f,s'} \right) \delta_{a+1} & 0 \leq a \leq x-2 \\ R_{t+1,x}^{m/f,s} &= (1 - D^{s,s'}) (\tilde{R}_{t,x}^{m/f,s} + \tilde{R}_{t,x-1}^{m/f,s}) \\ &+ D^{s',s} (\tilde{R}_{t,x}^{m/f,s'} + \tilde{R}_{t,x-1}^{m/f,s'}) & (B.1b) \\ U_{t+1,a+1}^{m/f,s} &= \left((1 - D^{s,s'}) \tilde{U}_{t,a}^{m/f,s} + D^{s',s} \tilde{U}_{t,a}^{m/f,s'} \right) (1 - \delta_{a+1}) \\ & & 0 \leq a \leq x-2 \end{aligned}$$

$R_{t,a}^{m/f,s}$ is the number of recruited males/females of age a in stock s at the start of year t ;

$U_{t,a}^{m/f,s}$ is the number of unrecruited males/females of age a in stock s at the start of year t ;

δ_a is the fraction of unrecruited animals of age $a-1$ which recruit at age a (assumed to be independent of stock and sex);

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);

$\tilde{R}_{t,a}^{m/f,s}$ is the number of recruited males/females of age a in stock s at the start of year t that survive to the end of the year;

$$\tilde{R}_{t,a}^{m/f,s} = \left(R_{t,a}^{m/f,s} - C_{t,a}^{m/f,s} \right) S_a \quad (B.1c)$$

$\tilde{U}_{t,a}^{m/f,s}$ is the number of unrecruited males/females of age a in stock s at the start of year t that survive to the end of the year;

$$\tilde{U}_{t,a}^{m/f,s} = U_{t,a}^{m/f,s} S_a \quad (B.1d)$$

S_a is the instantaneous survival rate for animals of age a , and is equal to $\exp(-M_a)$ where M_a is the instantaneous natural mortality rate for animals of age a (assumed to be independent of stock, sex and whether or not an animal is recruited);

$C_{t,a}^{m/f,s}$ is the catch of males/females of age a from stock s during year t ; and

$D^{s,s'}$ is the dispersal rate (i.e. the probability of an animal moving permanently) from stock s to s' .

Note that year $t=0$, for which catch limits might first be set, corresponds to 2000.

For computational ease, the numbers-at-age and by sex are updated at the end of each year only, even though catching is assumed to occur from April to September. This simplification is unlikely to affect the results substantially for two reasons: (1) catches are at most only a few percent of the size of the recruited stock; 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.

$$\begin{aligned} U_{t,0}^{m/f,s} &= 0.5 (1 - \alpha_0) B^s N_t^{f,s} \{ 1 + A^s (1 - (N_t^{f,s} / K^{f,s})^{z^s}) \} \\ R_{t,0}^{m/f,s} &= 0.5 \alpha_0 B^s N_t^{f,s} \{ 1 + A^s (1 - (N_t^{f,s} / K^{f,s})^{z^s}) \} & (C.1) \end{aligned}$$

B^s is the average number of live births (both sexes) per year for mature females in stock s in the pristine population;

A^s is the resilience parameter for stock s ;

z^s is the degree of compensation for stock s ;

$N_t^{f,s}$ is the number of mature females in stock s at the start of year t ;

$$N_t^{f,s} = \sum_{a=1}^x \beta_a (R_{t,a}^{f,s} + U_{t,a}^{f,s}) \quad (C.2)$$

α_0 is the proportion of animals of age 0 which are recruited (assumed to be zero for this case);

β_a is the proportion of females of age a which are mature (assumed to be independent of stock, year and whether or not an animal is recruited); and

$K^{f,s}$ is the number of mature females in stock s in the pristine (pre-exploitation, denoted by $t = -\infty$) population:

$$K^{f,s} = \sum_{a=1}^x \beta_a (R_{-\infty,a}^{f,s} + U_{-\infty,a}^{f,s}) \quad (C.3)$$

The values for the parameters A^s and z^s for each stock are calculated from pre-specified values for $MSYL^s$ and $MSYR^s$ as detailed in IWC (1991, p.112). Their calculation ignores the impact of dispersal and assumes harvesting equal proportions of males and females.

D. Catches

The operating model considers two sources for non-natural mortality (incidental catches and commercial catches). In future ($t \geq 2000$), the former are pre-specified, while the latter are set by the RMP. In cases in which the catch limit set by the RMP is less than the (pre-specified) 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, the level of the commercial removals is taken to be the difference between the RMP catch limit and the incidental catch. In trials when future incidental catches are misreported (sensitivity trial 11 — see Section G) the level of the commercial removals is set by subtracting the *reported* incidental catch from the catch limit set by the RMP.

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.:

$$C_{t,a}^{m/f,s} = \sum_k \sum_q C_{t,a}^{m/f,s,k,q} \quad (D.1)$$

$$C_{t,a}^{m/f,s,k,q} = C_t^{m/f,k,q} \{ V_{t,a}^{m/f,s,k,q} R_{t,a}^{m/f,s} / \sum_j \sum_{a'=1}^x V_{t,a'}^{m/f,j,k,q} R_{t,a'}^{m/f,j} \}$$

$C_t^{m/f,s,k,q}$ is the catch of males/females of age a from stock s in sub-area k during month q of year t ; and
 $C_t^{m/f,k,q}$ is the catch of males/females from sub-area k during month q of year t .

Each entry in the catch mixing matrix, $V_{t,a}^{m/f,s,k,q}$, is the fraction of males/females of age a from stock s 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 1 gives the catch mixing matrices considered. The rationale for the values used is given in IWC (1997a, p.225-6) and SC/54/Rep1. The catch mixing matrices give the relative fraction of an age-class in each of the sub-areas during the months April-September. Once the values of the mixing rate parameters $\gamma_1 - \gamma_{24}$ and $\eta_1 - \eta_4$ are specified (these are estimated separately for each trial 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 and η parameters are selected to mimic available data (see Section F). In many trials, the catch mixing matrix for each of the 100 simulations and for each

of the years of the associated pre-management and 100-year management periods is selected at random from two possibilities (e.g. matrices A and B for the 'J' stock). In this case, a random number is generated for each year from $U[0,1]$; if this number is larger than a given proportion (0.5 unless otherwise specified), then the catch mixing matrix used for stock 'J' is matrix A, otherwise it is matrix B.

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 calculated by interpolating linearly between those for ages 4 and 10.

The model considers a future six-month whaling season (April-September). In order to account for historical catches outside these months, all catches in January-March are added to those in April and the catches after September are assumed to have been taken in September. The historic commercial and scientific catches by sex, sub-area, month and year are given in Adjunct 2.

The trials are conducted assuming that the sub-areas for which future catch limits might be set are:

7W, 7E, 8W, 8E, 9W, 9E (April)²
 7W, 7E, 8W, 8E, 9W, 9E, 11, 12SW, 12NE
 (May-June + Aug-Sept)
 7W, 7E, 8W, 8E, 9W, 9E, 12SW, 12NE (July)

For sensitivity test 24, sub-area 11 is closed in all months, together with sub-area 12SW in June to investigate whether more stringent spatial closures to further reduce catches of 'J' stock whales would provide any substantial additional benefit. The future ($t \geq 2000$) commercial catches by sex, sub-area, month and year are calculated using the equation:

$$C_t^{m/f,k,q} = C_t^k Q^{m/f,k,q} \quad (D.2)$$

$Q^{m/f,k,q}$ is the fraction of the commercial catch in sub-area k which is taken during month q and are males/females, the values of which are given in Table 4; and

C_t^k is the commercial catch limit for sub-area k and year t ($t \geq 2000$). Note that C_t^k is equal to the catch limit set by the RMP less the 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 (i.e. Q is zero in April for sub-areas 11 and 12). The non-zero entries in the Q matrix (see Table 2) 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, 9 and 12), the entries in the Q matrix are set using the entire historic commercial and scientific catch in these sub-areas. Sensitivity to these assumptions may be investigated in future trials. For the trials based on *Small Areas* that are combinations of sub-area 11 and other

² Note: the Q matrix is zero for sub-areas 7E, 8 and 9 in April so no catches will be allocated to these sub-areas in April. The elements in Q for these sub-areas are based on a very small number of catches. In practice, the split by month will be dictated by operational factors as well as by the numbers of whales available (which the historic catches are intended to represent).

Table 2

Q matrix: the fraction of the 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.

Sub-area	Males							Females						
	Jan-Apr	May	Jun	Jul	Aug	Sept-Dec	Sample size	Jan-Apr	May	Jun	Jul	Aug	Sept-Dec	Sample size
7W	0.127	0.118	0.097	0.108	0.083	0.127	1,760	0.121	0.088	0.043	0.042	0.019	0.028	909
7E	0.0	0.472	0.038	0.0	0.0	0.264	41	0.0	0.075	0.0	0.0	0.0	0.151	12
8W	0.0	0.161	0.429	0.0	0.018	0.143	42	0.0	0.036	0.036	0.054	0.036	0.089	14
8E	0.0	0.0	0.118	0.603	0.074	0.118	62	0.0	0.0	0.029	0.015	0.0	0.044	6
9W	0.0	0.016	0.216	0.512	0.080	0.008	104	0.0	0.016	0.048	0.080	0.024	0.0	21
9E	0.0	0.170	0.226	0.038	0.302	0.047	83	0.0	0.047	0.028	0.009	0.132	0.0	23
11	-	0.124	0.108	-	0.034	0.068	186	-	0.351	0.245	-	0.022	0.047	369
12SW	-	0.0	0.015	0.118	0.118	0.0	17	-	0.0	0.074	0.235	0.368	0.074	51
12NE	-	0.0	0.008	0.301	0.073	0.098	59	-	0.024	0.041	0.260	0.122	0.073	64

sub-areas, the entire catch is assumed to be taken from sub-area 11 (except for management variant (6) – see section H) as this should reflect the highest risk to the J stock. For trials based on *Small Areas* that are combinations of sub-areas including sub-area 7W but not sub-area 11, the entire catch is assumed to be taken from sub-area 7W.

In order to comply with RMP specifications regarding the sex ratio in catches (IWC, 1999, p.251-9) which state that if the proportion, P_f of females in total catch taken from a *Small Area* in the five years prior to the catch limit calculation exceeds 50%, the catch limits shall be adjusted downwards by the ratio $0.5/P_f$. On this event occurring in the trials the quota is reduced.

Incidental catches of minke whales are known to occur off the Republic of Korea and Japan but the level of such catches is uncertain (IWC, 2000, p.84). Two options are considered for both the incidental catch off Korea and off Japan. The incidental catches are apportioned to stock and age class in the same way as for the commercial catches (i.e. using Equation D.1).

Incidental catch off the Republic of Korea

OPTION (Ki)

The incidental catch off the Republic of Korea in sub-area 6 is assumed to be zero until 1988 after which it increases linearly to 78 in 1995. (The rationale for this linear increase is a comment by Kim that minke whales returned to inshore areas only gradually after the end of commercial whaling in 1986). It is 129 in 1996, 78 in 1997, 45 in 1998, 56 in 1999, 77 in 2000 and 148 in 2001 (this last figure excludes 12 drifting and stranded animals). The catch in each year is apportioned to month according to the average of the proportions of the annual incidental catch by month taken in 1996-99 (Table 3(a)) and is apportioned by sex according to the incidental catches in 1998 and 1999 (the only years for which the sexes of the incidental catches are known). These values are also given in Table 3(a). In future years the incidental catch in year t is set at $89 P_t^{k=6} / P_{1997/8}^{k=6}$ where 89 is the mean catch in 1996-2001 (excluding drifting and stranded animals) and $P_t^{k=6}$ is the mean 1+ population size (over the period April-September) in year t in sub-area 6. The catch is apportioned by month and sex as for the historic catch above. The Ki option is used in conjunction with the Ji option.

OPTION (Kii)

The historic catch is the same as for option Ki. In future years the incidental catch in year t is set at $P_t^{k=6} / P_{1997/8}^{k=6}$ where 148 is the maximum of the actual annual reported bycatch

Table 3(a)

Table of incidental catches by the Republic of Korea by month, provided by Kim. (The catches for Jan-Apr and for Sept-Dec are combined for input to the trials).

Month	Monthly catch in 1996	Monthly catch in 1997	Monthly catch in 1998	Monthly catch in 1999
			M : F	M : F
Jan.	7	18	1 : 5	0 : 2
Feb.	2	5	0 : 4	1 : 4
Mar.	2	1	0 : 5	1 : 2
Apr.	8	11	1 : 5	2 : 3
May	11	11	2 : 2	0 : 2
Jun.	7	7	3 : 5	0 : 2
Jul.	8	3	1 : 0	1 : 1
Aug.	6	3	0 : 1	3 : 6
Sept.	7	6	0 : 2	2 : 3
Oct.	26	6	0 : 2	3 : 7
Nov.	11	4	1 : 2	1 : 1
Dec.	34	3	0 : 3	3 : 6
Total	129	78	9 : 36	17 : 39

1996-2001 The catch is apportioned by month and sex as for Option Ki. The Kii option is used in conjunction with the Jii option.

Sensitivity trial 12 sets the level of Korean incidental catch in the future to a constant (= 89), independent of population size.

Incidental catch off Japan:

OPTION (Ji)

The incidental catches off Japan between 1955-1999 are given in Table 3(b) where the catches from 1979-99 are taken to be the reported catches as listed in Japanese progress reports. Future catches are taken in proportion to the population size in the sub-area and are given by $C_t^k = \tilde{C}^k P_t^k / \tilde{P}^k$ where $\tilde{P}^k$ is the mean 1+ population size (over the period April-September) in sub-area k from 1996-98 and $\tilde{C}^k$ is the reference incidental catch as given in Table 3(c). The total reference catch is 25 whales and it is allocated to sub-areas in the ratio of the 1996-98 catch. The sex and timing within the year of both historic and future catches are selected according to the historic ratio of catches off Japan within the relevant sub-area since 1979, or if there was none then the entire historic catch.

The RMP is given the actual historic and future catch series, except in sensitivity trial 11 (see Section G) when the reported catch is over-reported at a level equal to 4 times (= 100/25) the actual values.

Table 3(b)

Table of incidental catches by Japan Option (Ji).

Year/Sub-area	1	2	6	7W	10	11	Total
1955-1978 ¹	0	0.1	2.2	1.1	0.2	0.2	3.8
1979	0	0	0	0	0	0	0
1980	0	0	1	2	0	0	3
1981	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0
1983 ²	0	0	5	1.7	0.7	0.7	8
1984	0	0	0	2	1	1	4
1985	0	0	2	0	0	0	2
1986	0	1	9	3	0	0	13
1987	0	0	3	1	0	0	4
1988 ³	0	1.6	4.8	1.6	0	0	8
1989 ⁴	0	2.7	4	1.3	0	0	8
1990	0	1	4	15	0	0	20
1991	0	2	2	1	0	0	5
1992	0	1	7	0	0	0	8
1993	0	4	9	1	0	0	14
1994	0	9	6	1	0	0	16
1995	0	8	12	0	0	0	20
1996 ²	1	11	13	1.3	0.3	0.3	27
1997	0	18	8	1	0	0	27
1998	0	9	15	0	0	0	24
1999	1	4	13	1	0	0	19
Total (1979-1999)	2	72.3	117.8	33.9	2	2	230

¹Catches are assumed to begin in 1955 when fishery nets were substantially improved. Catches are taken to equal the mean values from 1979 to 1987 (years of commercial whaling). ²Catches off Hokkaido are allocated evenly to sub-areas 7W, 10 and 11. ³Catches in 1988 are allocated to sub-areas using information from 1987 and 1989. ⁴Two individuals in 1989 whose catch position is unknown, were allocated in proportion to the composition of the 6 of known position.

Table 3(c)

Table of reference catches $\tilde{C}^k$ used in setting future incidental catches by Japan, Option(Ji). The division of numbers by sub-area are taken from the incidental catch in years 1996-98 (Table 3(b)).

Year/Sub-area	1	2	6	7W	10	11	Total
Reference catch $\tilde{C}^k$	0.3	12.2	11.6	0.7	0.1	0.1	25

In sensitivity trial 13 the total reference catch is changed to 50 whales, to test the extent to which interpolation can be achieved reliably (the RMP is given the actual catch values for this trial).

OPTION (Jii)

An incidental catch of 100 animals (Annex D, item 3.1) is assumed to have been taken in each year from 1900 to the present (Table 3(d)). Future catches are taken in proportion to the population size in the sub-area and are given by $C_t^k = \tilde{C}^k P_t^k / \tilde{P}^k$ where $\tilde{P}^k$ is the mean 1+ population size (over the period April-September) in sub-area k from 1979-99 and $\tilde{C}^k$ is the reference incidental catch as given in Table 3(d). Catches (both historic and future) are allocated among sub-areas in the same ratio as the 1979-99 catches listed in Table 3(b), and the sex and timing within years as for option Ji. For this option, the RMP is not given the true historic catch series, but is rather given the smaller Japanese catches listed for Option Ji. The RMP is given the actual future catches, except in sensitivity trial 11 when the future reported catch is under-reported at a level equal to 1/4 times (= 25/100) the actual values. In sensitivity trial 13, both the annual historic catch and the total reference catch are changed to 150 whales, to test the extent to which extrapolation can be achieved reliably (the RMP is given the actual catch values for this trial).

Table 3(d)

Table of historic incidental catches and the reference catches $\tilde{C}^k$ used in setting future incidental catches by Japan, Option(Jii). The division of numbers by sub-area are taken from the reported incidental catch in years 1979-99 (Table 3(b)).

Year/Sub-area	1	2	6	7W	10	11	Total
1900 – present	0.9	31.4	51.2	14.7	0.9	0.9	100
Reference catch $\tilde{C}^k$	0.9	31.4	51.2	14.7	0.9	0.9	100

Some of the incidental catch by Japan is taken from sub-areas for which a catch limit is set. For all trials the total catch (commercial + incidental) from the sub-areas is taken as equal to the catch limit set by the RMP if the RMP catch limit exceeds the incidental catch.

E. Generation of data

The estimates of absolute abundance (and their associated CVs) for the years prior to 1999 provided to the CLA are identical to the actual estimates and CVs for North Pacific minke whales from surveys conducted in August/September (see Table 5(a)). To allow for results of surveys already conducted, but for which the results are not yet available, estimates of abundance are generated for sub-area 12 in 2000 using the same method as for future estimates.

The sightings mixing matrix for a year in which a survey takes place is the average of the catch mixing matrices for August and September for that year. 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 5(a). The future estimates of abundance for a *Small Area* (say *Small Area E*) are generated using the formula:

$$\hat{P} = P Y w / \mu = P^* \beta^2 Y w \quad (\text{E.1})$$

Y is a lognormal random variable $Y = e^\varepsilon$ where $\varepsilon \sim N[0, \sigma^2]$ and $\sigma^2 = \text{Ln}(\alpha^2 + 1)$;

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 August-September:

$$P = P_t^E = \frac{1}{2} \sum_{k \in F} \sum_{q \in \text{Aug/Sept}} \sum_s \sum_{a=1}^x \left(V_{t,a}^{m,s,k,q} (R_{t,a}^{m,s} + U_{t,a}^{m,s}) + V_{t,a}^{f,s,k,q} (R_{t,a}^{f,s} + U_{t,a}^{f,s}) \right) \quad (\text{E.2})$$

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 $\text{CV}^2(ab) = \text{CV}^2(a) + \text{CV}^2(b)$: $E(\hat{P}) = P$ and $\text{CV}^2(\hat{P}) = \alpha^2 + \beta^2 P^* / P$

For consistency with the first stage screening trials for a single stock (IWC, 1991, p.109; IWC, 1994, p.85-86), the ratio $\alpha^2:\beta^2 = 0.12:0.025$, so that:

$$\text{CV}(\hat{P}) = \tau(0.12 + 0.025 P^* / P)^{1/2} \quad (\text{E.3})$$

and the CV of a survey estimate prior to the commencement of exploitation in the area being surveyed would be:

$$\sqrt{(\alpha^2 + \beta^2)} = 0.38\tau \quad (\text{E.4})$$

The value of τ is calculated from the equation defining the true value of the CV by substituting the value of the CV for each abundance estimate and the depletion to which it corresponds (Equation E.3), and solving for τ . 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. The values of τ applicable to each sub-area are calculated separately for each replicate once the conditioning has been accomplished.

An estimate of the CV, X_t is also generated for each sightings estimate, $\hat{P}_t$:

$$X_t = \sqrt{(\sigma_t^2 \chi^2 / n)} \quad (\text{E.5})$$

where $\sigma_t^2 = \text{Ln}(1 + \alpha^2 + \beta^2 P^* / \hat{P}_t)$ 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*.

Sensitivity trial 10 considers the case where $g(0) = 0.5$. To implement this, the observed P is taken to be half of its actual value (Equation E.2). In sensitivity trial 23, an additional coefficient of variance of 0.4^2 is added to the CV used to generate the abundance estimate. This is implemented by changing equation E.4 to:

$$\alpha^2 + \beta^2 = 0.38^2 \tau^2 + 0.4^2 \quad (\text{E.6})$$

The CV supplied to the *CLA* ignores the additional variance.

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 2000 would first be used for setting the catch limit in 2002. Table 4 lists the pattern for future surveys and also shows how results of surveys from different sub-areas are combined. In trials in which *Small Areas* are comprised of sub-areas that

are surveyed in different years, the 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.

F. Parameter values and Conditioning

Following the decision by the sub-committee on North Pacific minke whales (IWC, 1992a, p.160), the values of the biological and technological parameters are taken to be equal to those for the North Atlantic minke *Implementation Simulation Trials* (IWC, 1992b, p.249), i.e.:

$$\begin{aligned} r_{50} &= 4; & \sigma_r &= 1.2 & \text{where } r \text{ is recruitment} \\ m_{50} &= 7; & \sigma_m &= 1.2 & \text{where } m \text{ is maturity} \\ \text{MSYL} &= 0.6 \end{aligned}$$

The maturity ogive is modified so that the first age at which a female can be mature is three, i.e. $\beta_0 = \beta_1 = \beta_2 = 0$.

Natural mortality is age-dependent, and identical to that for the North Atlantic minke trials:

$$M_a = \begin{cases} 0.085 & \text{if } a \leq 4 \\ 0.0775 + 0.001875a & \text{if } 4 < a < 20 \\ 0.115 & \text{if } a \geq 20 \end{cases}$$

The MSYR scenarios are specified in Section G. The *MSYR* used does not apply to the recruited populations defined for this model, but rather applies to the rates that would apply if the age at recruitment were equal to the age at maturity.

The process used to select the initial (pre-exploitation) sizes of each of the stocks and the values for the γ and η parameters used to define the catch mixing matrices is known as the conditioning process. This process involves first generating the target data, as detailed in steps (a) to (i) below, that will be 'fitted' to the above model. Values for the initial population sizes and the γ s and η s are then selected by minimising the negative of a log-likelihood which contains terms related to the target data generated in steps (a) to (i). The number of animals in sub-area k at the start of year t is

Table 4

Years and sub-areas for which survey estimates are available or expected. For areas that are combinations of sub-areas, the last five columns specify how the survey estimates for the component sub-areas are combined (see also Table 5a and notes thereto). 0=No survey, 1=survey

Year	Sub-area									Sub-area Combination				
	7W	7E	8W	8E	9W	9E	11	12SW	12NE	C1 = 7+8	C2 = 7+8+11+12	C3 = 7E+8+12	C4 = 9	C5 = 12
1990	0	1	1	1	1	1	1	1	1				1	
1991	1	0	0	0	0	0	0	0	0	1 = 90+91	1 = 90+91+92	1 = 90+91+92		1 = 90+92
1992	0	0	0	0	0	0	0	0	1					
1999	0	0	0	0	0	0	1	0	0					
2000	0	0	0	0	0	0	0	1	1					1
2001	0	0	0	0	0	0	1	1	1		1 = 99-03			1
2002	0	0	0	0	1	1	0	0	0			1 = 00-03	1	
2003	1	1	1	1	0	0	0	0	0	1				
2004	0	0	0	0	0	0	1	1	1					1
2005	0	0	0	0	1	1	0	0	0		1 = 04+05+06	1 = 04+05+06	1	
2006	1	1	1	1	0	0	0	0	0	1				
2007	0	0	0	0	0	0	1	1	1					1
2008	0	0	0	0	1	1	0	0	0		1 = 07+08+09	1 = 07+08+09	1	
2009	1	1	1	1	0	0	0	0	0	1				

and so on in this pattern

calculated starting with guessed values of the initial population sizes and projecting the operating model forward to 2000 in order to obtain values of abundance etc. for comparison with the generated data³. (When performing the projections, mixing is stochastic, and the catches from each sub-area are set to their historic values – Tables 3 and 5.) In order to avoid using datasets containing incompatible data, the following algorithm is used:

- (1) Generate a number of pseudo datasets based on the data in Tables 5a and 5b (say 200).
- (2) Fit the operating model to each and record the value of the objective function.
- (3) Select the 100 simulations with the lowest objective function values for use in the trials.

³ In order to check that the conditioning exercise has been successfully achieved, plots such as those shown in annex D of SC/54/Rep1 will be examined, together with time-trajectories of the fraction of each stock in the sub-areas/months for which information is available. A small group consisting of Butterworth, Kawahara, Polacheck, Punt and Wade was established to work interessionally with Allison to examine the details of some of the initial conditioning attempts and to develop summary statistics for conditioning.

The information used in the conditioning process is as follows.

- (a) The target values for the historical abundance by sub-area (excepting for the minimum values, which are taken to be one standard error less than the corresponding best estimate – see below) are generated using the formula:

$$P_t^k = O_t^k \exp[\mu_t^k - (\sigma_t^k)^2 / 2] \quad \mu_t^k \sim N[0; (\sigma_t^k)^2] \quad (\text{F.1})$$

P_t^k is the abundance for sub-area k in year t ;
 O_t^k is the actual survey estimate for sub-area k in year t (see Table 5a)); and
 σ_t^k is the CV of O_t^k .

The levels of abundance listed in Table 5(a) for sub-areas 6 and 10 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 the specified values.

- (b) Estimates of the proportion of recruited ‘J’ stock whales in sub-areas 7W, 11 and 12SW are generated from

Table 5(a)

The abundance data used to condition the trials. Note: The data for sub-areas 7-9 were provided by Miyashita following the Seattle Workshop (SC/54/Rep1). The Working Group on abundance estimates (see annex C of SC/54/Rep1) reported that the abundance estimate used previously for sub-area 7 in 1990 was not acceptable for conditioning as the same data were used again in making the 1991 estimate. This is not the case in the revised estimates below.

Sub-area	Timing	Estimate	CV	Estimate also used by CLA?	Source
6	Aug.-Sept. 1992	893 ¹	0.670	No	Miyashita and Shimada (1994)
7W	Aug.-Sept. 1991	1,164	0.183	Yes	Miyashita (inverse-variance weighted average of 1990, 91 and 92 estimates)
7E	Aug.-Sept. 1990	791	1.848	Yes	Miyashita (pro-rata to fraction of area from 1990 estimate)
8W	Aug.-Sept. 1990	472	0.855	Yes	Miyashita (pro-rata to fraction of area surveyed)
8E	Aug.-Sept. 1990	585	1.071	Yes	Miyashita (pro-rata to fraction of area surveyed)
9W	Aug.-Sept. 1990	3,226	0.538	Yes	Miyashita (pro-rata to fraction of area surveyed)
9E	Aug.-Sept. 1990	5,038	0.405	Yes	Miyashita (pro-rata to fraction of area surveyed)
10	Aug.-Sept. 1992	707 ¹	0.570	No	Miyashita and Shimada (1994)
11	Aug.-Sept. 1990	2,120	0.449	Yes	Buckland <i>et al.</i> (1992); IWC (1997 p.211)
11	Aug.-Sept. 1999 ²	1,456	0.565	Yes	Cui <i>et al.</i> (2002); SC/54/Rep1 (annex C)
12SW	Aug-Sep 1990	5,244	0.806	Yes	Miyashita (CV recalculated after the Seattle Workshop, Jan 02)
12NE	Aug-Sep 1990	10,397	0.364	Yes	Miyashita (CV recalculated after the Seattle Workshop, Jan 02)
12NE	Aug-Sep 1992	11,544	0.380	Yes	Miyashita (CV recalculated after the Seattle Workshop, Jan 02)

¹Minimum estimates. Value to be used in trials is 1 standard error less (=295 sub-area 6 and 304 sub-area 10). ² Estimate is based on pooling data from 1999 and 2000 surveys (see Annex C of the SC/54/Rep1). Although the estimate is labelled as relating to year 2000 in Annex C it is labelled here as 1999 as management is considered to begin in year 2000 and other data from year 2000 are not available.

Table 5(b)

Estimates of the proportion of recruited ‘J’ whales used to condition the trials (see text re combining estimates)

Sub-area (months)	Sex	Years	Estimate	SE	Data used	Source
2 (Apr.-Sep.)	Both	1996–2000	0.705	0.120	mtDNA	SC/54/Rep1
7W (Apr.-Sep.)	Both	1983–87, 1996-99	0.028	0.012	mtDNA	SC/54/Rep1
11 (Apr.)	Females	1984-87	0.623	0.069	mtDNA	SC/54/Rep1
11 (May)	Females	1984-87	0.081	0.047	mtDNA	SC/54/Rep1
11 (May-June)	Males	1984-87	0.054	0.051	mtDNA	SC/54/Rep1
11 (Jun.)	Females	1984-87	0.224	0.101	mtDNA	SC/54/Rep1
11 (Jul.)	Females	1984-87, 1999	0.443	0.106	mtDNA	SC/54/Rep1
11 (Jul.)	Males	1986, 1999	0.201	0.079	mtDNA	SC/54/Rep1
11 (Aug.)	Females	1986-87, 1996	0.087	0.071	mtDNA	SC/54/Rep1
11 (Aug.)	Males	1986-87, 1996	0.363	0.109	mtDNA	SC/54/Rep1
12SW (Jun.)	Both	1973-75	0.278	0.159	Conception/ flipper colour	IWC, 1997 p.2152
12SW (Jul.)	Both	1973-75	0.0411	0.025	Conception/ flipper colour	IWC, 1997 p.2152
12SW (Aug.)	Both	1973-75	0.0461	0.028	Conception/ flipper colour	IWC, 1997 p.2152

¹Based on the centre of the confidence interval.

² The values for area 12SW are taken to equal those sampled in 12S (IWC, 1997, p.215).

beta distributions fitted to the posterior distributions (see annex F of SC/54/Rep1) for the observed year-specific proportions, which are based on mtDNA, conception date and flipper colour information (see Table 5(b)). Previous trials (IWC, 2002a) used appropriately truncated normal distributions rather than beta distributions, but it was found that the posterior distributions for the mixing proportions from the Bayesian approach are better approximated by a beta distribution. Although data do exist for sub-areas other than those listed in Table 5(b), the sample sizes are so low that their information content is effectively nil. 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.

The data for sub-area 12SW is limited and so a trial (sensitivity trial 6) has been added to simulate a higher proportion of 'J' stock animals in this sub-area. In sensitivity trial 6 the proportion estimates for sub-area 12SW are replaced by the highest value for the 1973-75 average proportion of recruited 'J' stock whales in sub-area 12(SW+NE) June-August which is $\leq 20\%$ and consistent with the other data used in conditioning, and which does not lead to more than 50% (median value over the 100 simulations) of mature 'J' stock females being in sub-area 12SW in June-August 1973-75.

(c) The trials shall be conditioned by fixing the depletion level of the mature female component of the 'J' stock to a certain percentage of its pre-exploitation size at the start of 2000. Four values for this depletion are used in the trials: 15%, 30%, 50% and 70%.

(d) **Baselines A and C:** The fraction of the 'O' (or 'O_W' and 'O_E') stock in sub-area 12 is fixed by setting the fraction of 1+ non-'J' stock animals in sub-area 12 (SW+NE) in August-September in the pristine state that are from the 'W' stock to equal the relative abundance of such animals in sub-areas 7, 8, 9W and 9E at that time. In sensitivity test 8 the fraction of 'W' animals in sub-area 12 is set equal to the relative abundance of such animals in sub-areas 7, 8 and 9W at that time.

(e) The definition of this condition depends on the underlying stock model — see Section G.

Baseline A: The fraction of the 'O' stock (1+ animals) in sub-area 9W is fixed by specifying the percentage that the 'O' stock comprises of the combined 'O'-'W' abundance in that sub-area in August-September 1995 (a year when the 'W' stock is defined to enter sub-area 9W). In Baseline A, the value for this fraction is taken to be 50%. (A value of 100% is used in Baseline B i.e. no 'W' stock). The value of 50% is based on the genetic differences found between sub-areas 7, 8 and 9E and sub-area 9W in 1995, 2000 and 2001.

Baseline C: The fractions of 'O_W' and 'O_E' stocks in sub-areas 7, 8, 11 and 12 are defined such that the pristine ratio of 'O_W': 'O_E' 1+ abundance in August/September in each of the sub-areas 7 (W+E), 11 and 12SW are equal i.e. the ratio of such animals in sub-area 7 (W+E) is equal both to the ratio in sub-area 11 and to the ratio in sub-area 12SW, which are themselves equal. In addition, the pristine ratio of 'O_W': 'O_E' 1+ abundance in August/September in sub-areas 7 (W+E) and 8 (W+E) combined is set equal to the ratio of such animals in sub-areas 11 and 12 (SW+NE) combined.

Baseline D: Details will be specified by the steering group. The model is outlined in annex G of SC/54/Rep1.

(f) For sensitivity trial 10 (case for which $g(0) = 0.5$) the values of the operating model abundances are halved for comparison with the conditioning targets.

(g) Dispersal rate. The model allows dispersal between two stocks. To ensure equilibrium in the pristine population:

$$K^{1+,O} D^{O,W} = K^{1+,W} D^{W,O} \quad (F.2)$$

where

$$K^{1+,s} = \sum_{a=1}^x R_{-\infty,a}^{f,s} + U_{-\infty,a}^{f,s} \quad (F.3)$$

$D^{O,W}$ and $D^{W,O}$ are evaluated by setting the mean dispersal rate D equal to the pertinent value above, where the mean dispersal rate is defined by the formula:

$$D = \left(K^{1+,W} D^{W,O} + K^{1+,O} D^{O,W} \right) / \left(K^{1+,W} + K^{1+,O} \right) \quad (F.4)$$

The best, higher and lower estimates of the mean dispersal rate (D) between the 'O' and 'W' stocks in Baseline A and between 2 of the stocks in Baseline C are to be provided by B. Taylor intersessionally, and to be agreed by the Steering Group. Dispersal is ignored for Baseline D.

(h) The historic catch is specified by month and sub-area (see Adjunct 2). In some simulation runs conducted in the iterative conditioning process, the modelled population size in a particular sub-area and month may not be sufficient to support the specified catch, in which case the population model amends the modelled catch to be smaller than the specified catch to prevent negatives occurring for some population components. However, to ensure that any final population trajectory output from the conditioning process is consistent with the historic catch series, a penalty term is added to the likelihood function to ensure that the entire recorded historic catch is taken.

(i) For sensitivity trial 14 (the case in which some 'W' animals are found in sub-area 8, in years when they are in sub-area 9), the fraction of the 'O' stock (1+ animals) in sub-area 8 to the combined 'O'-'W' abundance in that sub-area in August-September 1995 (a year when the 'W' stock is defined to enter sub-area 8) is set at 75% (see Pastene *et al.*, 2002).

G. Trials

The set of trials is given in Table 6. The sensitivity trials are variants of the baseline trials NPM-A, C and D (see section A).

The full set of trials is based on longitudinal boundaries at 147°E, 150°E, 153°E, 157°E and 162°E although all of the trials merge at least one of the longitudinal sectors defined by these boundaries when defining sub-areas. If a trial is specified in terms of a sub-area that is a combination of two of these longitudinal sectors, the relative fraction of each stock in each sector is the same (with the ratio of the abundances in the two sectors given by an η parameter in the catch mixing matrices).

In Baseline A, the 'W' stock occurs in sub-area 9 (and 12) each year with 60% probability, determined by random selection, except that the simulations will always ensure they are present in these sub-areas in 1995, 2000 and 2001 and absent in 1994 and 1997. There is no genetic data regarding the J:O ratio in 7E, but it has been assumed to be the same as that in 7W.

Table 6

Implementation Simulation Trials for North Pacific minke whales. All trials will be run using both the J1 and J2 incidental catch options.

6a: Baseline trials.					
Trial No. NPM-	MSYR	No. of stocks	Mixing Matrices	'J' status in 2000	Description
A	1% & 4%	3	AB F KL(60:40)	30% <i>K</i>	3 stocks with 2 in sub-area 9
B	1% & 4%	2	AB G	30% <i>K</i>	2 stock variant
C	1% & 4%	4	AB C D E	30% <i>K</i>	4 stocks with hard boundary at 147°
D	1% & 4%	3	AB P Q	30% <i>K</i>	3 stocks with mixing gradient {all moving left}
6b: Sensitivity trials. (All trials are based on Baseline trial A with MSYR=1% etc.)					
Baseline	Sensitivity trial no.	MSYR	Mixing matrices	'J' status in 2000	Description
A1	1	1%	AB F KL(60:40)	30% <i>K</i>	Lower dispersal rate
A4	1	4%	AB F KL(60:40)	30% <i>K</i>	Lower dispersal rate
A1	2	1%	AB F KL(60:40)	30% <i>K</i>	Higher dispersal rate
A1	3	1%	AB F KL(60:40)	15% <i>K</i>	15% 'J' stock depletion
A1	4	1%	AB F KL(60:40)	50% <i>K</i>	50% 'J' stock depletion
A1	5	1%	AB F KL(60:40)	70% <i>K</i>	70% 'J' stock depletion
A4	5	4%	AB F KL(60:40)	70% <i>K</i>	70% 'J' stock depletion
A1	6	1%	AB F KL(60:40)	30% <i>K</i>	20% 'J' in sub-area 12SW (or max. achievable)
A1	7	1%	AB F KL(60:40)	15% <i>K</i>	15% 'J' stock depletion + 20% 'J' in 12SW (or max. achievable)
A1	8	1%		30% <i>K</i>	Some whales from 9 go east of Kamchatka (162° line)
A1	9	1%	AB F/H KL(60:40)	30% <i>K</i>	Some 'O' animals in sub-area 10
A1	10	1%	AB F KL(60:40)	30% <i>K</i>	$g(0) = 0.5$ (see item F.f)
A1	11	1%	AB F KL(60:40)	30% <i>K</i>	Misreport Japan incidental catch (*4 in opt Ji and /4 in opt Jii)
A1	12	1%	AB F KL(60:40)	30% <i>K</i>	Different Korean bycatch data model (constant catch)
A1	13	1%	AB F KL(60:40)	30% <i>K</i>	Different Japanese incidental catch level (50 in opt Ji and 150 in Jii)
A1	14	1%	AB F ML(60:40)	30% <i>K</i>	Sensitivity to A: some 'W' in 8 (see Item F.i)
A1	23	1%	AB F KL(60:40)	30% <i>K</i>	40% additional variance in CV supplied to CLA (see item 10.1)
A1	24	1%	AB F KL(60:40)	30% <i>K</i>	Sub-area 11 closed in all months + sub-area 12SW closed in June
C1	1	1%	AB C D E	30% <i>K</i>	Lower dispersal rate
C4	1	4%	AB C D E	30% <i>K</i>	Lower dispersal rate
C1	2	1%	AB C D E	30% <i>K</i>	Higher dispersal rate
C1	3	1%	AB C D E	15% <i>K</i>	15% 'J' stock depletion
C1	4	1%	AB C D E	50% <i>K</i>	50% 'J' stock depletion
C1	5	1%	AB C D E	70% <i>K</i>	70% 'J' stock depletion
C4	5	4%	AB C D E	70% <i>K</i>	70% 'J' stock depletion
C1	6	1%	AB C D E	30% <i>K</i>	20% 'J' in 12SW (or max. achievable)
C1	7	1%	AB C D E	15% <i>K</i>	15% 'J' stock depletion + 20% 'J' in 12SW (or max. achievable)
C1	8	1%		30% <i>K</i>	Some whales from 9 go east of Kamchatka (162° line)
C1	9	1%		30% <i>K</i>	Some 'O _w ' animals in sub-area 10
C1	10	1%	AB C D E	30% <i>K</i>	$g(0) = 0.5$ (see item F.f)
C1	11	1%	AB C D E	30% <i>K</i>	Misreport Japan incidental catch (*4 in opt Ji and /4 in opt Jii)
C1	12	1%	AB C D E	30% <i>K</i>	Different Korean bycatch data model (constant catch)
C1	13	1%	AB C D E	30% <i>K</i>	Different Japanese incidental catch level (50 in opt Ji and 150 in Jii)
C1	15	1%		30% <i>K</i>	More 'O _E ' in 12 SW (see Taylor and Martien (2002))
C1	16	1%		30% <i>K</i>	Less 'O _E ' in 12 SW (see Taylor and Martien (2002))
C1	17	1%		30% <i>K</i>	Hard 'O _w '/'O _E ' boundary at 153°
C1	18	1%		30% <i>K</i>	'O _w ' and 'O _E ' mixing between 147°E and 153°E
C1	19	1%		30% <i>K</i>	Further intrusion of 'O _E ' into sub-area 9
C1	20	1%	AB I J E	30% <i>K</i>	Intrusion with mixing: 'O _w ' and 'O _E ' mixing in 7 and 8
C4	20	4%	AB I J E	30% <i>K</i>	Intrusion with mixing: 'O _w ' and 'O _E ' mixing in 7 and 8
C1	23	1%	AB C D E	30% <i>K</i>	40% additional var in CV supplied to CLA (SC/54/Rep1 item 10.1)
C1	24	1%	AB C D E	30% <i>K</i>	Sub-area 11 closed in all months + sub-area 12SW closed in June
D1	3	1%	AB P Q	15% <i>K</i>	15% 'J' stock depletion
D1	4	1%	AB P Q	50% <i>K</i>	50% 'J' stock depletion
D1	5	1%	AB P Q	70% <i>K</i>	70% 'J' stock depletion
D4	5	4%	AB P Q	70% <i>K</i>	70% 'J' stock depletion
D1	6	1%	AB P Q	30% <i>K</i>	20% 'J' in 12SW (or max. achievable)
D1	7	1%	AB P Q	15% <i>K</i>	15% 'J' stock depletion + 20% 'J' in 12SW (or max. achievable)
D1	10	1%	AB P Q	30% <i>K</i>	$g(0) = 0.5$ (see item F.f)
D1	11	1%	AB P Q	30% <i>K</i>	Misreport Japan incidental catch (*4 in opt Ji and /4 in opt Jii)
D1	12	1%	AB P Q	30% <i>K</i>	Different Korean bycatch data model (constant catch)
D1	13	1%	AB P Q	30% <i>K</i>	Different Japanese incidental catch level (50 in opt Ji and 150 in Jii)
D1	21	1%		30% <i>K</i>	3 stocks with mixing gradient {all moving right}
D1	22	1%		30% <i>K</i>	3 stocks with stochastic mixing
D1	23	1%	AB P Q	30% <i>K</i>	40% additional variance in CV supplied to CLA (see item 10.1)
D1	24	1%	AB P Q	30% <i>K</i>	Sub-area 11 closed in all months + sub-area 12SW closed in June

Details of some sensitivity trials will be finalised intersessionally by the Steering Group. The figures in SC/54/Rep1 illustrate the baseline trials and sensitivity trials 17, 18 and 19.

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 selections listed below may be reconsidered once the results of the trials specified in this Appendix have been carried out.

Designation of areas

SMALL AND RESIDUAL AND COMBINATION AREAS

Sub-areas 1, 2, 3, 4, 5, 6, 9N, 10 and 13 are *Residual Areas*. There are four alternative *Small Area* definitions and two other management variants:

- (1) *Small Areas* equal sub-areas. For this option, the *Small Areas* for which catch limits would be set are 7W, 7E, 8W, 8E, 9W, 9E, 11, 12SW and 12NE.
- (2) 7+8, 9, 11 and 12 are *Small Areas* and catches are taken from sub-areas 7W, 9W, 11 and 12SW.
- (3) 7+8+11+12 and 9 are *Small Areas* and catches are taken from sub-areas 11 and 9W.
- (4) 7W, 7E+8+12, 9 and 11 are *Small Areas* and catches are taken from sub-areas 7W, 9W, 11 and 12SW.
- (5) 7+8+11+12 and 9 are combination areas and catches are cascaded to the sub-areas within each combination area.
- (6) As (3) except that the catches from the 7+8+11+12 *Small Area* are taken from sub-areas 7W and 11 using catch cascading across those two sub-areas.

Note: in cases where a *Small Area* consists of more than one sub-area, the general approach followed above is to assume the extreme that all catches are taken from the sub-area that would lead to the highest risk to the 'J' stock.

MEDIUM AREAS

Medium Areas are not used in this set of variants (previous trials having shown this feature to have only a slight impact on performance).

LARGE AREA

There is no *Large Area*.

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) Continuing catch (C_c): (a) median; (b) 5th value; (c) 95th value.

- (7) Catch by sub-area, stock and catch-type (incidental or commercial): (a) median; (b) 5th value; (c) 95th value.
- (8) The median percentage of mature 'J' stock females being in sub-area 12 in June-August 1973-75.
- (9) The median annual rate of decline in the number of whales assumed recruited to the Korean fishery over the period 1973-1986.
- (10) 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).
- (11) 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.

The continuing catch statistic is defined as follows.

The 'sustainable yield' function of population size is defined as:

$$SY(P) = \begin{cases} MSY & \text{for } P > MSYL \\ \text{long-term equilibrium RY} & \text{for } P < MSYL \end{cases}$$

The average catch over the final ten years of the simulation, $\bar{C}$, and the average 'sustainable yield' over this period, $\bar{SY}$, are calculated. The continuing catch statistic is defined as the minimum of $\bar{C}$ and $\bar{SY}$.

The continuing catch statistic is evaluated under the assumption that the dispersal rate is zero, even in trials where there is actually dispersal between stocks.

REFERENCES

- Buckland, S.T., Cattanach, K.L. and Miyashita, T. 1992. Minke whale abundance in the northwest Pacific and the Okhotsk Sea, estimated from 1989 and 1990 sighting surveys. *Rep. int. Whal. Commn* 42:387-92.
- Cui, G., Punt, A.E., Pastene, L.A. and Goto, M. 2002. Bayes and Empirical Bayes approaches to addressing stock structure questions using mtDNA, with an illustrative application to North Pacific minke whales. *J. Cetacean Res. Manage.* 4(2):123-34.
- International Whaling Commission. 1991. Report of the Sub-Committee on Management Procedures, Appendix 4. Report of the *ad-hoc* trials subgroup. *Rep. int. Whal. Commn* 41:108-12C.
- International Whaling Commission. 1992a. Report of the Scientific Committee, Annex F. Report of the Sub-Committee on North Pacific Minke Whales. *Rep. int. Whal. Commn* 42:156-77.
- International Whaling Commission. 1992b. Report of the Scientific Committee, Annex K. Report of the Working Group on North Atlantic Minke Trials. *Rep. int. Whal. Commn* 42:246-51.
- International Whaling Commission. 1994. Report of the Scientific Committee, Annex D. Report of the Sub-Committee on Management Procedures, Appendix 2. Minimum Standards Trials. *Rep. int. Whal. Commn* 44:85-8.
- International Whaling Commission. 1997a. Report of the Scientific Committee, Annex J, Appendix 4. Specifications of the North Pacific minke whaling trials. *Rep. int. Whal. Commn* 47:216-25.
- International Whaling Commission. 1997b. Report of the Scientific Committee, Annex J. Report of the Working Group on North Pacific Minke Whale Trials. *Rep. int. Whal. Commn* 47:203-26.
- International Whaling Commission. 1997c. Report of the Scientific Committee, Annex J. Report of the Working Group on North Pacific minke whale trials, Appendix 3. Estimates of mixing between J and O stocks. *Rep. int. Whal. Commn* 47:214-5.
- International Whaling Commission. 1999. Report of the Scientific Committee, Annex N. The Revised Management Procedure (RMP) for Baleen Whales. *J. Cetacean Res. Manage. (Suppl.)* 1:251-8.
- International Whaling Commission. 2000. Report of the Scientific Committee, Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 2:79-92.
- International Whaling Commission. 2002a. Report of the Scientific Committee, Annex D. Report of the Sub-Committee on the Revised

- Management Procedure. Appendix 12. Specifications of the North Pacific minke whaling trials. *J. Cetacean Res. Manage. (Suppl.)* 4:127-38.
- International Whaling Commission. 2002b. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 15. North Pacific minke whale trials Working Group: details of trial modifications. *J. Cetacean Res. Manage. (Suppl.)* 4:140-7.
- Miyashita, T. and Shimada, H. 1994. Minke whale abundance in the Okhotsk Sea, the Sea of Japan and off the Pacific coast of Northern Japan estimated from sighting data. Paper SC/46/NP6 presented to the IWC Scientific Committee, May 1994 (unpublished). 9pp.[Paper available from the Office of this Journal].
- Pastene, L., Goto, M. and Kanda, N. 2002. Proposal on an update to the defaults on stock structure in item 3 of Appendix 15 of Annex D (RMP sub-committee report). Paper SC/J02/NP7 presented to the Scientific Committee Workshop on North Pacific common minke (*Balaenoptera acutorostrata*) *Implementation Simulation Trials* held in Seattle, USA, 19-22 January, 2002 (unpublished). [Paper available from the Office of this Journal].
- Taylor, B.L. and Martien, K. 2002. Proposed trial specifications for four stock scenarios. Paper SC/J02/NP5 presented to the Scientific Committee Workshop on North Pacific common minke (*Balaenoptera acutorostrata*) *Implementation Simulation Trials* held in Seattle, USA, 19-22 January, 2002 (unpublished). [Paper available from the Office of this Journal].

[Adjunct 1 and 2 on the following pages]

Adjunct 1

The catch mixing matrices (the sightings mixing matrices are calculated from the catch mixing matrices for August and September)

The values of the γ and η parameters are estimated during conditioning.

Note: all of the 'J' stock animals in sub-areas 12SW+12NE occur in sub-area 12SW while all of the 'W' stock animals in sub-areas 12SW+12NE occur in sub-area 12NE. The specification regarding the proportion of 'J' stock animals in sub-area 12SW is based on the analyses of the flipper colour information which indicates a high proportion of 'J' stock animals in that sub-area in June (see Table 5b).

Summary of the changes to the mixing matrices (see below) from those given in IWC (2002).

Matrix	Sub-area	Changes
A & B ('J' stock)	11	New constants added to fit new proportion data by month and sex. See also section 8.1.
B ('J' stock)	7W + 7E	Altered to use the same γ parameter through out as the J/O proportion data no longer given by month
	12NE	Set to zero: 'J' stock not found in 12NE (see Seattle report section 10.1)
F ('O' stock)	9	O stock added into area 9 (W and E) in same proportions by month and sex as in the old K matrix. Juveniles were then allowed into 9W and 9E to improve the fit to the data (Sept 02)
K ('W' stock)	9E, 12SW	Set to zero: in baseline A, the 'W' stock is found in 9W but not 9E; the 'W' stock goes into 12NE but not 12SW.
L ('W' stock)	13	New matrix to allow all of the 'W' stock to be in sub-area 13 (in 40% of years)

Rationale for the parameters used in the new mixing matrices

Matrix	Sub-area	Notes
I ('O' stocks)	7W, 7E, 8	Assumes 30% of the 'O _w ' stock migrating northwards past the east coast of Japan intrudes into sub-areas 7E and 8.
J ('O' stocks)	7W, 7E, 8	Assumes 30% of the 'O _E ' stock migrating northwards past the east coast of Japan intrudes into sub-area 7W.

Month /Age class	Sub-area																
	1	2	3	4	5	6	7W	7E	8W	8E	9W	9E	10	11	12SW	12NE	13
Matrix A: 'J' Stock used in all Baselines (in 50% of years) $\gamma_{12} = \frac{1}{2}(\gamma_{11} + 2\gamma_{16})$ $\gamma_{18} = \frac{1}{2}(\gamma_2 + \gamma_{14})$ $\gamma_{19} = \frac{1}{2}(\gamma_4 + \gamma_{14})$ $\gamma_{20} = \frac{1}{2}(\gamma_{11} + \gamma_{16})$ $\gamma_{23} = \frac{1}{2}(\gamma_8 + \gamma_{22})$																	
Age 4																	
Apr. 1	2 γ_{17}	0	0	1	1	0	0	0	0	0	0	0	1	γ_1	0	0	0
May 0	γ_{17}	0	0	1	1	0	0	0	0	0	0	0	2	γ_{18}^1	0	0	0
Jun. 0	0	0	0	1	1	0	0	0	0	0	0	0	2	γ_{19}^1	0	0	0
Jul. 0	0	0	0	1	1	0	0	0	0	0	0	0	1	γ_{23}	0	0	0
Aug. 0	0	0	0	1	1	0	0	0	0	0	0	0	1	γ_{12}^1	0	0	0
Sept. 1	0	0	0	1	2	0	0	0	0	0	0	0	1	γ_{20}^1	0	0	0
Age 10 – male																	
Apr. 1	2 γ_{17}	0	0	1	1	0	0	0	0	0	0	0	1	γ_1	0	0	0
May 0	γ_{17}	0	0	1	1	0	0	0	0	0	0	0	2	γ_{14}	0	0	0
Jun. 0	0	0	0	1	1	0	0	0	0	0	0	0	2	γ_{14}	0	0	0
Jul. 0	0	0	0	1	1	0	0	0	0	0	0	0	1	γ_{22}	0	0	0
Aug. 0	0	0	0	1	1	0	0	0	0	0	0	0	1	γ_{11}	0	0	0
Sept. 1	0	0	0	1	2	0	0	0	0	0	0	0	1	γ_{11}	0	0	0
Age 10 – female																	
Apr. 1	2 γ_{17}	0	0	1	1	0	0	0	0	0	0	0	1	γ_1	0	0	0
May 0	γ_{17}	0	0	1	1	0	0	0	0	0	0	0	2	γ_2	0	0	0
Jun. 0	0	0	0	1	1	0	0	0	0	0	0	0	2	γ_4	0	0	0
Jul. 0	0	0	0	1	1	0	0	0	0	0	0	0	1	γ_8	0	0	0
Aug. 0	0	0	0	1	1	0	0	0	0	0	0	0	1	2 γ_{16}	0	0	0
Sept. 1	0	0	0	1	2	0	0	0	0	0	0	0	1	γ_{16}	0	0	0
Matrix B: 'J' Stock used in all Baselines (in 50% of years) $\gamma_{12} = \frac{1}{2}(\gamma_{11} + 2\gamma_{16})$ $\gamma_{18} = \frac{1}{2}(\gamma_2 + \gamma_{14})$ $\gamma_{19} = \frac{1}{2}(\gamma_4 + \gamma_{14})$ $\gamma_{20} = \frac{1}{2}(\gamma_{11} + \gamma_{16})$ $\gamma_{23} = \frac{1}{2}(\gamma_8 + \gamma_{22})$																	
Age 4																	
Apr. 1	2 γ_{17}	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	γ_1	0	0	0
May 0	γ_{17}	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	2	γ_{18}^1	0	0	0
Jun. 0	0	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	2	γ_{19}^1	0	0	0
Jul. 0	0	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	γ_{23}	0	0	0
Aug. 0	0	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	γ_{12}^1	0	0	0
Sept. 1	0	0	0	1	2	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	γ_{20}^1	0	0	0
Age 10 – male																	
Apr. 1	2 γ_{17}	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	γ_1	0	0	0
May 0	γ_{17}	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	2	γ_{14}	γ_3	0	0
Jun. 0	0	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	2	γ_{14}	γ_3	0	0
Jul. 0	0	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	γ_{22}	γ_5	0	0
Aug. 0	0	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	γ_{11}	γ_5	0	0
Sept. 1	0	0	0	1	2	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	γ_{11}	0	0	0
Age 10 – female																	
Apr. 1	2 γ_{17}	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	γ_1	0	0	0
May 0	γ_{17}	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	2	γ_2	γ_3	0	0
Jun. 0	0	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	2	γ_4	γ_3	0	0
Jul. 0	0	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	γ_8	γ_5	0	0
Aug. 0	0	0	0	1	1	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	2 γ_{16}	γ_5	0	0
Sept. 1	0	0	0	1	2	γ_{13}	$\eta_1\gamma_{13}$	0	0	0	0	0	1	γ_{16}	0	0	0

Month /Age class	Sub-area																
	1	2	3	4	5	6	7W	7E	8W	8E	9W	9E	10	11	12SW	12NE	13
Matrix F: 'O' Stock used in Baseline A (all years)																	
Age 4																	
Apr.	0	2	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	γ ₁₅	η ₃ γ ₁₅	0	γ ₇	0	0	0
May	0	1	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	γ ₁₅	η ₃ γ ₁₅	0	γ ₇	γ ₆	η ₄ γ ₆	0
Jun.	0	0	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	γ ₁₅	η ₃ γ ₁₅	0	γ ₇	γ ₆	η ₄ γ ₆	0
Jul.	0	0	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	γ ₁₅	η ₃ γ ₁₅	0	γ ₇	γ ₆	η ₄ γ ₆	0
Aug.	0	0	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	γ ₁₅	η ₃ γ ₁₅	0	γ ₇	γ ₆	η ₄ γ ₆	0
Sept.	0	0	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	γ ₁₅	η ₃ γ ₁₅	0	γ ₇	0	0	0
Age 10 – male																	
Apr.	0	2	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	2γ ₁₅	2η ₃ γ ₁₅	0	γ ₇	γ ₆	η ₄ γ ₆	0
May	0	1	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	3γ ₁₅	2η ₃ γ ₁₅	0	γ ₇	γ ₆	η ₄ γ ₆	0
Jun.	0	0	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	4γ ₁₅	4η ₃ γ ₁₅	0	γ ₇	γ ₆	η ₄ γ ₆	0
Jul.	0	0	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	4γ ₁₅	4η ₃ γ ₁₅	0	γ ₇	γ ₆	η ₄ γ ₆	0
Aug.	0	0	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	4γ ₁₅	4η ₃ γ ₁₅	0	γ ₇	γ ₆	η ₄ γ ₆	0
Sept.	0	0	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	3γ ₁₅	3η ₃ γ ₁₅	0	γ ₇	γ ₆	η ₄ γ ₆	0
Age 10 – female																	
Apr.	0	2	0	0	0	0	4	4η ₁	4γ ₉	4η ₂ γ ₉	2γ ₁₅	2η ₃ γ ₁₅	0	2γ ₇	2γ ₆	2η ₄ γ ₆	0
May	0	1	0	0	0	0	2	2η ₁	2γ ₉	2η ₂ γ ₉	γ ₁₅	η ₃ γ ₁₅	0	2γ ₇	3γ ₆	3η ₄ γ ₆	0
Jun.	0	0	0	0	0	0	1	η ₁	γ ₉	η ₂ γ ₉	γ ₁₅	η ₃ γ ₁₅	0	2γ ₇	3γ ₆	3η ₄ γ ₆	0
Jul.	0	0	0	0	0	0	1	η ₁	γ ₉	η ₂ γ ₉	γ ₁₅	η ₃ γ ₁₅	0	2γ ₇	3γ ₆	3η ₄ γ ₆	0
Aug.	0	0	0	0	0	0	1	η ₁	γ ₉	η ₂ γ ₉	γ ₁₅	η ₃ γ ₁₅	0	2γ ₇	2γ ₆	2η ₄ γ ₆	0
Sept.	0	0	0	0	0	0	1	η ₁	γ ₉	η ₂ γ ₉	γ ₁₅	η ₃ γ ₁₅	0	γ ₇	γ ₆	η ₄ γ ₆	0
Matrix K: 'W' Stock used in Baseline A (in 60% of years)																	
Age 4																	
Apr.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Sept.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Age 10 – male																	
Apr.	0	0	2	2	0	0	0	0	0	0	2	0	0	0	0	γ ₁₀	0
May	0	0	1	1	0	0	0	0	0	0	3	0	0	0	0	γ ₁₀	0
Jun.	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	2γ ₁₀	0
Jul.	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	2γ ₁₀	0
Aug.	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	γ ₁₀	0
Sept.	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	γ ₁₀	0
Age 10 – female																	
Apr.	0	0	2	2	0	0	0	0	0	0	2	0	0	0	0	γ ₁₀	0
May	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	2γ ₁₀	0
Jun.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2γ ₁₀	0
Jul.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3γ ₁₀	0
Aug.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3γ ₁₀	0
Sept.	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2γ ₁₀	0

Month	Sub-area																
/Age-class	1	2	3	4	5	6	7W	7E	8W	8E	9W	9E	10	11	12SW	12NE	13

Matrix L: 'W' Stock used in Baseline A (in 40% of years)

Age 4																	
Apr.	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	1
Jun.	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	1
Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sept.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Age 10 – male																	
Apr.	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	1
Jun.	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	1
Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sept.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Age 10 – female																	
Apr.	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	1
Jun.	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	1
Aug.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Sept.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1

Matrix G: 'O' Stock used in Baseline B (2 stock model, in all years)

Age 4																	
Apr.	0	2	1	1	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	γ_7	0	0	0
May	0	1	1	1	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Jun.	0	0	1	1	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Jul.	0	0	1	1	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Aug.	0	0	1	1	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Sept.	0	0	1	1	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	γ_7	0	0	0
Age 10 – male																	
Apr.	0	2	2	2	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	2 γ_{15}	2 $\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
May	0	1	1	1	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	3 γ_{15}	3 $\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Jun.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	4 γ_{15}	4 $\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Jul.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	4 γ_{15}	4 $\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Aug.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	4 γ_{15}	4 $\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Sept.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	3 γ_{15}	3 $\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Age 10 – female																	
Apr.	0	2	2	2	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	2 γ_{15}	2 $\eta_3\gamma_{15}$	0	2 γ_7	2 γ_6	2 $\eta_4\gamma_6$	0
May	0	1	1	1	0	0	2	2 η_1	2 γ_9	2 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	2 γ_7	3 γ_6	3 $\eta_4\gamma_6$	0
Jun.	0	0	0	0	0	0	1	η_1	γ_9	$\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	2 γ_7	3 γ_6	3 $\eta_4\gamma_6$	0
Jul.	0	0	0	0	0	0	1	η_1	γ_9	$\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	2 γ_7	3 γ_6	3 $\eta_4\gamma_6$	0
Aug.	0	0	0	0	0	0	1	η_1	γ_9	$\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	2 γ_7	2 γ_6	2 $\eta_4\gamma_6$	0
Sept.	0	0	0	0	0	0	1	η_1	γ_9	$\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0

Matrix H: 'O' Stock. As Matrix F but allowing 'O' stock into sub-area 10 (Sensitivity trial 9, all years) $\gamma_{21} = \frac{1}{2}\gamma_7$

Age 4																	
Apr.	0	2	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	γ_7	0	0	0
May	0	1	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	γ_{21}	γ_7	γ_6	$\eta_4\gamma_6$	0
Jun.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	γ_{21}	γ_7	γ_6	$\eta_4\gamma_6$	0
Jul.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	γ_{21}	γ_7	γ_6	$\eta_4\gamma_6$	0
Aug.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Sept.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	γ_7	0	0	0
Age 10 – male																	
Apr.	0	2	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	2 γ_{15}	2 $\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
May	0	1	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	3 γ_{15}	3 $\eta_3\gamma_{15}$	γ_{21}	γ_7	γ_6	$\eta_4\gamma_6$	0
Jun.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	4 γ_{15}	4 $\eta_3\gamma_{15}$	γ_{21}	γ_7	γ_6	$\eta_4\gamma_6$	0
Jul.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	4 γ_{15}	4 $\eta_3\gamma_{15}$	γ_{21}	γ_7	γ_6	$\eta_4\gamma_6$	0
Aug.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	4 γ_{15}	4 $\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Sept.	0	0	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	3 γ_{15}	3 $\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0
Age 10 – female																	
Apr.	0	2	0	0	0	0	4	4 η_1	4 γ_9	4 $\eta_2\gamma_9$	2 γ_{15}	2 $\eta_3\gamma_{15}$	0	2 γ_7	2 γ_6	2 $\eta_4\gamma_6$	0
May	0	1	0	0	0	0	2	2 η_1	2 γ_9	2 $\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	γ_{21}	2 γ_7	3 γ_6	3 $\eta_4\gamma_6$	0
Jun.	0	0	0	0	0	0	1	η_1	γ_9	$\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	γ_{21}	2 γ_7	3 γ_6	3 $\eta_4\gamma_6$	0
Jul.	0	0	0	0	0	0	1	η_1	γ_9	$\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	γ_{21}	2 γ_7	3 γ_6	3 $\eta_4\gamma_6$	0
Aug.	0	0	0	0	0	0	1	η_1	γ_9	$\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	2 γ_7	2 γ_6	2 $\eta_4\gamma_6$	0
Sept.	0	0	0	0	0	0	1	η_1	γ_9	$\eta_2\gamma_9$	γ_{15}	$\eta_3\gamma_{15}$	0	γ_7	γ_6	$\eta_4\gamma_6$	0

Month	Sub-area																
/Age-																	
class	1	2	3	4	5	6	7W	7E	8W	8E	9W	9E	10	11	12SW	12NE	13

Matrix M: 'W' Stock. As Matrix K but allowing 'W' stock into sub-area 8 and 9E (Sensitivity trial 14, 60% of years)

Age 4																	
Apr.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Sept.	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Age 10 – male																	
Apr.	0	0	2	2	0	0	0	0	4 γ_{30}	4 $\eta_2\gamma_{30}$	2	2 η_3	0	0	0	γ_{10}	0
May	0	0	1	1	0	0	0	0	4 γ_{30}	4 $\eta_2\gamma_{30}$	3	3 η_3	0	0	0	γ_{10}	0
Jun.	0	0	0	0	0	0	0	0	4 γ_{30}	4 $\eta_2\gamma_{30}$	4	4 η_3	0	0	0	2 γ_{10}	0
Jul.	0	0	0	0	0	0	0	0	4 γ_{30}	4 $\eta_2\gamma_{30}$	4	4 η_3	0	0	0	2 γ_{10}	0
Aug.	0	0	0	0	0	0	0	0	4 γ_{30}	4 $\eta_2\gamma_{30}$	4	4 η_3	0	0	0	γ_{10v}	0
Sept.	0	0	0	0	0	0	0	0	4 γ_{30}	4 $\eta_2\gamma_{30}$	3	3 η_3	0	0	0	γ_{10}	0
Age 10 – female																	
Apr.	0	0	2	2	0	0	0	0	4 γ_{30}	4 $\eta_2\gamma_{30}$	2	2 η_3	0	0	0	γ_{10}	0
May	0	0	1	1	0	0	0	0	2 γ_{30}	2 $\eta_2\gamma_{30}$	1	η_3	0	0	0	2 γ_{10}	0
Jun.	0	0	0	0	0	0	0	0	γ_{30}	$\eta_2\gamma_{30}$	1	η_3	0	0	0	2 γ_{10}	0
Jul.	0	0	0	0	0	0	0	0	γ_{30}	$\eta_2\gamma_{30}$	1	η_3	0	0	0	3 γ_{10}	0
Aug.	0	0	0	0	0	0	0	0	γ_{30}	$\eta_2\gamma_{30}$	1	η_3	0	0	0	3 γ_{10}	0
Sept.	0	0	0	0	0	0	0	0	γ_{30}	$\eta_2\gamma_{30}$	1	η_3	0	0	0	2 γ_{10}	0

Month /Age- class	Sub-area														
	1	2	3	4	5	6	7W	7E	8W	8E	9W	9E	10	11	12SW 12NE 13
Matrix E: 'W' Stock used in Baseline C (all years)															
Age 4															
Apr.	0	0	0	1	0	0	0	0	0	0	1	η_3	0	0	0
May	0	0	0	1	0	0	0	0	0	0	1	η_3	0	0	0
Jun.	0	0	0	1	0	0	0	0	0	0	1	η_3	0	0	0
Jul.	0	0	0	1	0	0	0	0	0	0	1	η_3	0	0	0
Aug.	0	0	0	1	0	0	0	0	0	0	1	η_3	0	0	0
Sept.	0	0	0	1	0	0	0	0	0	0	1	η_3	0	0	0
Age 10 – male															
Apr.	0	0	0	2	0	0	0	0	0	0	2	$2\eta_3$	0	0	γ_{10} 0
May	0	0	0	1	0	0	0	0	0	0	3	$3\eta_3$	0	0	γ_{10} 0
Jun.	0	0	0	0	0	0	0	0	0	0	4	$4\eta_3$	0	0	$2\gamma_{10}$ 0
Jul.	0	0	0	0	0	0	0	0	0	0	4	$4\eta_3$	0	0	$2\gamma_{10}$ 0
Aug.	0	0	0	0	0	0	0	0	0	0	4	$4\eta_3$	0	0	γ_{10} 0
Sept.	0	0	0	0	0	0	0	0	0	0	3	$3\eta_3$	0	0	γ_{10} 0
Age 10 – female															
Apr.	0	0	0	2	0	0	0	0	0	0	2	$2\eta_3$	0	0	γ_{10} 0
May	0	0	0	1	0	0	0	0	0	0	1	η_3	0	0	$2\gamma_{10}$ 0
Jun.	0	0	0	0	0	0	0	0	0	0	1	η_3	0	0	$2\gamma_{10}$ 0
Jul.	0	0	0	0	0	0	0	0	0	0	1	η_3	0	0	$3\gamma_{10}$ 0
Aug.	0	0	0	0	0	0	0	0	0	0	1	η_3	0	0	$3\gamma_{10}$ 0
Sept.	0	0	0	0	0	0	0	0	0	0	1	η_3	0	0	$2\gamma_{10}$ 0
Matrix I: 'O_w' Stock used in sensitivity trial 20 (all years) $\gamma_{28} = (0.7/0.3) *$ ($1+\gamma_9+\eta_2\gamma_9$)															
Age 4															
Apr.	0	2	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	0 0 0
May	0	1	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	γ_6 γ_{24} 0
Jun.	0	0	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	γ_6 γ_{24} 0
Jul.	0	0	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	γ_6 γ_{24} 0
Aug.	0	0	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	γ_6 γ_{24} 0
Sept.	0	0	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	0 0 0
Age 10 – male															
Apr.	0	2	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	γ_6 γ_{24} 0
May	0	1	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	γ_6 γ_{24} 0
Jun.	0	0	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	γ_6 γ_{24} 0
Jul.	0	0	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	γ_6 γ_{24} 0
Aug.	0	0	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	γ_6 γ_{24} 0
Sept.	0	0	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_7	γ_6 γ_{24} 0
Age 10 – female															
Apr.	0	2	0	0	0	0	$4\gamma_{28}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	$2\gamma_7$	$2\gamma_6$ $2\gamma_{24}$ 0
May	0	1	0	0	0	0	$2\gamma_{28}$	2	$2\gamma_9$	$2\eta_2\gamma_9$	0	0	0	$2\gamma_7$	$3\gamma_6$ $3\gamma_{24}$ 0
Jun.	0	0	0	0	0	0	γ_{28}	1	γ_9	$\eta_2\gamma_9$	0	0	0	$2\gamma_7$	$3\gamma_6$ $3\gamma_{24}$ 0
Jul.	0	0	0	0	0	0	γ_{28}	1	γ_9	$\eta_2\gamma_9$	0	0	0	$2\gamma_7$	$3\gamma_6$ $3\gamma_{24}$ 0
Aug.	0	0	0	0	0	0	γ_{28}	1	γ_9	$\eta_2\gamma_9$	0	0	0	$2\gamma_7$	$2\gamma_6$ $2\gamma_{24}$ 0
Sept.	0	0	0	0	0	0	γ_{28}	1	γ_9	$\eta_2\gamma_9$	0	0	0	γ_7	γ_6 γ_{24} 0

Month /Age- class	Sub-area														
	1	2	3	4	5	6	7W	7E	8W	8E	9W	9E	10	11	12SW 12NE 13
Matrix J : 'O_e' Stock used in sensitivity trial 20 (all years) where $\gamma_{27} = (0.3/0.7) *$ ($1+\gamma_9+\eta_2\gamma_9$)															
Age 4															
Apr.	0	2	4	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	0 0 0
May	0	1	2	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	γ_{26} γ_{29} 0
Jun.	0	0	0	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	γ_{26} γ_{29} 0
Jul.	0	0	0	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	γ_{26} γ_{29} 0
Aug.	0	0	0	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	γ_{26} γ_{29} 0
Sept.	0	0	0	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	0 0 0
Age 10 – male															
Apr.	0	2	4	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	γ_{26} γ_{29} 0
May	0	1	2	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	γ_{26} γ_{29} 0
Jun.	0	0	0	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	γ_{26} γ_{29} 0
Jul.	0	0	0	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	γ_{26} γ_{29} 0
Aug.	0	0	0	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	γ_{26} γ_{29} 0
Sept.	0	0	0	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	γ_{25}	γ_{26} γ_{29} 0
Age 10 – female															
Apr.	0	2	4	0	0	0	$4\gamma_{27}$	4	$4\gamma_9$	$4\eta_2\gamma_9$	0	0	0	$2\gamma_{25}$	$2\gamma_{26}$ $2\gamma_{29}$ 0
May	0	1	2	0	0	0	$2\gamma_{27}$	2	$2\gamma_9$	$2\eta_2\gamma_9$	0	0	0	$2\gamma_{25}$	$3\gamma_{26}$ $3\gamma_{29}$ 0
Jun.	0	0	0	0	0	0	γ_{27}	1	γ_9	$\eta_2\gamma_9$	0	0	0	$2\gamma_{25}$	$3\gamma_{26}$ $3\gamma_{29}$ 0
Jul.	0	0	0	0	0	0	γ_{27}	1	γ_9	$\eta_2\gamma_9$	0	0	0	$2\gamma_{25}$	$3\gamma_{26}$ $3\gamma_{29}$ 0
Aug.	0	0	0	0	0	0	γ_{27}	1	γ_9	$\eta_2\gamma_9$	0	0	0	$2\gamma_{25}$	$2\gamma_{26}$ $2\gamma_{29}$ 0
Sept.	0	0	0	0	0	0	γ_{27}	1	γ_9	$\eta_2\gamma_9$	0	0	0	γ_{25}	γ_{26} γ_{29} 0

Adjunct 2

Table of commercial catches by area and sex for each season and year

[Table is on following page]

Sub-areas 1-12 are shown in Fig. 1 of Appendix 10.

Adjunct 2
Table of commercial catches by area and sex for each season and year

Sub-area	Year	Males					Females				
		J-A	M	J	J	A S-D	J-A	M	J	J	A S-D
1	1951	1	0	0	0	0	0	0	0	0	0
1	1957	17	0	0	0	0	0	11	0	0	0
2	1948	3	0	0	0	0	0	0	0	0	0
2	1950	3	0	0	0	0	0	2	0	0	0
2	1951	0	1	0	0	0	0	0	0	0	0
2	1952	1	0	0	0	0	0	1	0	0	0
2	1954	1	0	0	0	0	0	1	0	0	0
2	1957	1	0	0	0	0	0	1	0	0	0
2	1965	1	0	0	0	0	0	1	0	0	0
2	1966	2	0	0	0	0	0	1	0	0	0
2	1981	0	1	0	0	0	0	0	0	0	0
2	1985	1	0	0	0	0	0	0	0	0	0
5	1940	13	4	4	3	2	3	11	4	3	2
5	1941	25	8	7	6	4	4	22	7	6	3
5	1942	32	10	9	8	5	7	30	10	8	4
5	1943	25	8	7	6	4	4	22	7	6	3
5	1944	24	7	6	6	3	4	20	7	6	3
5	1945	2	1	1	1	1	0	0	0	0	0
5	1955	0	1	1	0	0	0	3	3	2	0
5	1956	0	1	1	0	0	0	3	3	2	0
5	1957	34	11	11	7	4	6	36	14	12	7
5	1958	46	11	13	6	3	4	55	22	21	7
5	1959	53	13	13	8	5	6	67	28	25	9
5	1960	36	18	13	11	5	5	57	38	31	12
5	1961	22	14	10	4	1	2	50	33	21	5
5	1962	7	21	16	10	1	1	35	39	27	12
5	1963	79	14	16	12	12	6	108	25	17	14
5	1964	83	18	14	18	8	21	98	25	14	18
5	1965	22	11	12	12	9	5	28	14	14	13
5	1966	19	22	10	20	19	17	46	41	22	21
5	1967	74	25	16	9	9	0	102	43	27	11
5	1968	54	17	16	22	7	7	83	35	28	23
5	1969	54	20	25	17	17	4	83	39	37	19
5	1970	88	41	52	35	2	4	116	60	63	37
5	1971	98	42	55	20	14	0	125	61	66	21
5	1972	108	41	52	36	11	37	134	59	63	38
5	1973	110	44	60	34	14	15	136	63	72	36
5	1974	80	40	18	9	5	7	108	58	30	11
5	1975	4	61	40	18	5	12	33	80	51	20
5	1976	143	23	19	5	0	5	170	41	30	6
5	1977	169	53	15	9	1	78	197	72	27	10
5	1978	83	44	32	8	0	38	97	49	34	7
5	1979	115	44	5	2	0	0	144	62	17	4
5	1980	101	67	60	63	41	12	100	67	59	62
5	1981	149	4	4	25	21	17	147	4	3	24
5	1982	113	2	15	29	17	8	89	5	18	44
5	1983	50	11	0	23	13	6	48	15	1	20
5	1984	21	43	14	10	0	1	18	36	11	15
5	1985	14	3	1	4	5	1	15	2	1	3
5	1986	0	0	0	0	0	0	0	0	0	0
6	1940	0	7	6	2	1	8	0	6	5	1
6	1941	1	12	11	3	1	14	0	12	11	2
6	1942	1	16	15	3	2	18	0	16	14	3
6	1943	1	13	11	3	1	13	0	12	11	2
6	1944	1	11	10	2	1	14	0	11	10	2
6	1945	0	1	1	0	0	2	0	0	0	0
6	1948	43	13	0	0	0	0	32	6	0	0
6	1949	15	5	0	0	0	0	17	12	0	0
6	1950	0	11	3	0	0	1	0	7	2	0
6	1951	34	25	2	1	0	0	28	9	1	1
6	1952	110	31	1	0	0	0	27	13	3	0
6	1953	76	11	3	0	0	0	42	4	2	0
6	1954	26	6	1	0	0	0	20	7	0	0
6	1955	13	7	0	0	0	0	9	6	0	0
6	1956	13	2	1	0	0	0	18	5	0	0
6	1957	3	16	18	3	2	17	0	16	17	3
6	1958	1	16	23	2	1	10	0	15	22	2
6	1959	1	19	23	3	2	11	0	18	23	2
6	1960	1	14	18	3	2	9	0	14	18	3
6	1961	1	10	8	1	1	4	0	9	8	0
6	1962	0	20	19	3	0	3	0	20	18	3
6	1963	1	7	11	4	4	8	0	6	11	4
6	1964	3	22	16	7	3	12	2	22	15	7
6	1965	6	19	18	5	3	23	5	17	17	5
6	1966	0	23	9	7	7	15	2	23	9	7
6	1967	4	28	18	3	3	3	8	27	18	3
6	1968	10	14	20	8	3	12	3	14	19	8
6	1969	11	20	35	7	6	9	10	19	35	6
6	1970	7	55	82	14	1	6	3	54	81	14
6	1971	5	57	86	8	5	1	3	56	86	7
6	1972	2	36	41	6	3	35	1	35	41	5
6	1973	1	35	42	10	8	86	3	35	42	9
6	1974	7	32	45	13	5	47	6	32	44	12
6	1975	13	87	60	7	2	8	3	87	60	6
6	1976	3	24	24	1	0	25	1	23	24	1
6	1977	4	74	18	3	0	117	2	74	17	2
6	1978	1	57	41	2	0	234	1	56	40	2
6	1979	5	82	108	37	13	64	23	82	108	36
6	1980	0	33	9	2	3	75	0	32	9	2
6	1981	1	69	31	11	6	47	0	68	30	11
6	1982	8	32	25	8	7	95	1	39	28	14
6	1983	0	30	37	4	2	65	0	31	37	3
6	1984	6	60	11	6	5	21	4	69	13	5
6	1985	0	8	7	2	2	18	0	5	8	1
6	1986	8	9	4	31	0	0	4	8	1	4
7W	1930	1	3	2	1	0	0	1	2	1	0
7W	1931	1	3	2	1	0	0	1	2	1	0
7W	1932	1	3	2	1	0	0	1	2	1	0
7W	1933	1	3	2	1	0	0	1	2	1	0
7W	1934	3	5	3	1	1	1	2	4	2	0
7W	1935	3	5	3	1	1	1	2	4	2	0
7W	1936	3	5	3	1	1	1	2	4	2	0
7W	1937	7	14	7	2	1	1	7	9	5	1
7W	1938	8	16	8	2	2	2	8	11	6	1
7W	1939	8	16	8	2	2	2	8	11	6	1
7W	1940	10	19	10	2	2	2	9	12	7	1
7W	1941	7	14	7	2	1	1	7	9	5	1
7W	1942	8	16	8	2	2	2	8	11	6	1
7W	1943	12	25	12	3	2	3	12	16	9	2
7W	1944	10	19	10	2	2	2	9	12	7	1
7W	1945	8	16	8	2	2	2	8	11	6	1
7W	1946	8	15	7	2	1	1	8	9	5	1
7W	1947	9	17	9	2	2	2	9	11	6	1
7W	1948	15	26	13	1	0	0	11	16	9	0
7W	1949	13	34	15	1	0	0	10	18	4	0
7W	1950	0	45	16	2	19	22	0	19	5	1
7W	1951	23	38	24	14	0	0	17	16	10	2
7W	1952	31	39	22	1	0	0	35	32	11	2
7W	1953	30	16	29	1	0	0	33	8	15	2
7W	1954	10	10	8	22	1	0	7	15	6	9
7W	1955	32	53	23	1	6	4	25	31	24	0
7W	1956	15	92	33	1	8	18	12	64	39	7
7W	1957	46	48	21	5	4	6	50	39	20	4
7W	1958	32	49	24	6	11	9	43	57	23	4
7W	1959	18	27	13	3	6	5	23	31	13	2
7W	1960	17	26	13	3	6	4	23	30	12	2
7W	1961	22	33	16	4	8	5	30	39	16	3
7W	1962	13	20	10	2	5	3	17	23	9	2
7W	1963	13	21	10	3	5	3	17	24	10	2
7W	1964	22	33	16	4	8	6	30	40	16	3
7W	1965	15	22	19	4	0	0	21	35	36	0
7W	1966	22	34	16	4	8	6	34	46	18	3
7W	1967	14	21	10	3	5	3	23	31	12	2
7W	1968	14	20	12	1	2	4	24	39	13	2
7W	1969	4	12	7	1	3	1	8	17	6	1
7W	1970	19	64	10	7	4	2	27	54	6	5
7W	1971	23	20	34	7	3	0	23	19	22	4
7W	1972	15	13	5	0	1	12	35	38	2	0
7W	1973	32	42	11	1	14	16	34	36	25	2
7W	1974	15	27	7	5	24	4	34	34	1	3
7W	1975	11	27	2	16	38	7	13	33	0	6
7W	1976	32	17	2							

Adjunct 2 cont.

Sub-area	Year	Males						Females					
		J-A	M	J	J	A	S-D	J-A	M	J	J	A	S-D
7W	1979	34	53	9	31	55	64	26	21	3	10	9	8
7W	1980	33	22	25	37	9	35	40	40	7	9	1	5
7W	1981	30	38	55	38	25	3	32	29	11	9	3	2
7W	1982	37	34	46	25	13	7	38	24	14	12	6	1
7W	1983	24	34	24	32	10	10	42	27	18	13	6	4
7W	1984	37	22	18	16	17	42	29	7	19	13	10	16
7W	1985	30	7	37	35	12	43	17	16	18	10	4	7
7W	1986	44	13	20	28	20	33	26	9	12	17	5	15
7W	1987	32	46	15	13	10	50	25	17	11	6	2	12
7W	1996	0	0	0	0	15	13	0	0	0	1	0	2
7W	1997	0	0	1	0	0	0	0	0	0	0	0	0
7W	1998	0	22	0	0	0	0	0	3	0	0	0	0
7W	1999	0	0	43	0	0	0	0	0	7	0	0	0
7E	1973	0	0	0	0	0	2	0	0	0	0	0	2
7E	1974	0	0	0	0	0	9	0	0	0	0	0	2
7E	1975	0	0	0	0	0	3	0	0	0	0	0	4
7E	1997	0	0	1	0	0	0	0	0	0	0	0	0
7E	1998	0	25	1	0	0	0	0	4	0	0	0	0
8W	1949	0	0	0	0	0	0	0	0	1	0	0	0
8W	1952	0	0	0	0	0	0	0	0	0	0	1	0
8W	1953	0	0	0	0	0	0	0	0	0	0	0	1
8W	1954	0	0	0	0	0	1	0	0	0	0	0	0
8W	1955	0	0	0	0	0	0	0	0	0	1	0	0
8W	1956	0	0	0	0	0	0	0	0	0	1	0	0
8W	1957	0	0	0	0	0	1	0	1	0	1	0	0
8W	1959	0	0	0	0	0	0	0	0	0	0	1	0
8W	1960	0	0	0	0	1	0	0	0	0	0	0	0
8W	1973	0	0	0	0	0	6	0	0	0	0	0	4
8W	1998	0	9	24	0	0	0	1	1	0	0	0	0
8E	1973	0	0	0	0	0	8	0	0	0	0	0	3
8E	1996	0	0	0	11	5	0	0	0	0	0	0	0
8E	1997	0	0	0	30	0	0	0	0	1	0	0	0
8E	1998	0	0	8	0	0	0	0	2	0	0	0	0
9W	1949	0	0	0	0	0	0	0	0	0	1	0	0
9W	1950	0	0	0	0	1	0	0	0	0	0	0	0
9W	1951	0	0	0	0	0	0	0	0	1	1	0	0
9W	1953	0	0	0	0	3	0	0	0	0	1	1	0
9W	1955	0	0	0	0	0	1	0	0	0	0	0	0
9W	1956	0	0	1	0	1	0	0	0	0	1	0	0
9W	1957	0	0	0	1	0	0	0	0	0	0	0	0
9W	1958	0	0	0	1	0	0	0	1	0	1	0	0
9W	1960	0	0	0	1	0	0	0	0	0	0	0	0
9W	1970	0	0	0	1	0	0	0	0	0	0	0	0
9W	1994	0	0	0	4	2	0	0	0	0	1	0	0
9W	1995	0	0	13	56	3	0	0	0	0	5	1	0
9W	1997	0	2	13	0	0	0	2	4	0	0	0	0
9E	1949	0	0	0	0	1	1	0	0	0	0	0	0
9E	1950	0	0	0	1	0	0	0	0	0	0	0	0
9E	1951	0	0	0	0	0	0	0	0	1	0	0	0
9E	1952	0	0	0	1	0	0	0	0	1	0	0	0
9E	1954	0	0	0	0	0	0	0	0	0	0	1	0
9E	1956	0	0	0	0	0	0	0	0	0	0	1	0
9E	1969	0	0	0	0	3	0	0	0	0	0	8	0
9E	1970	0	0	1	0	4	0	0	0	0	0	0	0
9E	1994	0	0	0	2	6	4	0	0	0	1	1	0
9E	1995	0	0	1	0	18	0	0	0	0	0	3	0
9E	1997	0	18	22	0	0	0	0	5	1	0	0	0
10	1949	0	0	0	1	4	0	1	1	0	0	3	0
10	1950	0	3	2	1	2	5	0	0	0	0	0	0
10	1951	0	2	3	0	0	0	0	1	0	1	0	0
10	1952	0	0	5	4	0	0	0	0	0	0	0	0
10	1953	12	13	11	2	0	0	3	1	0	0	0	0
10	1954	9	4	15	4	0	0	4	0	0	0	0	0
10	1955	2	1	6	11	0	0	5	0	2	0	0	0
10	1956	3	10	17	17	0	0	2	5	6	0	0	0
10	1957	1	5	8	16	1	0	1	2	6	4	0	0
10	1964	0	0	4	1	0	0	0	1	3	0	0	0
10	1967	0	0	2	0	0	0	0	1	2	0	0	0
10	1968	0	0	2	0	0	0	0	12	0	0	0	0
10	1969	0	0	5	2	0	0	0	1	4	0	0	0
10	1970	0	1	6	1	0	0	2	2	0	0	0	0
10	1971	0	0	5	2	1	0	2	5	2	0	0	0
10	1972	0	0	2	0	0	0	0	1	1	0	0	0
10	1973	0	1	12	0	2	0	0	1	4	0	1	0
10	1974	0	0	5	1	0	0	0	0	0	0	0	0
10	1975	0	7	11	0	0	2	0	1	5	0	0	0
10	1976	0	0	0	6	1	0	3	0	0	0	0	6
10	1977	0	0	0	0	0	0	0	0	0	0	0	0
10	1979	0	0	8	0	0	0	0	0	0	0	7	0
10	1980	0	0	0	5	5	0	0	0	5	0	0	0
10	1981	0	0	0	7	6	0	0	0	0	2	0	0
10	1982	0	0	4	5	0	0	0	0	6	0	0	0
10	1983	0	0	1	2	3	0	0	0	0	1	4	0
10	1985	0	0	0	2	0	0	0	0	3	0	1	1
11	1930	0	0	0	0	0	0	0	1	1	0	0	0
11	1931	0	0	0	0	0	0	0	1	1	0	0	0
11	1932	0	0	0	0	0	0	0	1	1	0	0	0
11	1933	0	0	0	0	0	0	0	1	1	0	0	0
11	1934	0	0	0	0	0	0	0	1	1	0	0	0
11	1935	0	0	0	0	0	0	0	1	1	0	0	0
11	1936	0	0	0	0	0	0	0	1	1	0	0	0
11	1937	0	0	0	0	0	0	0	1	1	0	0	0
11	1938	0	0	0	0	0	0	0	1	1	0	0	0
11	1939	0	0	0	0	0	0	0	1	1	0	0	0
11	1940	0	0	0	0	0	0	0	1	1	0	0	0
11	1941	0	0	0	0	0	0	0	1	1	0	0	0
11	1942	0	0	0	0	0	0	0	1	1	0	0	0
11	1943	0	0	0	0	0	0	0	1	1	0	0	0
11	1944	0	0	0	0	0	0	0	1	1	0	0	0
11	1945	0	0	0	0	0	0	0	1	1	0	0	0
11	1946	1	1	3	4	1	2	5	8	7	4	1	1
11	1947	1	1	3	5	1	2	6	9	9	5	1	1
11	1948	0	1	2	13	7	3	19	10	9	12	1	0
11	1949	0	0	4	1	1	0	6	8	6	3	4	0
11	1950	0	5	5	3	0	5	0	12	16	3	0	1
11	1951	1	3	3	7	0	0	27	17	20	6	0	0
11	1952	1	7	3	9	0	0	30	37	20	9	0	0
11	1953	2	3	12	18	1	0	12	17	19	9	0	0
11	1954	10	9	21	18	0	0	15	30	53	21	1	1
11	1955	0	1	17	16	4	5	15	33	37	26	5	3
11	1956	2	4	9	25	13	15	9	22	11	22	11	8
11	1957	2	1	7	6	2	12	10	31	14	3	1	10
11	1958	1	9	32	32	14	5	9	25	50	40	22	8
11	1959	1	5	17	18	8	2	5	14	27	22	12	4
11	1960	1	4	14	15	6	2	4	11	23	18	10	4
11	1961	1	5	19	20	9	3	5	15	31	25	14	5
11	1962	1	4	17	17	8	2	5	13	27	21	12	4
11	1963	1	4	14	14	6	2	4	11	22	18	10	3
11	1964	0	4	14	14	6	2	4	11	22	17	10	3
11	1965	1	5	16	31	13	1	9	21	22	22	18	1
11	1966	1	7	24	25	11	3	5	15	30	24	13	5
11	1967	1	5	19	19	9	2	5	14	28	23	12	5
11	1968	0	2	11	5	5	1	1	12	25	8	6	4
11	1969	1	3	15	18	5	1	2	24	38	17	11	5
11	1970	1	2	27	6	1	1	6	11	30	12	2	4
11	1971	2	4	11	21	10	6	6	6	10	13	9	8
11	1972	1	1	22	40	17	1						

Adjunct 2 cont.

Sub-area	Year	Males					Females						
		J-A	M	J	J	A	S-D	J-A	M	J	J	A	S-D
12NE	1954	0	0	0	0	0	1	0	0	0	0	0	2
12NE	1955	0	0	0	2	1	0	0	0	0	2	0	0
12NE	1956	0	0	0	0	0	1	0	0	1	1	0	0
12NE	1957	0	0	0	0	0	0	0	0	1	1	0	0
12NE	1958	0	0	0	0	0	0	0	0	0	0	0	1
12NE	1960	0	0	0	0	0	0	0	1	0	0	1	0
12NE	1961	0	0	0	0	0	0	0	0	1	0	0	0
12NE	1962	0	0	0	0	0	0	0	0	1	0	0	0
12NE	1973	0	0	0	10	8	10	0	0	0	9	12	6
12NE	1974	0	0	0	22	0	0	0	0	0	18	0	0
12NE	1975	0	0	0	1	0	0	0	0	0	0	0	0

Appendix 11**MODIFICATIONS TO BYCATCH LEVELS TO BE USED IN THE TRIALS**

Hiroshi Hatanaka and Shigeyuki Kawahara

Hatanaka and Kawahara opposed the modifications to trials concerning the incidental catch off Japan proposed in Appendix 9, for the following reasons: (1) the modifications were proposed at the 2002 meeting, at the final stage of *ISTs* although much effort has already been spent on this issue for the past several years. The proposal should be made at the next *Implementation*; (2) the proposal is based on only the

last half year's statistics of incidental catch submitted by Japan, for which seasonal and yearly changes are known; (3) the incidental catch option is applied to the historic catch from 1900 as well as the future. So the proposed incidental catch, especially 150 whales in the sensitivity trial, must be overestimated.

Appendix 12**STOCK STRUCTURE HYPOTHESES FOR THE NORTH ATLANTIC MINKE WHALE IMPLEMENTATION REVIEW**

Justin G. Cooke

The analyses of microsatellite and mitochondrial DNA from the Norwegian genetic samples 1997-2001 (SC/54/RMP6) suggest a relatively low level of genetic differentiation between sub-areas within the Northeastern Atlantic. In the context of the RMP *Implementation Review* it will be necessary to formulate plausible stock structure hypotheses that are consistent with these findings.

The following tentative hypotheses are proposed:

(H0) Null hypothesis

Animals move randomly between sub-areas each year. Abundance in sub-areas fluctuates from year to year (the so-called *Additional Variance*, an estimate of which is given in SC/54/RMP5) but no identifiable area-specific sub stocks exist. Under this hypothesis, the allocation of animals to a sub-area is independent of the previous year.

(H1) Site fidelity without inheritance

Young animals recruit randomly to a 'home' sub-area, to which they retain a degree of site fidelity throughout life. The site fidelity cannot be complete, because in order to

model the shifts of abundance between areas, it is necessary to allow for them to feed in neighbouring sub-areas in some years. This is equivalent to the 'Overlap with Shift-at-Random' hypothesis used for the Southern Hemisphere minke whale *Implementation*.

Under this hypothesis, the abundance in each sub-area will be correlated with the abundance in the previous year, but the new recruitment to a sub-area will be independent of the previous abundance in the sub-area, except to the extent that it is dependent on the total population of all sub-areas.

(H2) Site fidelity with partial inheritance ('quasi-humpback')

Young animals recruit to a home sub-area, as in Hypothesis 1, but there is a degree of partial maternal 'inheritance' in the choice of sub-area. Each year, $X\%$ of surviving calves recruit to the home sub-area of their mothers, while $(100-X)\%$ are allocated randomly to a home sub-area independently of their parentage.

The following approach is proposed to select the value of X :

- (i) determine, on the basis of standard mitochondrial DNA divergence models, the maximum value of X consistent with the observed low level of area-specific haplotype segregation, assuming typical mutation rates;
- (ii) select, to span the plausible range: (*H2a*) this maximum plausible value of X ; (*H2b*) half the maximum plausible value.

The case $X = 0$ is hypothesis *H2*.

Issues of mating and paternity are not considered here, because they are not relevant for the modelling of abundance and population dynamics, and thus are not incorporated explicitly into the simulation models used for

Implementation Simulation Trials. The simplest hypothesis to account for the apparent lack of area-specific effect in the microsatellite data would be that mating occurs randomly on the breeding grounds, but it is not necessary to assume this in the context of the above hypotheses.

Issues of leakage, seepage, etc, whereby animals permanently change their home sub-area designation, are not considered, because experience with the Southern Hemisphere minke whale *Implementation* suggests they are not critical in determining the safety of different RMP variants, as they tend to reduce the severity of effects of harvesting on populations.

Appendix 13

'PLAUSIBILITY': IN THE CONTEXT OF THE RMP IMPLEMENTATION SCHEDULE

T. Smith, J. Cooke, H. Hatanaka, M. Taylor, P. Wade and D. Butterworth

'Plausibility' as the Scientific Committee has discussed has several meanings and arises under several of the boxes in the *Schedule for Implementation* described in table 2 (Item 6.2) of the Committee's report. The important aspects of the meaning of plausibility vary somewhat in the issues to be addressed in the different boxes in the table. Here, a rough outline is provided of how discussions of plausibility could be structured at next year's meeting.

Such considerations could be facilitated by a small intersessional Working Group (Smith (Chair), Cooke, Hatanaka, M. Taylor, Wade, Butterworth, Kawahara, Givens) that would endeavour to improve this outline and encourage submissions for next year's meeting to address the items in the outline.

It is noted that there is a connection with the Stock Definition Working Group, especially in defining stock structure archetypes, and with the planned intersessional work on the North Pacific minke implementation. Plausibility discussions would benefit from input from the planned intersessional work of these groups.

Suggested terms of reference include developing general approaches to all elements of plausibility arising in the *Schedule for Implementation* as identified in the outline below.

Outline for Scientific Committee Discussion of Plausibility in relation to RMP Implementation

- I. Pre-Implementation Assessment (Box 1 of table 2)
 - A. Generation of hypotheses:
 - (1) From data.
 - (2) Selecting suitable null hypotheses in absence of data.
 - B. Selecting plausible ranges of uncertainty about:
 - (1) Past and future catches.

- (2) Abundance.
- (3) Biological rates.
- C. Selecting a set of plausible stock structure archetypes to be defined by the Stock Definition Working Group.
- II. Deciding Trial Structure (Box 2)
 - A. Plausibility of trial structure.
 - B. Plausibility of implementation of stock structure hypotheses.
- III. Conditioning and final trial structure (Box 3)
 - A. Evaluation of adequacy of fitted models ('conditioned') for each hypothesis.
 - B. Principles for weighting hypotheses and trials.
 - C. Types of weights:
 - (1) High-Medium-Low.
 - (2) Ranking.
 - (3) Numerical.
 - D. Methods of assigning weights:
 - (1) Subjective.
 - (2) Data-fit.
 - (3) 'Prior probability'.
 - E. Methods of interpreting results of multiple trials:
 - (1) Subjective.
 - (2) Multi-criteria decision making.
 - (3) Other.
 - F. Evaluation of the implications for RMP performance:
 - (1) For each hypothesis in the total set of hypotheses.
 - (2) For each trial.
- IV. Review results of final trials (Box 4)
 - A. Selection of RMP management areas options.
 - B. Selecting one or more implementations.
 - C. Defining any additional data requirements.

Appendix 14

REPORT OF THE WORKING GROUP ON THE NORTH ATLANTIC MINKE WHALE RMP IMPLEMENTATION REVIEW

D. Butterworth, J. Cooke, T. Smith, L. Walløe and T. Lyrholm

General planning and timeline

The Group noted that an RMP *Implementation Review* was now (over-)due, according to the Committee's guideline in its annotation (9) to the RMP (IWC, 1999, p.255), which

recommends that a *Review* normally be scheduled within five years of completion of the *Implementation*, which in this case was completed in 1993. The group noted that implementation of the RMP, in terms of a *Catch Limit*

Calculation (CLC) using the CLA, is not tied to the *Implementation Review* process. However, it would be desirable for the time series of abundance estimates to be updated prior to a CLC, because the currently accepted estimates are based on data to 1995. If the time series is not updated, the phase-out rule would apply from 2004 onwards. The group considered that updating of the time series of abundance estimates would be feasible at the 2003 meeting, and that the *Implementation Review* could probably be completed at the 2004 meeting, unless new information on stock structure necessitated substantial revision of management areas and/or *Implementation Simulation Trials*.

Abundance estimates

Sources of abundance information known to the group are listed in Table 1. The group noted that for the purpose of conditioning potential *Implementation Simulation Trials*, the Committee could use available abundance estimates without necessarily requiring access to all the basic data. For actual RMP *Implementation*, data would need to be lodged with the Secretariat and accessible according to the RMP provisions. Following this year's annual meetings, the Secretariat should locate all the relevant data and arrange for access to be obtained, or renewed where this has expired.

Catch/bycatch data

All catches to 1990

The data files compiled by the Secretariat for the 1992 *Implementation* can be used. Generally these include detailed records from the early 1950s onwards, plus some earlier catches which have been allocated to sex and area using the best available information.

Catches 1991-2001

Norway: data have been submitted to the Secretariat: permission for their use in the *Implementation Review* to be sought.

Greenland: data contained in Danish Progress Reports.

Iceland: no catches recorded during 1991-2001.

Bycatches: these appear to have been low, but Smith will compile information from Progress Reports and national sources, especially from countries bordering designated RMP Management Areas (e.g. UK, Ireland, Denmark, Norway, Iceland).

Projected whaling

Norwegian whaling is expected to continue at levels set according to a retuned version of the RMP. The current tuning used is to 0.62; Walløe advised that it would likely be further modified to 0.60. The Group noted that the primary task of the Committee was to predict the performance of the Commission's RMP, which is based on the 0.72 tuning, but that some projections based on possible levels of actual catch, such as the national management procedure, could be made, by analogy with the way additional mortality such as bycatches are handled. It would be assumed that catch limits assigned to all Northeastern areas and to the CM area would be taken.

Pending development of an AWMP for Greenland, it would be assumed that aboriginal whaling would continue, based on the catch limits currently in effect for East and West Greenland.

No information on possible future minke whaling was available from Iceland. For the purpose of simulating the operation of the RMP, it would be assumed that RMP catch

Table 1
Abundance estimates and trends for conditioning.

Small Area(s)	Year(s)	Organiser/ Programme	Platform	Reference(s) for estimates	Data status
Northeast Atlantic					
ES, EB, EC, EN	1988-89	Norway/NASS	ship	Schweder <i>et al.</i> (1997)	submitted, avail.
ES, EB, EC, EN	1995	Norway/NILS	ship	Schweder <i>et al.</i> (1997)	submitted, avail.
ES, EB, EC, EN	1996-2001	Norway/NILS	ship	SC/54/RMP5	submitted, avail.
NS (part of EN)	1994	SCANS	ship	Hammond <i>et al.</i> (2002)	available ²
Central North Atlantic					
CM	1987	Norway/Iceland	ship	Øien (2000)	submitted, avail.
CM	1988-89	Norway	ship	Schweder <i>et al.</i> (1997)	submitted, avail.
CM	1995	Norway/Iceland	ship	Schweder <i>et al.</i> (1997) + Borchers <i>et al.</i> (1998)	submitted, avail.
CM	1997	Norway/NILS	ship	SC/54/RMP5	submitted, avail.
CIC	1987	Iceland/NASS	aircraft	Hiby <i>et al.</i> (1989) ¹	not found
CIC	1995	Iceland/NASS	aircraft	Borchers <i>et al.</i> (1997)	
CIC	2001	Iceland/NASS	aircraft	Borchers <i>et al.</i> (2003)	not submitted
Note: Borchers <i>et al.</i> (2002) recommend, due to methodology issues, using only the 2001 absolute abundance estimate, plus the trend from 1987-2001					
CG, CIP	1987-89	Iceland	ship	IWC (1993) p.66	access expired
CG, CIP	1995	Iceland/NASS	ship	Borchers <i>et al.</i> (2002)	access expired
CG, CIP	2001	Iceland/NASS	ship	analysis pending	not submitted
Western North Atlantic					
WG	1987-88	Greenland	aircraft	IWC (1990) p.43	
WG	1993	Greenland	aircraft	Larsen (1995)	not submitted
WC				Guessed value in IWC (1992) p.251	
WC: G. of Maine	1995-98 ?	USA	ship	Waring <i>et al.</i> (2002)	
WC: G. of St. L.	1995-96	Canada	aircraft	Kingsley and Reeves (1998)	

¹ An alternative analysis of these data is given in Borchers *et al.* (1997).

² Available from RUWPA.

limits would be taken from all areas in which there are no other forms of whaling, including the CIC (Iceland coastal) and CIP (central pelagic) areas.

Stock structure hypotheses and analyses

The group noted that the stock structure hypotheses considered in the 1992 Implementation may need to be revised in light of: (a) analysis of the data collected since that time; (b) general advances in stock structure concepts since that time.

A provisional analysis of Norwegian microsatellite and mtDNA (SC/54/RMP6) found no evidence of distinction between the *Small Areas* in the Northeastern *Medium Area*, but some evidence of difference between samples from the CM *Small Area* and the remaining areas. Other work in press suggests that EN (North Sea plus southern Norwegian Sea) may contain a distinct stock.

The group identified the following work to be done before next year's meeting:

Various modern analytical techniques should be applied to the microsatellite and mtDNA data analysed in SC/54/RMP6, including the Boundary Rank Method and other approaches, with a view to determining whether the data contained further evidence of stock structure. Martin and Skaug have expressed interest in pursuing various approaches.

Other available information should be compiled and taken into account, e.g. Palsboll's work which involves samples from several areas (e.g. Palsboll *et al.*, 1997), the data used by Andersen *et al.* (2000) and data from any other available samples from Greenland and Iceland. The Norwegian samples from CM are mainly from the northeastern part of the area (around Jan Mayen). It would be useful to determine whether these samples relate more closely to samples from other parts of the Central Area or to samples from the Northeastern area.

Determination of maximum 'inheritance' of feeding area migration consistent with the available genetic data (the quantity denoted 'X' in Annex D, Appendix 12) should be attempted for the stock structure hypotheses proposed in Annex D, Appendix 12, based on the appropriate theory.

All stock structure hypotheses will need to be fully specified (so that they can potentially be included in *ISTs*), and will need to incorporate a provision for interannual variability, which should be tuned to roughly match the range of additional variability estimated from the data (e.g. $\sigma_{\eta} = 0.30$; SC/54/RMP5).

Management areas and RMP variants

Choice of *Small* and *Medium* and/or *Combination Area* options will depend to some extent on the results of further work on stock structure hypotheses. Based on the analyses published or submitted to date, the following changes might be considered:

- (1) treating EN as a separate stock (*Medium Area*);
- (2) combining the EC, EB and ES *Small Areas*;
- (3) reconsideration of the status of the CM *Small Area*, depending on whether provisional evidence of separation between CM and the areas to the north and east (SC/54/RMP6) is confirmed by further analysis, and on whether comparison between Norwegian and Icelandic data indicates inhomogeneity within the CM *Small Area*.

In the 1992 *Implementation*, capping and cascading at *Medium Area* level (Northeast and Central North Atlantic) had been tested, and also the *Small Area* option. Cascading

at *Medium Area* level was the option recommended to the Commission (IWC, 1994, p.49). The same options could be considered this time, although with possibly revised *Small* and *Medium Area* definitions.

Implementation Simulation Trials

Priority to North Pacific minke and AWMP will limit Allison's time to work on North Atlantic minke trials this year. Other members of the intersessional group could pursue the option of using simpler generic models to check which factors are potentially important, before specifying trials (see table 2 of the Scientific Committee's report). At the 2003 Annual Meeting, it can be judged whether *ISTs* need to be conducted, and initial specifications drawn up if applicable.

Intersessional work

The group recommended that an intersessional correspondence group be established to continue preparations for the *Implementation Review* and to facilitate the accomplishment of the tasks identified above. The membership should include Allison, Butterworth, Cooke, Lyrholm, Martien, Øien, Palka, Schweder, Skaug, Smith, Vikingsson, Witting. The terms of reference are:

- (1) Compile abundance estimates and catch data for use in conditioning possible *Implementation Simulation Trials*.
- (2) Ensure that appropriate further analyses of genetic data are conducted.
- (3) Prepare an appropriate set of fully-specified stock structure hypotheses, consistent with the available data and analyses, for the 2003 Annual Meeting.
- (4) Review any other relevant material on plausible scenarios for *ISTs*.
- (5) Report on progress prior to 2003 Annual Meeting.

REFERENCES

- Andersen, L.W., Born, E.W., Dietz, R., Haug, T., Øien, N. and Bendixen, C. 2000. Population structure of Greenland and NE Atlantic minke whales (*Balaenoptera acutorostrata*) based on sequence variation of the D-loop of mtDNA and DNA microsatellite variation. Paper SC/52/AS8 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal.]
- Borchers, D.L., McCracken, M., Gunnlaugsson, T. and Burt, M.L. 1997. Estimates of minke whale abundance from the 1987 and 1995 NASS aerial surveys. Working paper SC/5/AE/2 for the NAMMCO Scientific Committee Working group on Abundance Estimates (unpublished). [Available from www.nammco.no.]
- Borchers, D.L., Øien, N., Gunnlaugsson, T. and Burt, M.L. 1998. Minke whale abundance in the NVS stratum of the CM Management Area from NASS95. Paper SC/50/RMP10 presented to the IWC Scientific Committee, April 1998 (unpublished). [Paper available from the Office of this Journal.]
- Borchers, D.L., Pike, D., Gunnlaugsson, Th. and Vikingsson, G. 2003. Analyses of the NASS 1987 and 2001 minke whale cue counting surveys taking account of distance estimation errors. [Available from: dlb@mcs.st-and.ac.uk, to be submitted to SC/55].
- Hammond, P., Benke, H., Berggren, P., Borchers, D.L., Buckland, S.T., Collet, A., Heide-Jørgensen, M.-P., Heimlich-Boran, S., Hiby, A.R., Leopold, M. and Øien, N. 2002. Abundance of harbour porpoises and other cetaceans in the North Sea and adjacent waters. *J. Appl. Ecol.* 39:361-76.
- Hiby, A.R., Ward, A. and Lovell, P. 1989. Analysis of the North Atlantic Sightings Survey 1987: aerial survey results. *Rep. int. Whal. Commn* 39:447-55.
- International Whaling Commission. 1990. Report of the Scientific Committee. *Rep. int. Whal. Commn* 40:39-180.
- International Whaling Commission. 1992. Report of the Scientific Committee, Annex K. Report of the Working Group on North Atlantic Minke Trials. *Rep. int. Whal. Commn* 42:246-51.
- International Whaling Commission. 1993. Report of the Scientific Committee. *Rep. int. Whal. Commn* 43:55-92.

- International Whaling Commission. 1994. Report of the Scientific Committee. *Rep. int. Whal. Commn* 44:41-67.
- International Whaling Commission. 1999. Report of the Scientific Committee. Annex N. The Revised Management Procedure (RMP) for Baleen Whales. *J. Cetacean Res. Manage. (Suppl.)* 1:251-8.
- Kingsley, M.C.S. and Reeves, R.R. 1998. Aerial surveys of cetaceans in the Gulf of St. Lawrence in 1995 and 1996. *Can. J. Zool.* 76:1529-50.
- Larsen, F. 1995. Abundance of minke and fin whales off West Greenland, 1993. *Rep. int. Whal. Commn* 45:365-70.
- Oien, N. 2000. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 8. NASS-87 abundance of minke whales in the CM Management Area. *J. Cetacean Res. Manage. (Suppl.)* 2:123-4.
- Palsboll, P.J., Bérubé, M., Haug, T., Heiberg, A.C., Larsen, F., Sears, R. and Sigurjónsson, J. 1997. Preliminary analysis of population genetic data obtained from North Atlantic minke whales, *Balaenoptera acutorostrata*. Paper SC/49/NA4 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 17pp. [Paper available from the Office of this Journal.]
- Schweder, T., Skaug, H.J., Dimakos, X.K., Langaas, M. and Oien, N. 1997. Abundance of northeastern Atlantic minke whales, estimates for 1989 and 1995. *Rep. int. Whal. Commn* 47:453-84.
- Waring, G.T., Quintal, J.M. and Fairfield, C.P. 2002. US Atlantic and Gulf of Mexico Marine Mammal Stock Assessments – 2002. *NOAA Technical Memorandum NMFS-NE XXX* [Available at <http://www.nefsc.noaa.gov/psb>].
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Annex E

Report of the Standing Working Group (SWG) on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP)

Members: Donovan (Chair), Allison, Borodin, Bravington, Breiwick, Butterworth, Clark (C), Cooke, Dereksdóttir, Etylina, George, Givens, Gunnlaugsson, Johnston, Kim, Kingsley, Magnússon, Melnikov, O'Hara, Pike, Punt, Rogan, Rooney, Rosenbaum, Rowles, Schweder, Sutaria, Suydam, Taylor (M), Tichotsky, Wade, Walløe, Witting, Zeh, Zelensky.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks

Donovan welcomed the participants. He reminded them that the Commission was expecting the Scientific Committee to present them with a recommended *SLA* for consideration at this year's meeting. This will also entail consideration of how to present the recommended *SLA* to the Scientific Committee and the Commission, and continued discussion of scientific aspects of an aboriginal subsistence whaling scheme in the light of comments received at the Commission meeting in Hammersmith (IWC, 2002a). He also hoped to complete discussions of the gray whale trial structure and review progress on research in Greenland. He recalled the proposed GUP solution to the selection issue raised in Seattle, which seemed to him both elegant, scientifically valid and in the best interests of both the Commission and the hunters, provided the GUP performance satisfied the needs of the Commission.

1.2 Election of Chair

Donovan was elected Chair.

1.3 Appointment of rapporteurs

Allison, George, Givens, Johnston, O'Hara and Punt acted as rapporteurs, with assistance from the Chair.

1.4 Adoption of agenda

The adopted agenda is given as Appendix 1.

1.5 Review of documents

The documents available to the SWG were SC/54/AWMP1-5 and SC/54/Rep2 the report of the Fourth Workshop on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP).

For ease of reading, unless another reference is given, 'Last meeting' refers to SC/54/Rep2. A glossary of terms is given as Appendix 2 and the full trial specifications are given in Appendix 3.

2. BOWHEAD WHALES AND SELECTION OF AN *SLA*

2.1 Modifications to *SLAs* since the Fourth Workshop

2.1.1 The G-G *SLA*

SC/54/AWMP3 provided a complete description of the G-G *SLA*. At the core of this *SLA* is a penalised maximum likelihood estimator that generates estimates of three predictor variables: carrying capacity, net yield and stock size. An optimal Bayes rule linear model is then fit to these predictors and one interaction term using the statistical merging and optimisation strategy published by Givens (1997; 1999; 2000). The goal of this fit is to best match the strike limits provided by the idealised catch control law *H* (IWC, 1998, pp.207-8) on a weighted subset of *Evaluation Trials*. The final strike limit also includes variability dampening and snap-to-need features. Included in the *SLA* are two protection levels: a 30% reduction in strike limit if the stock is believed to be moderately reduced from the current level (2002) and a zero strike limit if the stock is believed to be below 2,000 whales. Several tunings are described.

SC/54/AWMP3 described how the resulting *SLA* generally focuses on safely satisfying moderate need, while favouring stock protection by setting strike limits below what would be required to fully satisfy need in the final portion of this century in extreme scenarios where need might triple from present levels. When faced with plausible data suggesting risk to the stock, the *SLA* is constructed to reduce the strike limit, thereby undesirably reducing need satisfaction when the data are misleading but desirably protecting the stock when the data reflect reality. In terms of need satisfaction, the *SLA* incrementally downweights the importance of greater need satisfaction as the absolute level of need satisfaction increases. In other words, as need approaches full satisfaction, the *SLA* focuses increasingly on risk avoidance. Details of the procedure are given in *J. Cetacean Res. Manage.* 5(1).

2.1.2 The D-M *SLA*

SC/54/AWMP5 described the D-M *SLA* and recent modifications. The *SLA* is based on the concept of Adaptive Kalman Filtering (AKF), the combination of Kalman filtering and Bayesian methodology. The *MSYR-K* parameter space is represented by a two-dimensional grid of values that are initially assumed to be equally likely. For each point in the parameter grid an Extended Kalman Filter is applied, which is appropriate when the underlying dynamics are non-linear. Every time a new survey estimate

becomes available, the stock estimate is updated and, furthermore, a posterior probability is calculated by Bayesian methods for each point in the parameter grid. A catch control law is specified and a strike limit then calculated, conditional on the values of the two parameters ($MSYR$, K) and the stock estimate, and with its associated posterior probability. A cumulative probability distribution is then constructed from the sequence of strike limits and their associated posterior probabilities. The final strike limit is based on a pre-specified percentile of this distribution. The *SLA* is tuned by specifying the steepness of the catch control law and the percentile in the cumulative distribution function for the conditional strike limit. Before the final strike limit is given, a 20% maximum change in strike limits between blocks is imposed and a snap-to-need feature is incorporated.

This *SLA* is thus based on well-established methodologies and therefore has a sound theoretical basis; the stock estimates are obtained by the filters in a well understood way. It is also transparent in the sense that the conditional estimates of the state and their associated probabilities are always available, as is the cumulative distribution function for the strike limit. The catch control law is of a general form which has been used in the past by the IWC. This version of the D-M differs from that presented last year because: (1) a more flexible catch control law is used instead of the H-rule, resulting in removal of any discontinuities; (2) the number of *MSYR*-filters has been increased from four to seven, giving a smoother cumulative distribution function for the strike limit; and (3) two tuning parameters are used instead of one.

The ($MSYR$, K) grid for the D-M *SLA* is discrete and was deliberately made fairly coarse for computational reasons. Filters corresponding to seven *MSYR* values are used and this can give the cumulative distribution function a shape of alternating flat and steep parts where the 'plateaus' correspond to the different *MSYR* values. Magnússon noted that this feature can be removed by using a finer *MSYR* grid, giving a smoother cumulative distribution function (c.f. SC/54/AWMP5). He also noted that if need fulfilment in the first 20 years is considered to be a major goal, the snap-to-need percentage can be lowered at the beginning of management and then increased to 95% over time. This change will result in full need satisfaction initially in most trials without any significant change in depletion statistics.

2.1.3 The GUP *SLA*

Following agreement at the last meeting, the SWG also considered an *SLA* (henceforth referred to as the 'Grand Unified Procedure' or GUP) that is based on combining the G-G and D-M *SLAs*. This *SLA* is based on applying the baseline variants of the D-M and G-G *SLAs*, ignoring their 'snap-to-need' features¹, to obtain two strike limits. These strike limits are then pooled by simple arithmetic averaging and the 'snap-to-need' feature applied. Although Givens and Dereksdóttir had discussed several alternative ways of constructing a GUP they had not identified a formulation that performed better than simple arithmetic averaging during the intersessional period.

2.1.4 Conclusion

The Chair recalled that at the last Annual Meeting, the Scientific Committee had agreed that it had two excellent procedures available to it. Subsequently the developers had

carried out further refinements to their procedures as agreed, as well as contributing to the GUP *SLA*. The SWG thanked the developers and Allison for their extensive intersessional work, noting, in particular, that the intersessional development period following the January 2002 workshop had been very short. Full technical specifications for the two *SLAs* are given in *J. Cetacean Res. Manage.* 5(1).

2.2 Review of results for the D-M, G-G and GUP *SLAs*

At its last meeting, the SWG requested that the Secretariat finalise coding and conditioning of the *Evaluation* and *Robustness Trials* for B-C-B bowheads, and run the full set of *Evaluation* and *Robustness Trials* for each of two variants of each candidate *SLA*, the GUP, the *CLA* of the *RMP*, and when the catch is set equal to: (a) 0; (b) need; and (c) *H*. It also requested that the Secretariat compile the results in the form of the following tables and plots (in principle, each table and plot could be produced for each trial):

- (1) 5th, median and 96th percentiles for all the statistics (see Table 1 for the details of the statistics).
- (2) 5th, median and 96th percentiles for the mandatory statistics.
- (3) Plots of time-trajectories (2003-2102) of 1+ population size for: (a) all 100 simulations for the case catch = *H* (from the start of the simulation rather than 2003); (b) the pointwise medians for each candidate *SLA*; and (c) simulations 1-5 for each candidate *SLA*.
- (4) Plots of the 100 time-trajectories (2003-2102) of 1+ population size for each candidate *SLA*.
- (5) Plots of the 100 time-trajectories (2003-2102) of strike limit for each candidate *SLA*.
- (6) Plots of pointwise medians and for simulations 1-5 of the time-trajectories (2003-2102) of the strike limit for each candidate *SLA*.
- (7) The Zeh/Brewick plots of the mandatory performance statistics produced by the simulation software.
- (8) The Givens trade-off plot.
- (9) Plots of the 100 time-trajectories (1848-2102) for catch = 0, catch = *H* and for the GUP *SLA*.

Allison reported that she had corrected a coding error in the trials with time varying survivorship (BR10c and BR11) and had re-conditioned some of the BR6, BR13 and BR16 trials that had exhibited unexpected behaviour in the past or that had previously not been conditioned. She reported that all of the trials had been run for all of the *SLA* variants as requested and that the full set of results would be archived at the Secretariat. She also reported that all of the requested tables and plots had been completed. Noting the enormous amount of work involved in this, the SWG expressed their appreciation in having all of the calculations completed and the results summarised prior to its first meeting.

A small group consisting of Dereksdóttir, Givens, Magnússon and Punt considered the complete set of results for the *Evaluation* and *Robustness Trials*. They developed a subset of the tables and plots for consideration by the SWG based primarily on eliminating results for those trials that were uninformative with respect to the relative performance of candidate *SLAs*. These results are available on request from the Secretariat but have not been appended to the SWG report in the interest of paper conservation. It was noted that particular attention should be paid to trials for which equating catch and need would not adequately protect the stock. It was **agreed** that the Chair, in consultation with the intersessional Steering Group, would decide on an appropriate selection of results for publication. At a

¹ The 'snap-to-need feature' involves setting the strike limit equal to the need level if the 'raw' strike limit from an *SLA* exceeds 95% of need.

Table 1
Performance statistics.

ID	Name	Mandatory	Optional	Time Periods	Use to explain performance to layperson	Use to evaluate performance for SC	Details
D1	Final Depletion	1+, mature		100	Yes	Yes	P_T / K
D2	Lowest Depletion		mature	100	Yes	Yes	$\min(P_t / K) : t = 0, 1, \dots, T$
D6	Trajectories 1 and 2		1+, mature	100	Yes	No	
D7	Pointwise Quantile Trajectories		1+, mature	100	Yes	No	
D8	Rescaled final Depletion	Yes		100		No	P_T / P_T^*
D9	Minimum number of whales		1+, mature	100		No	$\min(P_t) : t = 0, 1, \dots, T$
D10	Relative Increase	Yes		100		Yes	P_T / P_0
N1	Total Need Satisfaction		Yes	20, 100	Yes	Yes	$\sum_{t=0}^{T-1} C_t / \sum_{t=0}^{T-1} Q_t$
N2	Longest Shortfall		Yes	20, 100	Yes, after rescaling	Yes	(negative of the greatest number of consecutive years in which $C_t < Q_t$) / T
N4	Fraction of years in which catch = quota		Yes	20, 100	Yes	Yes	
N7	Percent Need Satisfaction Pointwise Quantile Trajectory Plot		Yes	100	No	Yes	
N8	Percent Need Satisfaction Trajectories 1 and 2 Plot		Yes	100	No	Yes	
N9	Average need satisfaction	Yes		20, 100	Yes	Yes	$\frac{1}{T} \sum_{t=0}^{T-1} \frac{C_t}{Q_t}$
N10	Average Annual Variation in Catch		Yes	100	No	Yes	
N11	Anti-curvature Catch Variation Statistic		Yes	100	No	Yes	
N12	Mean downstep	Yes					
R1	Relative Recovery	1+, mature		100	Yes	Yes	$P_{t_r} / P_{t_r}^*$ where t_r = 1st year in which P_{t_r} passes through $MSYL$
R3	Time Frequency in Recovered State after Recovery		1+, mature	100	Yes	Yes	
R4	Relative Time to Recovery		1+, mature	100	Yes	Yes	

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 $t \geq 2003$ (defined as $t=0$). K is the pristine population size. Results are calculated for $T=20$ and 100.

minimum, this will include the results of all of the *Evaluation Trials* in some combination of graphical and tabular presentation.

Before specifically addressing the results of the *Evaluation* and *Robustness Trials*, the SWG considered the results of a series of trials (BE01X, BE16X and BE16Xa) that were specified at the last meeting when it was noted that:

Section 5.4 of Annex E of IWC (2002b) describes a trial designed to test sensitivity of SLAs to a sharp decline in abundance (to 2000 whales). The Workshop reviewed this scenario and **agreed** that it should be implemented for trials BE01 and BE16. It reiterated, however, that such a scenario is not even remotely plausible and should not be considered an *Evaluation* or *Robustness Trial*. It is rather being used to assess the relative speed at which the SLAs react to large changes in population size. However, it recognised that the interpretation of the results will be difficult since there are both positive and negative aspects of reacting quickly to such a change.

These trials involve a reduction in the total population size to 2,000 whales in the first year of the projection period – in effect an instant four-five fold drop in the population size from the current size, estimated to be about 10,000.

In examining the results, the Committee noted that the variants of both the G-G and D-M procedures coped with BE01X (MSYR = 2.5%, need increasing to 134 from 67 over the period, 10-year survey) but did not for the most

extreme trial BE16X (MSYR = 1%, need increasing from 67 to 201 over the period). For the variant of BE16X² with a five-year survey interval (i.e. BE16Xa), the D-M SLAs showed that they responded more quickly than the G-G SLAs and did not extirpate the population.

In discussing these results, the SWG reiterated that the scenario of a drop of the magnitude in year zero tested in these trials was not even remotely plausible and these trials should not be considered as *Evaluation* or *Robustness Trials*. Differences of interpretation of these results emerged, as predicted at the last meeting. Some members considered the negative effects of not reacting to marked changes in survey estimates considerably outweighed any positive effects, whereas others believed that reacting to a signal that was extremely unlikely given current knowledge of the bowhead population, was not necessarily advantageous. Schweder indicated his preference for the D-M philosophy in this regard.

The SWG **agreed** that the scenario given in the 'X' trials was precisely the sort to 'trigger' the *Implementation Review* process (particularly in association with rapidly increasing need requests). M. Taylor questioned if existing simulation trials were sufficient in the light of some predicted habitat

² Later added at the suggestion of Derekadóttir and Magnússon.

impacts of global warming, referring to his paper SC/54/E11 and some recent model predictions of the virtual disappearance of Arctic sea ice by the end of the century. A number of points were raised in the discussion of this item, concerning the plausibility of the analysis in SC/54/E11. Many of these had also been raised in discussion of that paper in the sub-committee on bowhead, right and gray whales (Annex F) and are not repeated here in detail (e.g. questions over assumptions concerning mortality rates, past surveys, lack of conditioning of the simulations) as well as the fact that bowhead whales have historically persisted through ice-free periods. After this discussion the SWG proposed no further trials and referred to its discussions of the role of *Implementation Reviews* below and under Item 6.3.2.

It has been recognised from the start of the development process that any individual factor or combination of factors that occurred in the future which suggested that the range of explored parameter space covered in the present trials might have been exceeded will result in an *Implementation Review*. It was noted that there are many potential outcomes from an *Implementation Review* including recommendations to continue use of the current *SLA*; to set a zero strike limit; to carry out an abundance estimate immediately; to establish further trials. Butterworth noted that it is possible to examine through simulation any 'meta-rules' that might be developed in conjunction with the *Implementation Review* process. Such an examination would necessarily consider the probability of: (1) unnecessarily initiating an early *Implementation Review*; and (2) not initiating an early *Implementation Review* when this is, in fact, needed. The nature of *Implementation Reviews* is discussed further under Item 6.3.

The 'X' trials did, as intended, highlight some of the design philosophies and features of the submitted *SLAs*. For example, the G-G *SLA* gave high priority to satisfying need in the first period over apparent signals in the early data. Givens noted that this was because he (and the G-G *SLA*) paid particular attention to the high quality bowhead data accumulated over the past 25 years that indicates that current need is sustainable (see the Committee's previous advice on this stock). Noting the preferences of some hunters for need satisfaction in the earlier simulated period over a hypothetical increase in need in the latter, the G-G *SLA* gave preference to the former. This feature is primarily implemented through the time-varying ε_t parameter, which Givens indicated could be reduced if required.

Similarly, the trial illustrated that the D-M *SLA* did not attempt to weigh satisfaction of short- versus long-term need differently. It reacts more quickly to data in the initial period than the G-G *SLA*. Magnússon and Dereksdóttir noted that it was straightforward to increase initial need satisfaction over a wider range of trials than it did at present by a simple modification to their *SLA* if required (i.e. changing the snap-to-need feature from 95% to 80% in the initial period). However, several participants indicated that they believed the philosophy of the current D-M procedure to be preferable.

It was noted that the performance of an *SLA* in situations in which carrying capacity was decreasing or natural mortality increasing needed to be compared to the performance of setting the strike limit equal to zero. This is because the purpose of an *SLA* is to manage aboriginal hunts and not, for example, climate change. The 30 variants of *Robustness Trials* BR09, BR10, BR11 and BR12 examine the impact on performance of time trends in K , time trends in $MSYR$, time trends in M , and episodic events. The trials

examine each of these factors separately, although some trials (e.g. BR10d-1, BR10d-8, BR10e-1, BR10f-1 and BR10f-1) involve combinations of factors. Taylor suggested that *Robustness Trials* were less plausible for not examining combinations of factors since environmental change could induce multiple adjustments in K , survival and reproduction. It was noted that the *Robustness Trials* do not include more trials that involve combinations of factors, primarily because of the difficulties associated with interpreting the results of such trials in the context of the relative performance of *SLAs*, and because the results of previous analyses during the development of the *RMP* did not show significant interactions among such factors, rather that the impact of combinations is largely additive.

2.3 Selection of an *SLA*

The SWG has spent a considerable amount of time considering the issue of the selection of an *SLA* (e.g. IWC, 2002b, pp.151-2). A variety of factors (e.g. design considerations, structure, elegance and performance) should be considered when selecting an *SLA*. The SWG reiterated its previous agreement that performance is, however, the key factor in the selection of an *SLA*. The SWG then examined the results for each of the *Evaluation Trials* in detail to assess differences in performance among five *SLAs* (G-G, GUP, D-M, G-G low and D-M low). In doing this, the medians were considered to represent 'anticipated performance' while the lower 5th percentiles represented 'guaranteed performance'. Appendix 4 lists the values for a subset of mandatory statistics for these five *SLAs* as well as those for catch = Need, catch = H and when the *CLA* of the *RMP* is used to determine the strike limit. Appendices 5 and 6 display the 100 time-trajectories of strike limit for each candidate *SLA* and the Breiwick/Zeh plots respectively for a subset of BE trials.

The SWG **agreed** that the major conclusion from the examination of the results of the *Evaluation Trials* was that all *SLAs* exhibited extremely good performance. Even where differences were identified these were generally relatively small. These are noted below:

- (1) As expected, the G-G *SLA* achieves greater need satisfaction in the first 20-40 years than the D-M *SLA*.
- (2) The G-G *SLA* is generally (though not always) more precise (in the sense of narrower 90% intervals) than the D-M *SLA*.
- (3) The D-M *SLA* outperforms the G-G *SLA* on trial BE04.
- (4) The emphasis by the G-G *SLA* on need satisfaction in the first 20-40 years leads to wider intervals for strike limits in the last 50 years compared with the D-M *SLA*.
- (5) The GUP never performs worse than both of the G-G and D-M *SLAs*, and sometimes outperforms both (e.g. BE07-SE).
- (6) The G-G *SLA* has an undesirable feature in that, for some trials (e.g. BE04, BE14), the strike limits increase in the first 50 years and then decrease. This behaviour occurs because of the emphasis placed on satisfying need in the short-term. Givens noted that it would be possible to modify the G-G *SLA* to reduce this effect.
- (7) On the pessimistic set of BE12 trials, median stock increase after 100 years was higher for G-G than D-M. On the risky high need trials (BE16, 16SE), median increase was higher for D-M than G-G.
- (8) Given the use of discrete levels for K and $MSYR$ in the D-M *SLA*, the strike limits for some of the trials (e.g. BE14) are stratified into several bands. Magnússon

commented that increasing the number of filters could be used to remove this feature of the results.

- (9) The 'low' tuning of the G-G *SLA* does not always incur a lower need satisfaction than the baseline tuning of this *SLA* (e.g. BE12, BE12a, BE04).

The SWG **agreed** that the performance of all of the *SLAs* was good. However, both the G-G and D-M *SLAs* exhibited the undesirable features mentioned above. Both developers indicated that their *SLAs* could be modified in the future to remove the remaining undesirable features. Various members attached lesser or greater importance to these factors and some members favoured one procedure over the other. Schweder indicated his preference for the D-M *SLA* on the general issue that it is based on the well-known Kalman filter technique and because of his views expressed earlier on the 'X' trials.

In discussion, it was noted that the GUP *SLA* does not exhibit these undesirable features to nearly the same extent as the G-G and D-M *SLAs* because it averages the strike limits from the component *SLAs*. For example, although the GUP does not always satisfy need in the first 20 years perfectly under all scenarios, it also almost never drops the strike limit below the current level of need.

The SWG also examined the performance of the *SLAs* for the *Robustness Trials*. Once again, all of the candidate *SLAs* performed well and there was little to choose between them. Attention was drawn to the relatively poor performance of the *SLAs* under the scenario where mortality rate is doubled over the period. Although it was noted that such a scenario might seem extreme (see discussion of SC/54/E11 and in Annex F), the SWG agreed that it should be monitored when conducting the *Implementation Review* process in the long-term. The value of photo-identification results was noted in this case. Schweder noted that in accordance with his views on the overall philosophy and the 'X' and *Robustness* trials, he believed that the D-M *SLA* performed slightly better overall. However, there was general agreement that the GUP *SLA* performed better than the other two *SLAs* for most of the *Robustness Trials* although the D-M and G-G *SLAs* slightly outperformed the GUP for a very small number of these trials.

Given the excellent overall performance of the GUP *SLA*, the SWG considered the implications of selecting it from other perspectives.

There was some discussion of the 'elegance' of choosing the average of two procedures rather than one of the components. Comments were made supporting the view that from that perspective, choice of a single procedure might be considered more elegant, less complex to tune should that ever be required, and easier to explain to the wider scientific community. Other comments were made noting that when an MCDM (multiple-criteria-decision-making) expert was invited to participate in the development of the RMP, he had recommended averaging the results of different management procedures. Furthermore, members noted that averaging two results obtained from very different approaches had the possibility of reducing bias and reducing variability. It was also noted that the excellent performance and innovative nature of both *SLAs* warranted their exposure to the wider scientific community.

After considerable discussion, the SWG **agreed** that the improved performance of the GUP over the other candidate *SLAs* more than compensated for any increased complexity and reduced elegance. In reaching this agreement, the SWG reiterated its previous decision that performance was the key

factor associated with selecting an *SLA*. It was noted that as had been hoped when it was first proposed in Seattle, the GUP *SLA* included a built-in check-and-balance system because, if one of its component *SLAs* behaved somewhat erratically in one instance, the effect would be muted by the better performance of the other *SLA*.

Finally, the SWG referred to the Committee's agreement early in the development process (IWC, 1997, p.88), that the goal was to develop an *SLA* that fully met the Commission's management objectives, and that once it had achieved that, it would not waste resources attempting to achieve some hypothetical level of 'perfection'. Whilst the SWG recognised that further work could be undertaken to refine and 'polish' the constituent *SLAs* of the GUP *SLA* (as noted by the developers themselves), it strongly believed that these resources should be dedicated to completing the *SLA* for the management of the gray whale harvest and addressing the serious issue of the Greenland fisheries, for which the Committee has recognised that it has never been able to provide satisfactory advice.

The complete set of the 100 time trajectories of strike limit and population size for the GUP *SLA* are given in Appendix 7. The median and 90% trajectories are given in Appendix 8.

2.4 Conclusion and recommendation

After careful consideration of the results of the trials and the consideration of the other factors noted above, the SWG **strongly recommends** that the GUP *SLA* (hereafter the 'Bowhead *SLA*') be forwarded to the Commission. It believes that this *SLA* meets the objectives of the Commission set out in 1994 (IWC, 1995) and represents the best scientific advice that the Scientific Committee can offer the Commission with respect to the management of the Bering-Chukchi-Beaufort Seas stock of bowhead whales. In making this recommendation it refers to its comments regarding the nature of the *Implementation Review* process and the other aspects of management discussed under Item 6.

The SWG noted that this is the first of the *SLAs* that it has recommended. The Commission endorsed the concept of an aboriginal subsistence whaling scheme with case-specific and generic components in 1998 (IWC, 1999a, pp.10-14) and is expecting to receive a recommended *SLA* for this stock at this year's meeting based on the Scientific Committee's report last year.

The SWG particularly wishes to acknowledge the outstanding contribution made by all of the developers to the final recommended *SLA*. It notes that the *Bowhead SLA* contains elements of all of the procedures originally considered. It formally wishes to thank Eva Dereksdóttir, Kjartan Magnússon, Geof Givens, Andre Punt, Sue Johnston and Doug Butterworth for the enormous amount of thought and effort put in to developing their candidate procedures and the generosity of spirit in sharing ideas evident throughout the process. Finally, it wishes to acknowledge the tremendous support offered by Cherry Allison, without whom the whole process would have ground to a standstill.

2.5 Comparison of results with RMP

The SWG recalled that early in the development process, some members of the Commission had indicated an interest in a comparison of the AWMP with the RMP. That request predated the decision of the Commission to accept case-specific *SLAs* as part of an AWS. The SWG noted that a strict comparison of the *Bowhead SLA* with the *CLA* is not

possible for a number of reasons, particularly with respect to: (1) the different objectives of each, notably the difference between management aimed at producing the highest possible continuing yield and management aimed at satisfying a limited need requirement in perpetuity; and (2) the case-specific nature of the *Bowhead SLA* that was tailored to manage a data rich population as opposed to the generic *CLA*, that had to be able to cope with a variety of situations.

The results of the comparison revealed that the *CLA* whilst performing satisfactorily on the risk-related statistics performed poorly in satisfying need.

3. GRAY WHALE TRIALS STRUCTURE

3.1 Progress since the Fourth Workshop (SC/54/Rep2)

At the last meeting, a variety of modifications were made to the trial structure and conditioning strategy for gray whales. Allison reported that the control program was now ready with respect to all the GE trials except GE24 (the inertia model) and that some trials had been conditioned. She also reported that the details of the changes relating to the inertia model had been clarified with the assistance of Punt, and the corresponding modifications to the common control program had been coded. However, due to time constraints, these coding changes had not yet been tested.

3.2 Model related issues

An in-depth assessment of gray whales was carried out at the present meeting by the sub-committee on bowhead, right and gray whales (see Annex F). The SWG examined the results of the assessment via members who had attended both meetings and it was **agreed** that none of the new information from this assessment necessitated changes to the basic biological model or parameters used to simulate gray whale dynamics for AWMP trials. However, it noted that two new abundance estimates are available (see Item 3.3).

The SWG also considered whether it was necessary to develop a stochastic dynamics model for gray whale trials, noting that it had done so for the bowhead case. Given the results under the bowhead scenarios, it **agreed** that it would suffice to use 'episodic events' trials as a simple surrogate for truly stochastic dynamics. By allowing frequent, small stochastic events (either positive or negative) with potential correlation (either positive or negative), a wide variety of stochastic dynamics could be approximated. See details under Item 3.3.

3.3 Trial specifications

The SWG noted that calf counts on the northbound migration had been made in several recent years. These surveys were begun in the early 1990s and have proved to be informative (see Annex F). Thus, the SWG considered whether future calf count data should be generated as part of the common control program to be available for use by potential *SLAs*. A number of positive and negative aspects to including calf count data were discussed, but the SWG finally **agreed** not to expand the simulation framework to include calf count data because it was confident that it would be able to develop a *SLA* with excellent performance for eastern North Pacific (ENP) gray whales without reliance on these data and therefore it could not justify making such data collection a future data requirement. It was noted that most of the aboriginal harvest is taken in the Russian Federation whilst smaller catches and the censuses are undertaken in the USA.

It is hoped that co-operation between these two countries will continue. Breiwick noted that it is expected that these surveys will continue in the future.

A related issue was whether to use the existing calf count data when conditioning trials. Although this increases the computing time required, the SWG **agreed** that conditioning should use all available data if possible. To address practical computational issues, it **agreed** that *Evaluation Trials* should be conditioned on the calf count data, whereas *Robustness Trials* should provisionally ignore the calf count data at this stage. If changes in software or hardware speeded the conditioning process, then Allison would review this decision with a view towards conditioning all trials on the calf count data.

The 2000/01 and 2001/02 abundance estimates for ENP gray whales presented at this meeting (see Annex F) were notably lower than the last previous estimate (1997/98). The SWG **agreed** that the recent variations in surveyed abundance must be taken into account in its trial structure. Three plausible explanations for the recent surveys are:

- (1) The 2000/01 and 2000/02 surveys are biased due to variations in migration patterns or some unknown reason.
- (2) These two surveys are no different than the other recent ones, and the apparent differences in abundance are merely the result of natural variability.
- (3) The drop in abundance in these two surveys is attributable to a distinct mortality/productivity event.

The SWG **agreed** that trials should cover all three possible explanations, and noted that (2) and (3) would require reconditioning. Of these three options, the SWG considered that: Option (1) should be investigated by only a very small number of sensitivity tests; Option (3) should be investigated more thoroughly, although the extent to which this was primarily an evaluation or robustness scenario will be decided at the next meeting; and Option (2) should be treated as a very plausible explanation and investigated thoroughly with trials.

The time series of ENP gray whale abundance estimates, including the recent ones mentioned above, exhibits several anomalies with respect to coefficients of variation. The CVs are known to have changed (due to a change in analysis approach) in 1995-6. In addition, it has long been recognised that considerable process error probably exists in this series because it is not possible to fit a smooth trend line that is contained in sufficiently many of the associated confidence intervals. After reviewing this information in light of the gray whale assessment conducted at this meeting, the SWG **agreed** that its existing trial structure captured all of these important aspects of the abundance series and its CVs.

At the last meeting, the SWG had changed survey frequency in the GE/GR trials from five years to 10 years, with some sensitivity tests set with six-year intervals. To avoid the mismatch between six-year survey intervals and five-year block quotas, the SWG **agreed** that the six-year intervals should be changed back to five years.

The SWG **agreed** that trials with episodic events should play a substantial role in GE/GR trials, to model a plausible biological possibility and as a surrogate for stochastic dynamics as discussed in Item 3.2. If the recent reduction in surveyed abundance of ENP gray whales was due to a mortality event, calf counts suggest that this event was manifested (at least in part) by neonatal mortality. Therefore, the SWG **agreed** that episodic event trials should consider episodic changes in both mortality rates and/or productivity.

A small group was appointed to finalise this stage of the trial specifications and the results of their deliberations will be incorporated into Appendix 3iii. It was also **agreed** that further issues related to trial structure (e.g. those raised in SC/54/AWMP2) will be discussed more thoroughly at the next intersessional workshop (see Item 9).

4. CONSIDERATION OF FISHERY TYPE 3

There was insufficient time for this item to be discussed. It was agreed that it should be placed on the agenda of the intersessional workshop.

5. GREENLANDIC FISHERIES AND THE GREENLANDIC RESEARCH PROGRAMME

In 1998, the Committee had informed the Commission that it would be extremely difficult, if not impossible, to develop an *SLA* for the Greenlandic fisheries that will satisfy all of the Commission's objectives. To this end the Committee recommended and the Commission accepted, the need to develop a cooperative research programme. This has been discussed in recent meetings (e.g. IWC, 2001b, pp.361-2).

5.1 Review of results from programme

5.1.1 Stock structure, range and movement

Last year, the Committee provided funds towards an annual programme of satellite tagging, based on a target of four informative tracks per year (IWC, 2002b, p.156). SC/54/O21 described the satellite tracking of two fin whales between two major coastal areas where fin whales are caught in West Greenland and an offshore concentration area. Fin whale catches in West Greenland were concentrated in two coastal areas during 1988-1999: the northern area being the archipelago of Aasiaat (68-69°N) and the southern area lying between Nuuk and Maniitsoq (64-65°N). The whales, tagged in the northern area in September 2000 and August 2001 were tracked for 76 and 32 days, respectively. Both animals moved into the southern area. Fin whales are believed to concentrate offshore in the central part of the northern Davis Strait west of 56°W. The fin whale in 2000 travelled to the offshore area during its movement between the northern and southern catch areas. Observations from a commercial minke whaler *Kato* have documented these offshore concentrations of fin whales between 1979 and 1983 as late as September (Larsen and Kapel, 1982). The whalers believed that the offshore areas are used during the northward migration of fin whales, although this tagged animal moved south through the area. The appearance of one of the tracked fin whales at the offshore area in October indicates that fin whales are still present in that area during the autumn. The connection between inshore and offshore fin whales in West Greenland suggests that the two aggregations belong to the same stock. It was noted that the offshore distribution extends to at least 58°W and that the recent abundance estimates are derived from surveys that do not extend beyond 57°W, suggesting that the abundance estimates might be underestimates.

The SWG thanked the Greenlandic scientists for this report and congratulated the researchers on their success with these two animals. It encouraged the continuation of this effort for both minke and fin whales and suggested that, if possible, marking later in the season might provide more information on migratory routes and wintering areas. There is evidence of at least one tag remaining attached to a fin whale for one year (although not transmitting) and further work to increase battery life is recommended.

In response to a question about the level of genetic sampling of the harvested animals, Witting responded that dependent upon the year, between 25 and 65% of the minke whales and between 15 and 42% of the fin whales have been sampled. He noted that for logistical reasons, last year had not been particularly successful. There had been no new effort to analyse genetic samples collected later than 1999. This issue of genetic sampling is discussed further under Item 5.1.4.

5.1.2 Abundance and trends

In the original research programme, it had been envisioned that use of coastguard vessels in the inshore waters might provide a time series of index of abundance data, at least for minke whales. These surveys were to have begun in late summer 2002 (IWC, 2002b, p.156). Witting reported that unfortunately these surveys have proved unsatisfactory and they have not been pursued further.

The SWG was disappointed to receive this news, noting that the possibility of developing a management procedure that used a combination of an annual relative index and infrequent absolute abundance estimates had been discussed at last year's meeting (IWC, 2002b, p.156).

The SWG briefly reviewed recent (since 1995) catch data for Greenland. However, noting: (1) the lengthy discussions of the numerous problems in interpreting catch per unit effort (CPUE) data within the Committee (e.g. IWC, 1988); (2) the absence of any information on effort; and (3) the difficulty in measuring effort in an opportunistic hunt with various components, the SWG **agreed** that use of CPUE data to imply trends shows little promise.

5.1.3 Biological data

Last year under this item, the Committee noted that Greenland intended to collect tissue samples from as many animals as possible for comparison with existing samples from other countries (e.g. Iceland, Canada and the USA) in order to examine stock identity issues (IWC, 2002b, p.156 and see Item 5.1.1 above). The issue of future genetic sampling is discussed further under Item 5.1.4.

In response to a question regarding the collection of other biological samples, Witting noted that hunters have forms to record length, sex, pregnancy status, etc; logistical difficulties regarding timing and location of the flensing of the hunt makes sampling by biologists impractical. It was suggested that training hunters to take specific biological samples might prove fruitful if allied to some type of reward system.

5.1.4 Future work

5.1.4.1 STOCK STRUCTURE, RANGE AND MOVEMENT

Satellite tracking will continue in 2002 with five tags available for either minke or fin whales. The SWG **agreed** that equal importance be given to tagging minke and fin whales. The SWG repeated its previous **recommendation** that every effort be made to obtain tissue samples for genetic analysis from the catch and that efforts to compare these samples with those from neighbouring countries be continued.

5.1.4.2 ABUNDANCE AND TRENDS

SC/54/AWMP1 reported that an aerial survey for large cetaceans is to be conducted off West Greenland in July to September 2002. The survey area and effort is similar to the

aerial cue-counting survey conducted in 1993 (Larsen, 1995), but the 2002 survey will be an aerial strip-transect survey based on digital photos. This method was tested with success on narwhals in Northwest Greenland in 2001, and analysis suggests that an abundance estimate from a digital photo survey is more precise than an estimate from a comparable sightings survey. Documentation and repeatability of the photo survey is also better than for an ordinary sightings survey, which is important when results are presented to hunters and whalers in Greenland. But more effort will be needed in the coming years in order to develop suitable correction factors for the number of submerged whales.

A number of issues were raised in the discussion of this new approach. With respect to potential problems of identification of species from such photographs, it was noted that both species have notable features that are visible from the air and can be seen from good aerial photographs. The possibility of problems arising in relatively poor sea states and at the periphery of the frame were noted. Although photogrammetry is not an aim of the survey, Kingsley believed that it should be possible to obtain lengths of whales sufficiently accurately to separate fin and minke whales. This would become clear after analysing the results from the 2002 survey.

Kingsley commented on the dramatically improved resolution of new digital cameras and their comparative economy with respect to processing and archiving.

There were several comments made that it would have been preferable to have either tried out this new technique in a feasibility study prior to its use in a full survey or tried to combine the photo survey with a more traditional survey with observers. Witting noted that it was intended to try out the system in a high density area in Iceland first as a calibration exercise. Kingsley noted the practical difficulties in a combined survey approach given that to obtain sufficient coverage the photographs must be taken from 1,700ft whereas traditional surveys are flown at 750ft. Greenland did not have the resources to carry out a full feasibility study or consider the use of two planes, one with observers and one for the photo-survey.

In terms of calibration and the estimation of numbers of whales submerged, it was noted that (as in traditional line-transect or cue-counting approaches) care must be taken to allow for confounding variables such as sea state, visibility (atmospheric and oceanographic conditions) and variations in whale distribution and density, and that detection probabilities should be estimated for differing environmental conditions. There was some discussion of appropriate platforms and methods but Witting noted that correction factors for the 2002 survey cannot be expected to be developed before the 2003 field season.

The selection of survey areas was discussed and it was noted that the survey was similar to previous surveys and encompassed the known hunting areas along the western Greenlandic coast, and at least some of the offshore areas out to the outer slopes of the banks where whales are known to aggregate. It was emphasised that the total distribution area of the stock is not accurately known.

The SWG welcomed the fact that a new abundance survey was to be undertaken and hopes that this innovative approach proves successful, not least because any *SLA* will require periodic abundance estimates if strikes can safely be allowed. It noted that whatever approach is used, the primary factor involved in determining the success of surveys in Greenland is the weather. It looks forward to receiving a full report of the survey at its next meeting.

5.2 Preliminary consideration of management procedures

Last year, the Committee had nominated a small group (comprising Witting, Magnússon, Dereksdóttir and Cooke) to conduct exploratory simulation studies involving the use of an annual index of abundance and an infrequent absolute abundance estimate. In light of the decision not to pursue the index of abundance cruises above, this approach became unnecessary. The SWG **agreed** that the small group should correspond intersessionally on possible future approaches.

5.3 Conclusion

Given the extreme importance of the Greenlandic Research Programme to the Committee's ability to provide management advice to the Commission, the SWG **agreed** that reviewing progress and developing further recommendations should be a high priority item for discussion at the next annual meeting.

6. SCIENTIFIC ASPECTS OF AN ABORIGINAL WHALING SCHEME

6.1 Carryover

The Commission has requested the Committee to include provisions for carryover in its consideration of an AWMP. In 2000, the Committee presented the Commission with an illustration regarding block quotas and carryover. The Commission considered this and agreed (IWC, 2001a, p.20).

...that blocks of five years with an inter-annual variation of fifty percent were satisfactory in terms of allowing for the likely variability in hunting conditions. It therefore agreed that these values are appropriate for use in trials. It was recognised that this does not commit the Commission to these values in any final aboriginal whaling management procedure.

In order to allow the Commission to consider this further, the SWG notes that if under a recommended *SLA*, current need is met (and there is no indication from the present results that this will not be the case), then a revised Schedule paragraph for bowhead whales might look something like:

For the years [2003-2007] inclusive, the total number of strikes shall not exceed [335]. The Strike Limit in any one year shall not exceed [100³].

The Committee had also agreed that the same 50% allowance may be carried over between the last year of one block and the first year of the next. It is emphasised that from a scientific perspective, the *Bowhead SLA* is robust to such a scenario with respect to carryover provisions and the harvest at such a level.

In order to illustrate how such a provision may work in practice, two example future scenarios are presented in Table 2 based on the current provision in the Schedule for strikes (i.e. 67 per year) – this would give a block total of 335 with a maximum of 100 (i.e. $(335/5)*1.5$, rounded down) in any one year.

In the first example, as the remaining strikes in each block are less than 50% of the maximum strike limit in any one year (i.e. 50), they are carried over in full (see table note¹). Note that in the second block of this example, the block limit is that provided by the updated *SLA* calculation but the remaining strikes column (see table note²) has been updated to include the carryover strikes (i.e. $335+38-80 = 293$). In the second example, the remaining strikes at the end of the

³ The Commission's present paragraph also includes a limit on the number of landed animals. This is outside the scope of the SWG whose simulation exercises assume that all strikes result in death.

Table 2

Illustrations of how the carryover provisions might work. For explanation of table footnotes see text - Item 6.1, last paragraph.

Year	Block limit	Max	Strikes used	Remaining	Cumulative	Between block carryover
1	335	100	65	270	65	
2	335	100	40	230	105	
3	335	100	62	168	167	
4	335	100	55	113	222	
5	335	100	75	38	297	38 ¹
6	335	100	80	293 ²	80	
7	335	100	67	226	147	
8	335	100	88	138	235	
9	335	100	69	69	304	
10	335	69	59	10	363	10 ¹

Year	Block limit	Max	Strikes used	Remaining	Cumulative	Between block carryover
1	335	100	78	257	78	
2	335	100	40	217	118	
3	335	100	62	155	180	
4	335	100	30	125	210	
5	335	100	45	80	255	50 ³
6	335	100	80	305	80	
7	335	100	67	238	147	
8	335	100	88	150	235	
9	335	100	69	81	304	
10	335	81	59	22	363	22

first block (80) exceeds the maximum allowed to be carried over (50), the actual carryover is 50 whales (see table note³).

6.2 Survey intervals and related issues

In considering this item last year, the Committee had discussed what process it might need to follow in the absence of data essential to the *SLA*, notably a new abundance estimate. It was agreed that the concept of phaseout (also present in the RMP) was appropriate i.e. the process by which catch limits are reduced in the absence of new abundance data. In presenting the Committee's report to the Commission (including representatives of the AEWG – the Alaska Eskimo Whaling Commission) last year, the Chair noted that this concept was the most contentious.

Some views were expressed that the phase-out concept should apply only to commercial whaling and is overly harsh, and even suggests mistrust of aboriginal whalers and hunters. The AEWG believed that AWMP 'rules' should provide hunters with as much freedom as possible to cope with environmental variability, since it has such a significant effect on surveys and hunting success.

At the Intersessional Workshop, the SWG noted these concerns. It referred to its earlier discussions of the difficulties in carrying out successful censuses⁴ (and hunting) in the Arctic environment and its efforts to take this into account both by using a survey interval of 10 years and in the carryover provision described above. However, it noted that it was not possible to successfully manage in the absence of data; it did not believe that it was acceptable for

catches to be allowed to continue at level of need if there was no new abundance information for long periods, should such an unlikely situation arise. Under the grace period scenario, it would be up to 15 years after the previous survey that the *SLA* will set catches to zero). This certainly does not imply mistrust of hunters and in the case of the bowhead whale situation, the co-operation and major contribution of the AEWG in the census effort is well recognised and greatly appreciated. Whilst it is hoped and expected that any 'grace period⁵' rule will never need to be utilised, it is important that any comprehensive management procedure includes rules for such an eventuality. The SWG **endorsed** these views and the principles developed in SC/54/Rep2 given below:

- (1) the grace period should not exceed five years (after which time, the *SLA* will set strikes to zero and it is likely that an *Implementation Review* will be initiated);
- (2) over the five-year period, the block limit shall be reduced by 50%;
- (3) carryover from the last block is permissible (the same conditions that can render a survey unusable can also preclude the hunt);
- (4) the use and distribution of strikes over the time period is the responsibility of the user (for example it may be decided to place no restrictions at the beginning of the period – but in the absence of an estimate in that period the catch will be reduced to zero in less than the five years – see Table 3);
- (5) when a survey is successfully conducted during the grace period, the *SLA* is applied and a quota generated – the quota is then applied retroactively to the current block and the 'used' strikes subtracted from the resultant block limit.

⁴ Weather and ice conditions often prevent the completion of a successful bowhead abundance survey even when all the best efforts are made. Since 1988, three successful censuses have been made (1988, 1993, 2001) in six attempts.

⁵ This seems to more accurately reflect the philosophy than the term phase-out.

Table 3
Examples of how a grace period rule might operate.

(a)	Block	Year	Block limit	Max	Strikes used	Remaining	Cumulative	Between block carryover
	1	1	335	100	78	257	78	
		2	335	100	40	217	118	
		3	335	100	62	155	180	
		4	335	100	30	125	210	
		5	335	100	45	80	255	50 ¹
	2	6	335	100	80	305 ²	80	
		7	335	100	67	238	147	
		8	335	100	88	150	235	
		9	335	100	69	81	304	
		10	335	81	59	22	363	22 ³
	3	11	167 ⁴	100	80	109	80	Grace period
		12	167	100	67	42	147	
		13	167	42	42	0	189	
		14	167	0	0	0	189	
		15	167	0	0	0	189	0
(b)	Block	Year	Block limit	Max	Strikes used	Remaining	Cumulative	Between block carryover
	1	1	335	100	78	257	78	
		2	335	100	40	217	118	
		3	335	100	62	155	180	
		4	335	100	30	125	210	
		5	335	100	45	80	255	50 ¹
	2	6	335	100	80	305 ²	80	
		7	335	100	67	238	147	
		8	335	100	35	203	182	
		9	335	100	45	158	227	
		10	335	100	45	113	272	50 ¹
	3	11	167 ⁴	100	67	150	67	Grace period
		12	167	100	55	95	122	Still no census
		13	167	95	45	50	167	Still no census
		14	167	50	45	5	212	Still no census
		15	167	5	5	0	217	0
	1	1	335	100	78	257	78	
		2	335	100	40	217	118	
		3	335	100	62	155	180	
		4	335	100	30	125	210	
		5	335	100	45	80	255	50 ¹
	2	6	335	100	80	305 ²	80	
		7	335	100	67	238	147	
		8	335	100	35	203	182	
		9	335	100	45	158	227	
		10	335	100	45	113	272	50 ¹
	3	11	167 ⁴	100	67	150	67	Grace period and Census
		12	167	100	80	70	147	New estimate
		13	335	100	75	163	222	New block implemented
		14	335	100	48	115	270	
		15	335	100	67	48	337	48

¹Limited to maximum carryover; ²Block limit + carryover - catch in first year; ³Actual strikes remaining; ⁴Half block limit calculated by the *SLA*.

It was also noted in discussion that the Scientific Committee could offer advice about the best strategy to use in the event of a series of poor surveys or similar problem, so they could react well ahead of any grace period deadline.

6.2.1 Examples

Below are three scenarios for when 'grace periods' might be invoked:

In the first example (Table 3a), the quota in each of the first two blocks is 335. Because no census is conducted by the

end of the second block, the grace period begins and the quota is reduced by half (rounded down to 167) for the third block. A carryover of 22 is allowed from the second to the third block, thus giving a total number of strikes remaining for the third block of 189. The maximum allowed catch (100) in any one year in the third block is the same as for the previous blocks. At the choice of the users, the strike limit is used in years 11-13. Because all strikes are used and no census has been conducted, the strike limit is set to zero after the end of year 13.

In the second example (Table 3b), a census is attempted in

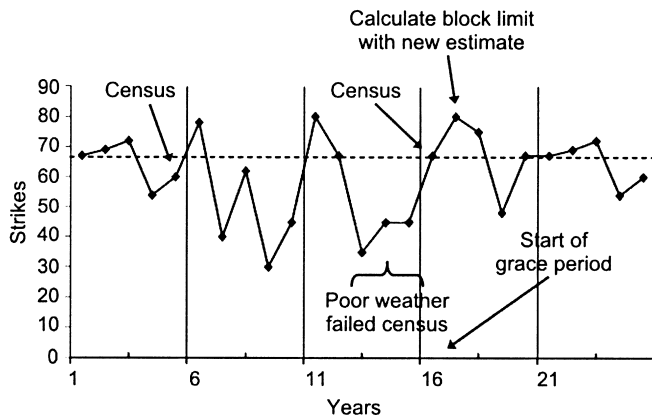


Fig. 1. Example of grace period scenario.

circumstances, an *Implementation Review* will be carried out every five years. One of the advantages of an AWMP is that it should reduce the workload of the Committee and obviate the need for the more traditional 'in-depth assessments' in their present form.

6.3.1 Regular Implementation Reviews

The SWG noted that *Implementation Reviews* will normally contain at least the following elements: (1) a review of information required for the *SLA* (i.e. catch data, abundance estimates); and (2) a review of information (e.g. biological and genetic data) to ascertain if the present situation is as expected and within tested parameter space (thus the review may result in the need to determine new trials). In order to account for the need for further action (e.g. before agreeing an abundance estimate or running new trials), the SWG **recommends** that *Implementation Reviews* are initiated the year before advice on a new block limit is expected. The SWG noted that it is not expected that every such review will entail a large amount of work. This will of course depend on a number of factors, largely dependent on the level of information available. This latter factor is related to the discussions under Item 6.4 below.

6.3.2 Unscheduled Implementation Reviews

Throughout its discussions, the SWG has also seen early *Implementation Reviews* as a safety feature if new information arrives that causes concern. It is recognised that calling such a review does not necessarily mean revising the Committee's advice to the Commission, although it may do so. The SWG did not believe it appropriate to try to compile a formal list of what factors might 'trigger' such an early review (by its very concept it implies unexpected/unpredictable factors). The following list is thus provided to give examples of some possible factors:

- (1) Major mortality events (e.g. suggested by large numbers of stranded animals).
- (2) Major changes in whale habitat (e.g. the occurrence of natural or anthropogenic disasters or changes, e.g. oil spill, dramatic change in sea-ice).
- (3) Major ecological changes resulting in major long-term changes in habitat or biological parameters.
- (4) A dramatically lower abundance estimate (although the *SLA* has been tested, the Committee would review the potential causes of unexpected very low estimates).
- (5) Information from the harvest and hunters (this might include very poor harvest results, reports of low abundance despite good conditions, reports of large numbers of unhealthy animals).

- (6) Changes in biological parameters that may result in changes to management advice (e.g. reproduction, survivorship).
- (7) If there are cases when need is not being satisfied, significant positive information that might narrow the plausibility range and allow an increase in block limits.

6.4 Guidelines for surveys

The SWG reviewed and reconfirmed the principles for surveys developed at last year's meeting agreed by the Commission regarding: survey/census methodology and design; Committee oversight; and data analysis. It **agreed** that it was not necessary to develop these into a formal document for inclusion in the overall AWS at the present time. It noted that if the *Bowhead SLA* was to be adopted at this meeting, some consideration would be needed of the fact that some of the criteria (e.g. submission of data by a particular time) may need to be relaxed.

6.4.1 Survey/census methodology and design

The SWG had **agreed** that plans for undertaking a survey/census should be submitted to the Scientific Committee in advance of their being carried out, although prior approval by the Committee is not a requirement. This should normally be at the Annual Meeting before the survey/census is carried out. Sufficient detail should be provided to allow the Committee to review the field and estimation methodology. Considerably more detail would be expected if novel methods are planned.

6.4.2 Committee oversight

The SWG had **agreed** that it was appropriate that should it desire, the Scientific Committee could nominate one of its members to observe the survey/census to ensure that proposed methods were adequately followed. This would be more important if novel methods were being used.

6.4.3 Data analysis and availability

The SWG had **agreed** that it was appropriate that all data to be used in the estimation of abundance were made available to the Scientific Committee suitably in advance of the Annual Meeting at which an estimate was to be presented. If new estimation methods are used, the Committee may require that computer programs (including documentation to allow such programs to be validated) shall be provided to the Secretariat for eventual validation by them.

6.4.4 Estimates to use in the SLA

The SWG **agreed** that the most recent estimate accepted by the Committee for any year should be incorporated in the *SLA* calculations. If a new or revised estimate is obtained for the same period, then the old one should be replaced at the next *Implementation Review*.

6.5 Guidelines for data/sample collection

The Committee has tried to take into account the difficulties associated with obtaining data and samples from subsistence fisheries in its recommendations below.

The SWG **recommends** that data from each harvested animal should be collected and made available to the IWC. The following information should normally be provided for each harvest or individual whale as appropriate: species; number of animals; sex; season; position of catch (to the nearest village); length of catch (to 0.1m). It further requested that information/samples on reproductive status and samples for genetic studies be collected where possible. It also noted the value of additional studies to the

Implementation Review process, such as the use of photo-identification data for estimating survivorship (see earlier discussion) and urges that such research continues, where possible. The value of traditional knowledge was noted, and it was **agreed** that any such information will be valuable when conducting *Implementation Reviews*. In this regard it noted that it may in the future, as a result of discussions during the *Implementation Review* process, suggest particular additional analyses or data collections.

7. PRESENTATION OF RESULTS TO THE COMMISSION

7.1 General presentation

The SWG noted that this was a particularly important meeting for the presentation of results to the Commission. In accordance with the Commission's instructions it was presenting the first case-specific *SLA* as part of the overall AWS. It noted that this was part of a long process that involved continual consultation with (and feedback from) the Commission.

The SWG **recommends**, as in previous years:

- (1) a presentation of the Committee's report by the Chair of the SWG; and
- (2) informal discussions among the Chair of the SWG and interested Commissioners.

The SWG also noted the success of informal discussions with interested members of the Commission's sub-committee on aboriginal subsistence whaling (including hunters' representatives) and agreed that this would be valuable.

In terms of the presentation, the SWG gave considerable freedom to the Chair to decide the format (e.g. a PowerPoint presentation) but **agreed** that it should include aspects of the following: the history of the development process (including the concept of the need envelope); explanation of the factors examined in the *Evaluation and Robustness Trials* (see Table 5); graphical presentation of results (including catch and population size trajectories) for the *Bowhead SLA* from Trials BE01, BE09 and BE14 encapsulating a range of scenarios; and description and illustrations of the aspects of the AWS described under Item 6.

7.2 Management advice and incorporation into the Schedule

The Commission is aware that the Committee will be presenting it with an *SLA* for bowhead whales at this year's meeting. The SWG also noted that the Commission will be establishing catch limits for bowhead whales at this meeting. The SWG spent some time considering the procedural aspects of how to present its results.

It was noted that from a purely scientific viewpoint, the SWG believed that the *Bowhead SLA* represented the best tool for providing management advice to the Commission⁶ on the bowhead whale harvest. On these grounds alone it would be prepared to use the *SLA* to calculate block strike limits and present that advice to the Commission. However, it recognised that there are some procedural issues that need to be considered (i.e. that the Commission has not formally approved the approach) and that the strict conditions for the Guidelines for surveys would not have been met in terms of

data provision (see Item 6.2). Given this, it requested that the Secretariat will be prepared to use the *SLA* to calculate block strike limits, should the Commission request this. This can easily be done at the Commission meeting.

It was noted that to do this, in addition to incorporating the latest strike data, a decision needed to be taken on whether to include the new 2001 abundance estimate discussed in Annex F and partially referred to in the management advice provided in that Annex. The SWG noted that whilst this represented a good estimate (and certainly within the tolerance covered in the trials), it was known that a revised estimate using different methodology was expected to be received next year. It was unlikely that this would be very different from the present estimate. The SWG **agreed** that the Secretariat should be prepared to run the *SLA* both with and without the latest estimate if required.

With respect to incorporation into the Schedule, the SWG **agreed** that this should not be seen as a necessary prerequisite of the *Bowhead SLA*. In or out of the *Schedule*, it represents the best method for the Committee to provide advice and could be used as the basis for modification of the current *Schedule* provisions with respect to bowhead whales which refer to catch and strike limits. This issue was not a Scientific Committee matter and was the responsibility of the Commission.

8. MANAGEMENT ADVICE FOR MINKE AND FIN WHALES OFF WEST GREENLAND

The Greenland catch for 2001 included 137 landed minke whales from West Greenland (32 males, 91 females and 14 unknown sex, plus 2 struck and lost), 14 landed minke whales from East Greenland (14 females, 0 males, with 3 struck and lost) and 7 fin whales (3 males and 4 females, and one struck and lost).

The Committee has never been able to provide satisfactory management advice for either the fin or minke whales off Greenland. This reflects the lack of data on stock structure and abundance and is the reason for the Committee to first call for the Greenland Research Programme in 1998 (IWC, 1999b).

This **inability to provide any advice on safe catch limits is a matter of great concern**, particularly in the case of fin whales where the best available abundance estimate dates from 1987/88 and is only 1,096 (95% CI 520-2,106). The SWG notes that there is to be an abundance survey (see Item 5.1.4) this year. The Committee stresses that obtaining adequate information for management should be seen as of very high priority by both the national authorities and the Commission.

Without this information, the SWG will not be able to provide safe management advice in accord with the Commission's management objectives, or develop a reliable *SLA* for many years, with potentially serious consequences for the status of the stocks involved.

9. WORK PLAN AND BUDGET REQUEST

The SWG noted that without intersessional workshops, it would have taken at least three more years to develop the *Bowhead SLA*. It believes that work to complete a similar exercise for gray whales and make progress on the Greenland fisheries case requires a similar strategy. With such a workshop it may be possible to recommend a *Gray*

⁶ It was also noted that the sub-committee on bowhead, right and gray whales had provided management advice based on the present situation but had also noted that the SWG was expecting to complete its work on an appropriate *SLA*.

Table 5
Factors tested in Bowhead trials (reference levels shown bold and underlined).

Factors	Other levels
$MSYR_{1+}$	1%, <u>2.5%</u> , 4%
$MSYL_{1+}$	0.4, <u>0.6</u> , 0.8
Density-dependent component	<u>1+</u> or mature
Population dynamics model	<u>Deterministic</u> , Stochastic (demographic), <u>Stochastic (demographic + serially corr.env.var.)</u>
Inertia model	<u>Constant</u> , Halve linearly over 100yr, Double linearly over 100yr, Sinusoidal from a base value in year 0 increasing to a maximum of 150% in year 40 Tent K: K doubles linearly from years-50 to 0 and halves from years 0 to 50 K halves linearly over 100 years + strategic surveys
Time dependence in K^*	<u>Constant</u> , Halve linearly over 100yr, Double linearly over 100yr, Step $MSYR$ 2½%→1%→2½% every 33 yrs Step $MSYR$ 2½%→1%→2½% every 33 yrs, in sync with halving / doubling M K and A halve linearly over 100 years K and A vary as tent
Time dependence in resilience*	<u>Constant</u> , Halve linearly over 100yr, Double linearly over 100yr, Step $MSYR$ 2½%→1%→2½% every 33 yrs Step $MSYR$ 2½%→1%→2½% every 33 yrs, in sync with halving / doubling M K and A halve linearly over 100 years K and A vary as tent
Time dependence in natural mortality, M^*	<u>Constant</u> , Halve linearly over 100yr, Double linearly over 100yr.
Episodic events*	<u>None</u> , 2 events occur, between years 1-50, in which 20% of animals die
Initial year of population projection	<u>1848</u> , (or 1748 for stochastic trials), 1940
Stochastic parameters	
(i) Correlation in recruitment	$\rho = 0.752$; Negative ($\rho = -0.75$); High ($\rho = 0.9$); High + Episodic events
(ii) Variation in population size	$\sigma_e^2 = 0.0254$; σ_e^2 changed to give 3* variation in pristine population size $\rho = 0.9$ + change σ_e^2 to give 3*pristine variation + episodic events
Time lag in density-dependence	<u>None</u> ; 20yr time lag in density dependence
Need in final year (linear change)	<u>67</u> , 134, <u>201</u>
Survey frequency	5yr, <u>10 yr</u> , 15 yr
Strategic surveys	<u>No</u> , Yes
Survey bias	
(i) constant	0.67, <u>1.0</u> , 1.5
(ii) historical time dependence	<u>None</u> , Increase by 50% from 1978 to 2002 (0.67→1, 1→1.5)
(iii) future time dependence	<u>None</u> , Decrease by 50% from year 0 to year 100, Increase by 50% from year 0 to year 100, Sinusoidal
Survey CV: (true, estimated)	(0.1, 0.1), (0.25, 0.1); (<u>0.25, 0.25</u>); (0.34, 0.25)
Historic (1848-1914) catch bias	0.5, <u>1.0</u> , 1.5
Integrated	<u>NA</u> , priors for $MSYR$, $MSYL$, historical catch bias, extent of environmental variation in the probability of birth, time lag in density dependence.

*Effects of these factors (except for the tent model) begin in year 2003 (i.e. at start of management).

whale SLA at next year's meeting; without one it will certainly not. The SWG therefore strongly **recommends** that a four-day intersessional workshop be held, probably in December, and thanked Breiwick and DeMaster for once again offering the facilities of the National Marine Mammal Laboratory in Seattle. The estimated costs for such a Workshop are £9,000. The Workshop will concentrate on

reviewing the first results of *Evaluation* and *Robustness Trials* for gray whales and initiating the major review of the Greenland Research Programme.

Similarly, the SWG notes the vital importance of continuing the Developers' Fund, at least at the present level of £8,400, if it is to make progress on the remaining issues.

Table 6
Computing tasks before the intersessional Workshop.

Task	By	Target deadline
Amend control program to implement any additions to GE trials (except inertia model), condition trials and circulate to developers	Allison	1 st August 2002
Condition GE inertia trials and circulate to Email correspondence group for selection of statistic to use in defining 'fast', 'medium' and 'slow' dynamics	Allison	
Circulate inertia model data file to developers	Allison	1 st September 2002
Develop SLAs and submit to Secretariat for testing	Developers	10 days prior to Intersessional meeting
Create input files for and condition GR trials; produce population trajectories.	Allison	Intersessional meeting
Run BE trials for candidate SLAs and prepare comparison plots and tables	Allison	Intersessional meeting

10. ADOPTION OF REPORT

The report was adopted at 20:00 on 8 May 2002. The Chair thanked all of the participants for their co-operation in this very important meeting. The participants expressed their appreciation to the Chair.

REFERENCES

- Givens, G.H. 1997. Separable multicriterion design and performance optimization of AWMPs. Paper SC/49/AS4 presented to the IWC Scientific Committee, September 1997 (unpublished). 21pp. [Paper available from the Office of this Journal].
- Givens, G.H. 1999. Multicriterion decision merging: competitive development of an aboriginal whaling management procedure. *J. Am. Stat. Assoc.* 94:1003-4.
- Givens, G. 2000. *Strike Limit Algorithm* optimisation: a realistic example. *J. Cetacean Res. Manage.* 2(1):75-83.
- International Whaling Commission. 1988. Report of the Comprehensive Assessment Workshop on Catch Per Unit Effort (CPUE). *Rep. int. Whal. Commn* 38:157-62. [Also published in *Rep. int. Whal. Commn* (special issue 11):15-20].
- International Whaling Commission. 1995. Chairman's Report of the Forty-Sixth Annual Meeting, Appendix 4. IWC Resolution 1994-4. Resolution on a Review of Aboriginal Subsistence Management Procedures. *Rep. int. Whal. Commn* 45:42-3.
- International Whaling Commission. 1998. Report of the Scientific Committee. Annex I. Report of the Standing Working Group on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP). *Rep. int. Whal. Commn* 48:203-36.
- International Whaling Commission. 1999a. Chairman's Report of the Fiftieth Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 1998:3-61.
- International Whaling Commission. 1999b. Report of the Scientific Committee. Annex P. Proposal for Developing a Cooperative Research Programme to Address Critical Research Needs for the Greenland Stocks. *J. Cetacean Res. Manage. (Suppl.)* 1:262.
- International Whaling Commission. 2001a. Chairman's Report of the 52nd Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2000:11-63.
- International Whaling Commission. 2001b. Report of the Scientific Committee. Annex T. Report of the Working Group on the Greenland Research Programme. *J. Cetacean Res. Manage. (Suppl.)* 3:361-2.
- International Whaling Commission. 2002a. Chair's Report of the Fifty-Third Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2001:5-106.
- International Whaling Commission. 2002b. Report of the Scientific Committee. Annex E. Report of the Standing Working Group (SWG) on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP). *J. Cetacean Res. Manage. (Suppl.)* 4:148-77.
- Larsen, F. 1995. Abundance of minke and fin whales off West Greenland, 1993. *Rep. int. Whal. Commn* 45:365-70.
- Larsen, F. and Kapel, F.O. 1982. Norwegian minke whaling off West Greenland, 1976-80 and biological studies of West Greenland minke whales. *Rep. int. Whal. Commn* 32:263-74.

Appendix 1

AGENDA

1. Introductory items	5.1.2 Abundance and trends
1.1 Convenor's opening remarks	5.1.3 Biological data
1.2 Election of Chair	5.1.4 Future work
1.3 Appointment of rapporteurs	5.2 Preliminary consideration of management procedures
1.4 Adoption of agenda	5.3 Conclusion
1.5 Review of documents	
2. Bowhead whales and selection of an SLA	6. Scientific aspects of an Aboriginal Subsistence Whaling Scheme
2.1 Modifications to SLAs since the Fourth Workshop	6.1 Carryover
2.2 Review of results for the D-M, G-G and GUP SLAs	6.2 Survey intervals and related issues
2.3 Selection of an SLA	6.3 Implementation Reviews
2.4 Conclusion and recommendation	6.4 Guidelines for surveys
2.5 Comparison of results with RMP	6.5 Guidelines for data/sample collection
3. Gray whale trials structure	7. Presentation of results to the Commission
3.1 Progress since the Fourth Workshop	7.1 General presentation
3.2 Model related issues	7.2 Management advice and incorporation into the Schedule
3.3 Trial specifications	
4. Consideration of Fishery Type 3	8. Management advice for minke and fin whales off west Greenland
5. Greenlandic fisheries and the Greenlandic Research Programme	9. Work plan and budget request
5.1 Review of results from programme	10. Adoption of report
5.1.1 Stock structure, range and movement	
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Appendix 2

TERMINOLOGY

Table follows

The following table contains working definitions agreed in order to ensure consistency in the terminology used during the development of the AWMP. No attempt was made to change the definition of terms currently used by the Committee, but rather it was considered important to be consistent in the use of terminology in describing the process by which the AWMS will be developed. This table is viewed as a living document whose contents may change to reflect AWMP development progress.

Term	Definition
PROCEDURES (Schemes, Procedures and Algorithms)	
AWMP:	Aboriginal Subsistence Whaling Management Procedure.
AWMS:	Aboriginal Subsistence Whaling Scheme.
SLA:	<i>Strike Limit Algorithm</i> : an algorithm that produces limits on strikes for a management stock (note: for some hunts all strikes may not result in a mortality).
OBJECTIVES	
Biological stock:	biological population.
Block limit:	limit on strikes, where applicable with a time period > 1yr.
Management stock:	management unit for which a limit on strikes is set and where the area must be specified on a case by case basis.
Minimum stock level:	(see Paragraph 13(a) of the Schedule - note: acceptable risk level not defined).
Need:	specified by the Commission.
DEVELOPMENT (Trials, Evaluations and Tuning)	
Additional variance:	the extent by which variability of successive abundance estimates exceeds the estimated variability of the estimates. This is implemented as the difference between the CV provided to the SLA (CV_{est}) and the true CV used when generating the abundance estimate (CV_{true}).
Carryover strikes:	unused strikes that can be added to the strike limit for the subsequent year or group of years.
Case-specific trial:	a trial in which the population size and other input parameters are customised to represent a specific application.
Common control program:	the computer code which is used by developers to conduct <i>Initial Exploitation Trials</i> and calculate performance statistics.
Conditioning:	the process of selecting specifications/parameter values for case-specific trials to ensure that they are not inconsistent with already existing data.
<i>Cross-validation Trials</i>	case-specific trials to be held aside from SLA development so that resulting SLAs can be subjected to a subsequent independent test.
Design criterion:	a way to evaluate an SLA, expressed in terms of what an SLA should look like, conceptually or structurally; any criterion that is not a performance criterion.
Demographic stochasticity:	taking account of random variability in the number of births and deaths each year.
Equivalence tuning:	a way to provide SLA developers with the opportunity to adjust their SLAs to strive towards a pre-specified balance of risk, satisfaction of need and recovery.
<i>Evaluation Trials</i>	trials used for formal comparisons of candidate SLAs. Their number would be limited, compared to the number of <i>Robustness Trials</i> . <i>Evaluation Trials</i> would be initiated prior to <i>Robustness Trials</i> .
Generic trial:	a trial in which the population size or the other input parameters are not customised to represent a specific application.
Grand Unified Procedure H:	an SLA constructed by averaging the baseline variants of the G-G and D-M SLAs. an SLA, which represents a particular balance among risk, need satisfaction and recovery and which operates in the idealised case when the parameters of the common control programme are known exactly.
H-optimisation	a method for improving performance of SLAs, singly or merged, by minimising the Bayes risk (i.e. weighted expected loss) of its strike limits relative to those of an idealised SLA, H.
Implementation Trials	the final set of trials upon which a SLA for a specific stock is recommended to the Commission.
<i>Initial Exploitation Trial:</i>	case-specific simulation trials for assessing the merits of performance statistics and to provide a framework for developers in the AWMP.
Merging of SLAs:	any method for combining SLAs that produces a new SLA which provides strike limits depending on the limits given by the component SLAs.
Need Envelope:	sets bounds on the situations that an AWMP will have to be able to cope with, at least with respect to the objective to fulfil 'need' requirements - used for the purposes of simulations only.
Performance criterion:	a way to evaluate an SLA, expressed in terms of a performance statistic.
Performance statistic:	a statistic used to evaluate how well a specific SLA achieves some or all of the objectives for the AWMP.
Performance tuning:	a way to change the behaviour of an SLA to reflect management objectives.
Retrofitting:	post hoc adjustment of the output of an SLA to optimally resemble a different SLA or set of management objectives.
<i>Robustness Trials</i>	trials to examine SLA performance for a full range of plausible scenarios. These would be applied to a restricted set of SLAs found to perform well in <i>Evaluation Trials</i> . The number of these trials would be potentially large.
Snap-to-need	set the strike limit equal to the need level if the 'raw' strike limit from an SLA exceeds 95% of need.
Type 1 fishery:	a case where there is relatively little available information and stock identity problems and where the Committee has had considerable problems providing advice under Para. 13(a).
Type 2 fishery:	a case where there is relatively large amount of information and Para. 13(a) has largely been met (e.g. Bering-Chukchi-Beaufort bowhead whales).
Type 3 fishery:	a case where there is relatively little available information, small population size and stock identity problems (e.g. West Greenland fin whales) and where the Committee has had or would have considerable problems providing advice under Para. 13(a).
U-optimisation	a method for calibrating performance of an SLA so that its strike limits optimally match an explicitly defined measure of risk.
REVISED MANAGEMENT PROCEDURE (RMP) The RMP is described in detail in IWC (1994, pp.145-52).	
CLA:	<i>Catch Limit Algorithm</i> , the process described in IWC* (1994, pp.147-8) that is used in the RMP to calculate a catch limit for a <i>Management Area</i> .
<i>Implementation/Simulation Trials:</i>	involve identifying the range of plausible hypotheses relevant to recommending an <i>Implementation</i> or <i>Implementation Review</i> for the RMP and formulating simulation models which conform with these hypotheses.

*International Whaling Commission. 1994. Report of the Scientific Committee, Annex H. The Revised Management Procedure (RMP) for Baleen Whales. *Rep. int. Whal. Commn* 44:145-52.

Appendix 3(i)

FISHERY TYPE 2: IMPLEMENTATION FOR BERING-CHUKCHI-BEAUFORT BOWHEAD WHALES

A list of the symbols used in this Appendix is given as Adjunct 1.

A. The population dynamics model

The underlying dynamics model is age- and sex-structured and is based on the Baleen II program (Punt, 1999). The base-case trials are run using a deterministic model. Trials are also run using a stochastic version of the model. Note: the stochastic model is not an individual-based or integer model as this would substantially complicate the task of conditioning the trials, but instead uses real arithmetic as does the deterministic model.

A.1 Basic dynamics

Equations (A1.1) and (A1.1s) respectively provide the deterministic and stochastic versions of the underlying 1+ dynamics.

$$\begin{aligned} R_{t+1,a+1}^{m/f} &= (R_{t,a}^{m/f} - C_{t,a}^{m/f}) S_a + U_{t,a}^{m/f} S_a \delta_{a+1} & 0 \leq a \leq x-2 \\ R_{t+1,x}^{m/f} &= (R_{t,x}^{m/f} - C_{t,x}^{m/f}) S_x + (R_{t,x-1}^{m/f} - C_{t,x-1}^{m/f}) S_{x-1} & (A1.1) \\ U_{t+1,a+1}^{m/f} &= U_{t,a}^{m/f} S_a (1 - \delta_{a+1}) & 0 \leq a \leq x-2 \end{aligned}$$

$$\begin{aligned} R_{t+1,a+1}^{m/f} &= \text{Bin}^*(R_{t,a}^{m/f} - C_{t,a}^{m/f} + U_{t,a}^{m/f} \delta_{a+1}, S_a) & 0 \leq a \leq x-2 \\ R_{t+1,x}^{m/f} &= \text{Bin}^*(R_{t,x}^{m/f} - C_{t,x}^{m/f}, S_x) + \text{Bin}^*(R_{t,x-1}^{m/f} - C_{t,x-1}^{m/f}, S_{x-1}) \\ U_{t+1,a+1}^{m/f} &= \text{Bin}^*(U_{t,a}^{m/f} (1 - \delta_{a+1}), S_a) & 0 \leq a \leq x-2 \end{aligned} \quad (A1.1s)$$

$R_{t,a}^{m/f}$ is the number of recruited males/females of age a at the start of year t ;

$U_{t,a}^{m/f}$ is the number of unrecruited males/females of age a at the start of year t ;

δ_a is the fraction of unrecruited animals of age $a-1$ which recruit at age a (assumed to be independent of sex);

$C_{t,a}^{m/f}$ 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);

S_a is the annual survival rate of animals of age a ($= \exp(-M_a)$ where M_a is the instantaneous natural mortality of animals of age a);

$$S_a = \begin{cases} S_{\text{juv}} & \text{if } a = 0 \\ S_{\text{juv}} & \text{if } 1 \leq a \leq a_{\text{adult}} \\ S_{\text{adult}} & \text{if } a > a_{\text{adult}} \end{cases} \quad (A1.2)$$

S_{juv} is the survival rate for 'juveniles' ($1 \leq a \leq a_{\text{adult}}$);

S_{adult} is the survival rate for adults ($a > a_{\text{adult}}$);

a_{adult} is the greatest age at which the 'juvenile' survival rate applies;

$\text{Bin}^*(n,p)$ is defined as $\text{Binomial}([n], p) + (n - [n]) p$, where $[n]$ is the integer part of n ; 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).

A.2 Births

Density-dependence is assumed to act on the 1+ component of the population and affects fecundity and infant survival. 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. The number of births at the start of year $t+1$, B_{t+1} , is given by Equation (A2.1) for the deterministic model and by Equation (A2.1s) for the stochastic model:

$$B_{t+1} = b_{t+1} \max(0, N_{t+1}^f - B_t S_{\text{adult}}) \quad (A2.1)$$

$$B_{t+1} = \text{Bin}^*(\max(0, N_{t+1}^f - B_t S_{\text{adult}}), \tilde{b}_{t+1}) \quad (A2.1s)$$

N_t^f is the number of mature females at the start of year t :

$$N_t^f = \sum_{a=a_m}^x (R_{t,a}^f + U_{t,a}^f) \quad (A2.2)$$

a_m is the age-at-maturity;

b_{t+1} is the probability of birth/calf survival for mature females that did not calve in the previous year (i.e. the average number of births per available female):

$$b_{t+1} = b_{-\infty} \{1 + A(1 - (D_{t+1} / D_{-\infty})^z)\} \quad (A2.3)$$

$\tilde{b}_{t+1}$ is a realisation of a random process as detailed below, and is equal to b_{t+1} in expectation;

$b_{-\infty}$ is the average number of live births per year per mature female that did not calve in the previous year in the pristine (pre-exploitation) population;

A is the resilience parameter;

z is the degree of compensation;

D_t is the size of the component of the population in year t upon which the density-dependence is assumed to act; and

$D_{-\infty}$ is the pristine size of the component of the population upon which the density-dependence is assumed to act.

Note that the $B_t S_{\text{adult}}$ term in Equation (A2.1) arises because of the restriction that females that calve one year may not calve again in the following year.

The stochastic model allows for the possibility that there is environmental variation in the probability of birth/calf survival. The number of female births, B_t^f , is computed from the total number of the births during year $t+1$ using Equations (A2.4) – deterministic model and (A2.4s) – stochastic model:

$$B_t^f = \begin{cases} 0.5 B_t & \\ \text{Bin}^*(B_t, 0.5) & \end{cases} \quad (A2.4)$$

$$B_t^f = \text{Bin}^*(B_t, 0.5) \quad (A2.4s)$$

The numbers of recruited/unrecruited calves are given by:

$$\begin{aligned} R_t^m &= \alpha_0 B_t^f & R_t^m &= \alpha_0 (B_t - B_t^f) \\ U_t^f &= (1 - \alpha_0) B_t^f & U_t^m &= (1 - \alpha_0) (B_t - B_t^f) \end{aligned} \quad (A2.5)$$

α_0 is the proportion of animals of age 0 which are recruited.

In these trials $D_t = N_t^{1+}$ and $D_{-\infty} = K^{1+}$ as density-dependence is assumed to act on the 1+ component of the population and affects fecundity and infant survival. N_t^{1+} and K^{1+} are defined according to the equations:

$$N_t^{1+} = \sum_{a=1}^x (R_{t,a}^f + U_{t,a}^f + R_{t,a}^m + U_{t,a}^m) \quad (\text{A2.6})$$

$$K^{1+} = \sum_{a=1}^x (R_{-\infty,a}^f + U_{-\infty,a}^f + R_{-\infty,a}^m + U_{-\infty,a}^m)$$

The common control program maintains the option to use $D_t = N_t^f$ and $D_{-\infty} = N_{-\infty}^f$ to implement some of the robustness trials.

Environmental stochasticity in births is implemented by assuming that Equation (A2.3) provides the expectation of b_t but that the actual birth/calf survival probability used when applying Equation (A2.1s), $\tilde{b}_t$, is a realisation of a random process:

$$\tilde{b}_t = \frac{e^{q_t}}{1 + e^{q_t}} \quad q_t = \mu_t + \rho(q_{t-1} - \mu_{t-1}) + \varepsilon_t \quad \varepsilon_t \sim N(0; \sigma_\varepsilon^2) \quad (\text{A2.7})$$

where σ_ε^2 is a pre-specified constant. μ_t is set each year, such that the expected value of $\tilde{b}_t$ is b_t , by solving the equation:

$$\int_{-\infty}^{\infty} \left(\frac{e^{q_t}}{1 + e^{q_t}} \right) \frac{\sqrt{1 - \rho^2}}{\sigma_\varepsilon \sqrt{2\pi}} e^{-\frac{(1 - \rho^2)}{2\sigma_\varepsilon^2} (q_t - \mu_t)^2} dq_t = b_t \quad (\text{A2.8})$$

where ρ is the correlation in recruitment.

Parameter values for environmental stochasticity:

An analysis by Givens *et al.* (1995) of bowhead calf data (Angliss *et al.*, 1995), based on the assumption of $\rho = 0$, suggested that the overall CV of the observed proportions of calves was 0.41, and $E(b_{t+1}) = 0.25$. Poole and Givens (2000) attributed 0.18 of the CV to extra environmental binomial variation and 0.23 to other sources. Using this, and an assumed value for $E(b_{t+1})$, the remaining variance parameters can be solved. The solution is insensitive to $E(b_{t+1})$, and 0.25 seems to be a reasonable value considering likely bowhead calving intervals and calf survival. Hence in trials with environmental variation with no auto-correlation (S_M trials) the following parameters are used: $\rho = 0$, and $\sigma_\varepsilon^2 = 0.585$. In trials with auto-correlation (S_E trials) setting $CV(b_{t+1}) = 0.18$, $E(b_{t+1}) = 0.25$ and serial correlation $\text{cor}(b_{t+1}, b_t) = 0.75$, yields $\rho = 0.752$ and $\sigma_\varepsilon^2 = 0.0254$. [NB. The model expressed in equations (A2.7) and (A2.8) implies that the variance of q_t is $\sigma_q^2 = \sigma_\varepsilon^2 / (1 - \rho^2)$. Thus, the corresponding values of σ_q^2 are 0.585 and 0.0585 for the S_M and S_E cases respectively].

A.3 Catches

The historical ($1848 < t < 2003$) catches are taken to be equal to the reported catches (Table 1). The sex-ratio of the catches (both historical and future) is assumed to be 50:50. Catches are taken uniformly from the recruited component of the population:

$$C_{t,a}^{m/f} = C_t^{m/f} R_{t,a}^{m/f} / \sum_{a'=0}^x R_{t,a'}^{m/f} \quad (\text{A3.1})$$

where $C_t^{m/f}$ is the catch of males/females in year t . The total catch in a given future year is taken to be the strike limit for that year, $C_t = C_t^m + C_t^f$.

A.4 Recruitment

All animals except those of age 0 are assumed to be recruited, i.e. α_a , the proportion of animals of age a that would be recruited if the population was pristine is a knife-edged function given by:

$$\alpha_a = \begin{cases} 0 & \text{if } a = 0 \\ 1 & \text{otherwise} \end{cases} \quad (\text{A4.1})$$

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 which then recruit is:

$$\delta_{a+1} = \begin{cases} [\alpha_{a+1} - \alpha_a] / [1 - \alpha_a] & \text{if } \alpha_a < 1 \\ 1 & \text{otherwise} \end{cases} \quad (\text{A4.2})$$

Larger animals were taken in preference to smaller ones during the early years of the fishery, but this is ignored here.

A.5 Maturity

The proportion mature (actually that past the age of first parturition) at each age is a knife-edged function of age at age a_m . The value of a_m is set during conditioning (see section A.8).

A.6 Initialising the population vector

The population is assumed to be at its pristine equilibrium size at the start of the first year (1848 for the deterministic model and 1748 for the stochastic model). The numbers at age in the pristine population are given by:

$$\begin{aligned} R_{-\infty,a}^{m/f} &= 0.5 \ N_{-\infty,0} \ \alpha_a \prod_{a'=0}^{a-1} S_{a'} & \text{if } a < x \\ U_{-\infty,a}^{m/f} &= 0.5 \ N_{-\infty,0} \ (1 - \alpha_a) \prod_{a'=0}^{a-1} S_{a'} & \text{if } a < x \\ R_{-\infty,x}^{m/f} &= 0.5 \ N_{-\infty,0} \ \prod_{a'=0}^{x-1} S_{a'} / (1 - S_x) & \text{if } a = x \end{aligned} \quad (\text{A6.1})$$

$R_{-\infty,a}^{m/f}$ is the number of animals of age a that would be recruited in the pristine population;

$U_{-\infty,a}^{m/f}$ is the number of animals of age a which would be unrecruited in the pristine population; and

$N_{-\infty,0}^{m/f}$ is the total number of animals of age 0 in the pristine population.

The total pristine population size is given by:

$$N_{-\infty} = \sum_{a=0}^x (R_{-\infty,a}^f + U_{-\infty,a}^f + R_{-\infty,a}^m + U_{-\infty,a}^m) \quad (\text{A6.2})$$

Table 1

Historical catches for the Bering-Chukchi-Beaufort Seas stock of bowhead whales (source: J.M. Breiwick, pers. comm.). Catches from 1998-2002 (indicated by *) are taken to be the maximum annual strike quota given in Para 13 b li of the Schedule.

Year	Catch	Year	Catch	Year	Catch	Year	Catch	Year	Catch
1848	18	1879	266	1910	37	1941	38	1972	44
1849	573	1880	480	1911	48	1942	26	1973	51
1850	2067	1881	435	1912	39	1943	14	1974	42
1851	898	1882	242	1913	23	1944	8	1975	32
1852	2709	1883	42	1914	61	1945	23	1976	74
1853	807	1884	160	1915	23	1946	20	1977	72
1854	166	1885	377	1916	23	1947	21	1978	17
1855	2	1886	168	1917	35	1948	8	1979	23
1856	0	1887	240	1918	27	1949	11	1980	38
1857	78	1888	160	1919	33	1950	23	1981	26
1858	461	1889	127	1920	33	1951	23	1982	14
1859	372	1890	136	1921	9	1952	11	1983	16
1860	221	1891	284	1922	39	1953	41	1984	16
1861	306	1892	346	1923	12	1954	9	1985	14
1862	157	1893	180	1924	41	1955	36	1986	22
1863	303	1894	234	1925	53	1956	11	1987	29
1864	434	1895	117	1926	35	1957	5	1988	28
1865	590	1896	118	1927	14	1958	5	1989	25
1866	554	1897	130	1928	30	1959	2	1990	41
1867	599	1898	309	1929	30	1960	33	1991	47
1868	516	1899	234	1930	17	1961	17	1992	46
1869	382	1900	148	1931	32	1962	20	1993	51
1870	637	1901	55	1932	27	1963	15	1994	38
1871	138	1902	162	1933	21	1964	24	1995	57
1872	200	1903	116	1934	21	1965	14	1996	45
1873	147	1904	86	1935	15	1966	24	1997	62
1874	95	1905	105	1936	24	1967	12	1998	67*
1875	200	1906	69	1937	53	1968	27	1999	67*
1876	76	1907	96	1938	36	1969	32	2000	67*
1877	270	1908	123	1939	18	1970	48	2001	67*
1878	80	1909	61	1940	20	1971	25	2002	67*

The stochastic model is run from 1748 to allow for the variability in births and deaths prior to exploitation. Any aboriginal catches prior to 1848 are ignored (Bockstoe and Botkin, 1983).

A.7 z and A

A, z and S_{juv} , are obtained by solving the system of equations that relate $MSYL$, $MSYR$, S_{adult} , S_{juv} , c_{min} , a_{adult} , a_m , A and z. The full details may be found in Punt (2000).

From Equation (A.2.3), the relationship that governs fecundity in equilibrium is given by:

$$2 f(F) = b_{-\infty} [1 - 2f(F) \sum_{y=1}^{n_y} (S_{adult})^y] [1 + A \{1 - (P^D(F)/K^D)^z\}] \quad (A7.1)$$

where:

$f(F)$ is the fecundity (number of female births per mature female) when the exploitation rate is F ;

n_y is the minimum possible interval between calvings (1 year for the B-C-B bowhead stock);

$P^D(F)$ is the size of the component of the population on which density-dependence acts when the exploitation rate is F ;

K^D is the pre-exploitation size of the component of the population on which density-dependence acts.

Solving Equation (A7.1) for A yields the relationship between A, z and

$$MSYL^D (= P^D(MSYR) / K^D = B(MSYR) \tilde{P}^D(MSYR) / K^D):$$

$$A = \frac{2f(MSYR)[1 + b_{-\infty} \sum_{y=1}^{n_y} (S_{adult})^y] - b_{-\infty}}{b_{-\infty}[1 - 2f(MSYR) \sum_{y=1}^{n_y} (S_{adult})^y] [1 - (MSYL^D)^z]} \quad (A7.2)$$

z is then obtained by solving the following equation:

$$-1 = F_{MSY} \left\{ \frac{1}{\tilde{P}(MSYR)} \frac{d\tilde{P}(F)}{dF} \right\}_{F=MSYR} - \frac{1}{\tilde{P}^D(MSYR)} \frac{d\tilde{P}^D(F)}{dF} \Big|_{F=F_{MSYR}} - \text{Term3} \quad (A7.3)$$

$$\text{Term3} = \left\{ \frac{[(MSYL^D)^{-z} - 1]}{z \left[1 - 2f(MSYR) \sum_{y=1}^{n_y} (S_{adult})^y \right] \left[2f(MSYR)[1 + b_{-\infty} \sum_{y=1}^{n_y} (S_{adult})^y] - b_{-\infty} \right]} \right\} \cdot \left. \frac{2df(F)}{dF} \right|_{F=MSYR}$$

$P(F)$ is the normalised equilibrium number of 'recruited' animals when the exploitation rate is fixed at F (either the number of animals which have reached the age at first parturition, or the number of age 1+ animals);

$\tilde{P}(F)$ is the number of ‘recruited’ animals per birth when the exploitation rate is fixed at F .

The normalisation is provided by dividing by the number of births at pre-exploitation equilibrium.

The inverse of the maximum theoretical pregnancy rate ($2f_{\max}$) is therefore given by:

$$2f_{\max} = \frac{b_{-\infty} (1+A)}{1+b_{-\infty} (1+A) \sum_{y=1}^{n_y} (S_{\text{adult}})^y} \quad (\text{A7.4})$$

A.8 Conditioning

The method for conditioning the trials (i.e. selecting the 100 sets of values for the parameters a_m , S_{juv} , a_{adult} , S_{adult} and K^{1+} , A and z) is based on a Bayesian assessment of the B-C-B Seas bowhead stock based on the ‘backwards’ methodology (Butterworth and Punt, 1995; Givens and Thompson, 1996). The algorithm for conducting the Bayesian assessment is as follows:

- Draw values for the parameters S_{adult} , $c_{\min}$, a_{adult} , a_m , $MSYR_{1+}$, $MSYL_{1+}$, and P_{1993} from the priors in Table 2, which are based on the values used by the bowhead assessment group (IWC, 1998). For most trials, 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. ($c_{\min} = 1/f_{\max}$, where $f_{\max}$ is the maximum theoretical pregnancy rate defined in section A.7).
- Solve the system of equations that relate $MSYL$, $MSYR$, S_{adult} , S_{juv} , $c_{\min}$, a_{adult} , a_m , A and z to find values for S_{juv} , A and z (see section A.7, with $n_y = 1$).
- Select the value of K^{1+} that hits the generated value for P_{1993} .
- Calculate the likelihood of the projection. The likelihood includes three terms:
 - The 1993 BEB point estimate of 8,293 (SE = 626) – assumed to be independently normally distributed about the 1993 1+ population size.
 - The 1978-88 N_4/P_4 estimates – assumed (after a correction from relative to absolute abundance by multiplying by 8,200/7,778) to be log-normally distributed about the corresponding 1+ population sizes, $\hat{N}_t^{1+}$ (see Table 3 for the estimates, CVs and correlation matrix).
 - The proportions of the population in 1988/89 that consist of calves and mature animals are assumed to have distributions equal to those of the random

variables $(t_5 - 0.052)/0.0164$ and $(t_5 - 0.411)/0.0286$, respectively, where t_5 is a random variable with five degrees of freedom.

- Repeat steps (a) – (d) a large number (typically 100,000) of times.
- Select 100 sets of parameter vectors randomly from those generated from repeated applications of steps (a) – (d) assigning a probability of selecting a particular vector proportional to its likelihood. The number of times steps (a) – (d) are repeated is chosen to ensure that each of the 100 parameter vectors are unique.

The population model estimates are divided by the bias factor when conditioning the trials that involve the assumption that the abundance estimates are biased.

Table 2
The Prior Distributions

Parameter	Prior
a_{adult}	DU[1,9] where DU = Discrete Uniform
age at maturity ¹	N(20,3 ²); rounded to the nearest integer and restricted to the range 14 – 26.
S_{adult}	N(0.99,0.02 ²) truncated at 0.995
$c_{\min} = 1/f_{\max}$	U[2, 4]*
P_{1993}	$\ell n P_{1993} \sim N(\ell n 7,800; 0.167^2)$

¹ a_m (the age at first parturition) = the age at maturity + 1; *Modified from the choice made during the 1998 bowhead assessment: $c_{\min}=2$ is allowed to enable $MSYR=4\%$ cases (with $MSYL=0.6$) to be conditioned.

B. Data generation

B.1 Absolute abundance estimates

The historic ($t < 1999$) abundance estimates (and their CVs) which are provided to the SLA are taken to be the N_4/P_4 values in Table 4 (Zeh *et al.*, 1995). Note that the correction factor of 8,200/7,778 to convert from relative to absolute abundance is ignored here, leading to a small negative bias.

The SLA is provided with an estimate of absolute abundance in 2001, together with an estimate of the CV. Thereafter an estimate is generated once every F years during the management period (where $F = 10$ for most trials) starting 4 years before the next strike limit comes into effect (this largely reflects the need to consider the ‘strategic’ survey issue – see section Dii). The CV of the abundance estimate (CV_{true}) may be different from the CV provided to the SLA. The distribution function for the random noise associated with the survey estimate is made up of two components: a lognormal variable that provides a population-independent component of the variation and a population-dependent variable with a Poisson distribution.

Table 3

Estimates, CVs (actually standard errors of the logarithms), and the correlation matrix for the logarithms of the indices of abundance for the B-C-B bowhead stock. The values in this Table are based on the estimation procedure described in Punt and Butterworth (1999).

Year	Estimate	CV	Correlation matrix									
1978	4,820	0.273	1.000									
1980	3,900	0.314	0.166	1.000								
1981	4,389	0.253	0.054	0.047	1.000							
1982	6,572	0.311	0.168	0.146	0.047	1.000						
1983	6,268	0.321	0.163	0.141	0.046	0.143	1.000					
1985	5,132	0.269	0.126	0.109	0.025	0.110	0.107	1.000				
1986	7,251	0.186	0.080	0.070	0.012	0.070	0.068	0.108	1.000			
1987	5,151	0.298	0.175	0.152	0.049	0.154	0.149	0.115	0.074	1.000		
1988	6,609	0.113	0.038	0.033	0.012	0.033	0.032	0.018	0.009	0.035	1.000	
1993	7,778	0.071	0.002	0.001	0.001	0.001	0.001	-0.002	-0.002	0.001	0.001	1.000

This follows the procedure developed for the trials for commercial whaling (IWC, 1991, p.109) where trials with spatially disaggregated data showed the lognormal alone to be unsuitable for high CVs.

The survey estimate, $\hat{S}$, may be written as:

$$\hat{S} = B_A P Y_w / \mu = B_A P^* \beta^2 Y_w \quad (\text{B1.1})$$

where: B_A is the bias;

P is the 1+ population at the start of year t and is given by:

$$P = N_t^{1+} \quad (\text{B1.2})$$

Y is a lognormal random variable: $Y = e^\phi$

$$\text{where: } \phi \sim N[0; \sigma_\phi^2] \text{ and } \sigma_\phi^2 = \ell n(1 + \alpha^2) \quad (\text{B1.3})$$

w is a Poisson random variable, independent of Y , with

$$E(w) = \text{var}(w) = \mu = (P / P^*) / \beta^2; \text{ and} \quad (\text{B1.4})$$

P^* is the reference population level and is equal to the pristine 1+ population: $P^* = K^{1+}$.

Note that under the approximation $CV^2(ab) = CV^2(a) + CV^2(b)$, $E(\hat{S}) = B_A P$, and

$$CV_{true}^2(\hat{S}) = \alpha^2 + \beta^2 P^* / P \quad (\text{B1.5})$$

In these trials the base-case value of CV_{true} is taken to be 0.25 when $P/P^* = 0.6$.

An estimate of the CV, X , is generated for each sightings estimate:

$$X = \sigma \sqrt{(\chi_n^2 / n)} \quad (\text{B1.6})$$

where: $\sigma^2 = \ell n(1 + CV_{est}^2)$

CV_{est} is (approximately) the expectation of the estimate of the CV provided to the SLA:

$$CV_{est}^2 = \theta^2(a^2 + b^2 / w\beta^2) \quad (\text{B1.7})$$

χ_n^2 is a random number from a Chi-square distribution with n degrees of freedom where $n = 19$ (the value assumed for the single stock trials for the RMP); and

a^2, b^2 are constants and equal to 0.02 and 0.012 respectively.

The value of θ is set so that the required CV_{est} is obtained when $P = 0.6K$, i.e. $\theta^2 = E(CV_{est}^2) / 0.04$ (using the approximation $E(1/w) \approx 1 / E(w) = \beta^2 P^* / P$). In these trials the base-case value of CV_{est} is taken to be 0.25 when $P/P^* = 0.6$.

The relationship between CV_{est} and CV_{true} is given by:

$$\eta = [E(CV_{true}^2) - E(CV_{est}^2)] / (0.1 + 0.013 P^* / P) \quad (\text{B1.8})$$

where η is a constant known as the additional variance factor and is used to compute the values of α^2 and β^2 as:

$$\alpha^2 = \theta^2 a^2 + \eta 0.1 \quad \beta^2 = \theta^2 b^2 + \eta 0.013 \quad (\text{B1.9})$$

Note: using these specifications the ratio of $\alpha^2 : \beta^2$ is not 0.12 : 0.025 as was used in the single stock CLA trials.

B.2 Age-class data

The information available to an SLA is estimates of the proportion of calves, n_c/n , and mature animals, n_m/n from a sample of n animals and n equals 250. The information is available in every year for which an abundance estimate is available. n_c and n_m are generated from n independent Bernoulli (p_c) or Bernoulli (p_m) trials in which p_c and p_m are generated from Beta (x, y) to account for overdispersion. The values for x and y are calculated separately for calves and mature animals:

$$x/(x+y) = \begin{cases} p(L) & \text{for mature animals} \\ 1-p(L) & \text{for calves} \end{cases} \quad (\text{B2.1a})$$

$$(\text{B2.1b})$$

$$xy(n^{-1} + (x+y)^{-1}) / ((x+y+1)(x+y)) = c \quad (\text{B2.1c})$$

Table 4

The N_4/P_4 estimates (with CVs) and the 'age' data.

	N_4/P_4 data		Age data		
	Estimate	CV	Calves	Mature	Total
1978	5,019	0.294		N/A	0
1980	4,061	0.336		N/A	0
1981	4,308	0.266		N/A	0
1982	6,843	0.333		N/A	0
1983	6,527	0.343		N/A	0
				N/A	
1985	6,039	0.317	7	275	623
1986	7,734	0.187	36	185	375
1987	5,364	0.320		N/A	0
1988	6,579	0.115		N/A	0
1989	N/A		13	88	196
1990	N/A		24	111	272
1991	N/A		8	63	195
1992	N/A		2	84	237
1993	7,770	0.071		N/A	0

[Equations (B2.1a) and (B2.1b) set the mean Bernoulli parameters, and (B2.1c) establishes the marginal variance of the Bernoulli observations.]

L is the length defining calves or mature animals;

c is 0.035^2 for the calves, and 0.07^2 for mature animals;

$p(L)$ is the proportion of whales larger than length L :

$$p(L) = \sum_{a=0}^x p_a(L) (R_a^f + R_a^m + U_a^f + U_a^m) / \sum_{a'=0}^x (R_{a'}^f + R_{a'}^m + U_{a'}^f + U_{a'}^m) \quad (\text{B2.2})$$

$p_a(L)$ is the proportion of whales of age a that are assigned as being larger than length L :

$$p_a(L) = \begin{cases} 0 & \text{if } a \leq a_{\min}(L) \\ (1 + \exp[-(a - a_{50}(L) + \gamma_L) / (\lambda_L \sigma_L)])^{-1} & \text{if } a \leq a_{\min}(L) \\ 1 & \text{if } a \leq a_{\min}(L) \end{cases} \quad (\text{B2.3})$$

$a_{\min}(L)$ is the last age at which no whales may exceed length L ;

$a_{\max}(L)$ is the age at which all whales exceed length L ;

$a_{50}(L)$ is the age at which the length of 50% of whales of that age exceed length L ;

σ_L is the dispersion parameter;

γ_L is a bias term to account for error in $a_{50}(L)$; and

λ_L is a term to account for error in σ_L .

This approach takes account of three sources of error: Bernoulli sampling error; over-dispersion through the Beta distribution of the Bernoulli parameter; and error in the assumed relationship between age and length through the values of γ_L and λ_L . If $\gamma_L = 0$ and $\lambda_L = 1$, $p_a(L)$ is not subject to error, otherwise, $p_a(L)$ allows for some error in the assignment of age classes.

The values for some of the parameters are taken to be fixed for these trials (see Table 5). The value 0 for σ_6 reflects the assumption that calves can be identified without error. The value 1.91 for $\sigma_{12.9}$ was chosen so that animals aged 13 or younger have at most a 2.5% chance of exceeding 12.9m

and animals aged 27 or older have at least a 97.5 chance of having reached 12.9m. The pre-management values of n_c/n , and n_m/n are taken to be the values given in Table 4.

Table 5
Age-class parameter values.

	Juveniles / adults ($L=6$)	Mature animals ($L=12.9$)
$a_{\min}(L)$	0	10
$a_{\max}(L)$	1	30
$a_{50}(L)$	1	20
σ_L	0	1.91

C. Need

The level of need in each year, Q_t is given by

$$Q_t = Q_{2003} + \frac{t - 2003}{100} (Q_{2103} - Q_{2003}) \text{ where } Q_{2003} \text{ is the need}$$

at the start of the first year in which the AWMP is applied and Q_{2003} is the value 100 years later. (Note that intermediate values may be non-integer). The level of need supplied to the SLA is the total need for the five-year period for which strike limits are to be set. The current annual need level is 67. Trials are performed with $Q_{2103} = Q_{2003}$ (i.e. constant need) and with $Q_{2103} = 3Q_{2003}$ (i.e. increasing need).

D. Trials

Table 6 lists the set of *Evaluation Trials* and Table 7 the *Robustness Trials*. For completeness, the set of *Initial Exploration Trials* is given in Table 8.

DETAILS OF FACTORS

The factors used in the trials are shown in Tables 6 and 7 and further details are given below where necessary.

(i) Time lag in density-dependent response

For trials with a time lag in the density-dependent response, Equation (A2.3) is replaced by

$$b_{t+1} = b_{-\infty} \{1 + A(1 - (D_{t+1-t_l} / D_{-\infty})^2)\} \quad (\text{Di.1})$$

where t_l is the density-dependent time lag ($= 0$ in base-case trials).

(ii) 'Strategic' inter-survey period

This factor involves conducting additional surveys if the strike limit based on the survey four years earlier is lower than that strike limit or if it is less than need in the case when need was satisfied over the previous five-year period. Table 9 shows how the decision whether to conduct a survey is made. If the strike limit is greater than the previous strike limit when need was previously unsatisfied or if it equals need, the inter-survey period is increased from 5 to 15 years. The trials that involve changing survey frequency should be conducted both with and without 'phase-out rules' to allow the impact of different survey frequency on performance to be determined without the confounding effect of 'phase-out rules'.

The strike limit for the five-year period starting in year t , C_t , is defined as being 'unacceptable' if either it is less than C_{t-5} or less than N_t when $N_{t-5} = C_{t-5}$. The following algorithm is applied to implement a 'strategic' strategy to conducting surveys:

- Generate a survey four years before the next strike limit is applied (i.e. in year $t-4$) and apply the SLA to the updated dataset to obtain a strike limit, C_t .
- If the strike limit is 'acceptable', then conduct the next survey in year $t+11$; stop. *or*
- Conduct a survey in year $t-3$ and apply the SLA to the updated dataset. If the resultant strike limit is again 'unacceptable', then conduct a survey in year $t-2$ and use

Table 6

The *Evaluation Trials* for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. (Survey interval = 10 years unless otherwise specified; differences from the base case are shown in bold; see items i-iii below for further details of the factors involving a time lag in density dependence, strategic surveys and the inertia model).

Trial No.	Description	Model	$MSYR_{1+}$	$MSYL_{1+}$	Final need	Historical survey bias	Future survey bias	Survey CV (true, est)	Age data [#]	Other
BE01*	Base case	D, S _E	2.5%	0.6	134	1	1	0.25, 0.25	Good	
BE02	Constant need	D	2.5%	0.6	67	1	1	0.25, 0.25	Good	
BE03	Future +ve bias	D, S _E	2.5%	0.6	134	1	1→1.5 in yr 25	0.25, 0.25	Good	
BE04	Future -ve bias	D	2.5%	0.6	134	1	1→.67 in yr 25	0.25, 0.25	Good	
BE04a	Future -ve bias	D	2.5%	0.6	134	1	1→.67 in yr 25	0.25, 0.25	Good	5yr surveys
BE05	Underestimated CVs	D	2.5%	0.6	134	1	1	0.25, 0.10	Good	
BE07*	$MSYL_{1+} = 0.8$	D, S _E	2.5%	0.8	134	1	1	0.25, 0.25	Good	
BE08	5 yr surveys	D	2.5%	0.6	134	1	1	0.25, 0.25	Good	5yr surveys
BE09*	$MSYR_{1+} = 1\%$	D, S _E	1%	0.6	134	0.67 → 1	1	0.25, 0.25	Good	
BE09a	$MSYR_{1+} = 1\%$	D	1%	0.6	134	0.67 → 1	1	0.25, 0.25	Good	5yr surveys
BE10*	$MSYR_{1+} = 4\%$	D	4%	0.8	134	1	1	0.25, 0.25	Good	
BE10a	$MSYR_{1+} = 4\%$	D	4%	0.8	134	1	1	0.25, 0.25	Good	5yr surveys
BE11	Bad data	D	2.5%	0.6	134	1	1→1.5 in yr 25	0.25, 0.10	Poor	
BE12*	Difficult 1%	D, S _E	1%	0.6	134	1 → 1.5	1.5	0.25, 0.10	Poor	
BE12a	Difficult 1%	D	1%	0.6	134	1 → 1.5	1.5	0.25, 0.10	Poor	5yr surveys
BE13	Difficult 1%; constant need	D	1%	0.6	67	1 → 1.5	1.5	0.25, 0.10	Poor	
BE14	Need increases to 201	D	2.5%	0.6	201	1	1	0.25, 0.25	Good	
BE16	$MSYR_{1+} = 1\%$; 201 need	D, S _E	1%	0.6	201	0.67 → 1	1	0.25, 0.25	Good	
BE20	$MSYR_{1+} = 4\%$; 201 need	D	4%	0.8	201	1	1	0.25, 0.25	Good	
BE21*	Integrated	D	U[1,4%]	U[.4-.8]	134	1	1	0.25, 0.25	Good	
BE22*	20yr time lag (see i)	D, S _E	2.5%	0.6	134	1	1	0.25, 0.25	Good	20yr lag
BE23	Strategic surveys; (see ii)	D	2.5%	0.6	201	1	1	0.25, 0.25	Good	Strategic surveys
BE24*	Inertia Model (see iii)	D	0.6% [§]	0.6	134	1	1	0.25, 0.25	Good	Inertia model

*Requires conditioning; #Age data: Good (no bias or extra variance): $\gamma_{12.9}=0$, $\lambda_{12.9}=1$; poor: $\gamma_{12.9}=2$, $\lambda_{12.9}=1.5$; § $MSYR_{1+}$ here refers to $MSYR$ in the absence of inertia dynamics. The value of 0.6% was set intersessionally by the Email correspondence group following inspection of trajectories.

Table 7
The *Robustness Trials* for the Bering-Chukchi-Beaufort Seas stock of bowhead whales.

Trial	Factor	Basic trials (Table 7)	Factor level
BR01	A: Density-dependence	1, 1 ^S , 9, 9 ^S	Density-dependence on mature (BE trials use 1+)
BR02	B1: Stochastic dynamics	8 ^S , 13 ^S	Stochastic dynamics (with serially-correlated environmental variation)
BR04	E: Survey frequency	9, 13, 14, 16, 20 16, 20	a) 15 yrs b) 5 yrs
BR05	F: Strategic surveys (see ii)	9 9	a) Yes + CV = (0.25, 0.25) b) Yes + CV = (0.34, 0.25)
BR06	G: Survey bias time dependence (see iv)	1 1 9, 9 ^S 12, 12 ^S 14	a) Historic bias (1978-2002): 1.5 constant; Future bias: decreasing (1.5→1) b) Historic bias (1978-2002): 0.67 constant; Future bias: increasing (0.67→1) c) Future bias: sinusoidal from base value in yr 0 to maximum of 150% in yr 40 (Fig1a) d) Future bias: decreasing (1.5→1) from year 0 to 100 e) Future bias: increasing from 1→1.5 in year 25 and constant thereafter (former BE15)
BR07	H: Future survey CV	1 1 ^S 9	a) CV = (0.1, 0.1) b) CV = (0.34, 0.25) c) (0.1, 0.1) + sinusoidal survey bias (Fig 1a)
BR08	I: Historic catch bias (see v below)	14, 16 ^S 14, 16, 16 ^S	a) 0.5 bias from 1848-1914 b) 1.5 bias from 1848-1914
BR09	K: Time dependence in <i>K</i> (see vi below)	1, 9, 10 1, 9, 10 1 1, 21 1, 9	a) <i>K</i> halves linearly over 100 years b) <i>K</i> doubles linearly over 100 years c) <i>K</i> sinusoidal from base value in year 0 to maximum of 150% in year 40 (Fig 1a) d) Tent <i>K</i> : <i>K</i> doubles linearly from years-50 to 0 and halves from years 0 to 50 (Fig1b) e) <i>K</i> halves linearly over 100 years + strategic surveys
BR10	L: Time dependence in <i>MSYR</i> (see vii below)	10 9 1, 8 1, 8 1 1, 21	a) Resilience (<i>A</i>) halves linearly over 100 years b) Resilience (<i>A</i>) doubles linearly over 100 years c) Resilience steps 2½%→1%→2½% every 33 yrs over 100 years d) Resilience steps 2½%→1%→2½% every 33 yrs over 100 years in sync with <i>M</i> (compute <i>MSYR</i> first) – if it is practical halve <i>M</i> for each age class e) <i>K</i> and <i>A</i> halve linearly over 100 years f) <i>K</i> and <i>A</i> vary as tent (see BR09 (d))
BR11	M: Time dependence in <i>M</i> (see viii below)	1, 9, 10 1, 9, 10	a) Natural mortality <i>M</i> halves linearly over 100 years b) <i>M</i> doubles linearly over 100 years
BR12	N: Episodic events (see ix below)	1, 1 ^S , 9, 9 ^S	2 events occur, between years 1-50, in which 20% of animals die
BR13	O: Integrated	1, 11, 14 11, 14 1, 1 ^S , 11, 11 ^S , 14 1 ^S , 11 ^S	a) $MSYR_{1+} \sim U[0.01, 0.04]$; fixed $MSYL_{1+}=0.6$ b) $MSYR_{1+} \sim U[0.01, 0.04]$; $MSYL_{1+} \sim U[0.4, 0.8]$ c) $MSYR_{1+} \sim U[0.01, 0.04]$; $MSYL_{1+} \sim U[0.4, 0.8]$; historical catch bias $\sim U[0.5, 1.5]$; serial correlation $\sim U[0.47, 0.95]$ (see xi below) d) $MSYR_{1+} \sim U[0.01, 0.04]$; $MSYL_{1+} \sim U[0.4, 0.8]$; historical catch bias $\sim U[0.5, 1.5]$; serial correlation $\rho \sim U[0.47, 0.95]$, time delay in density-dependence $\sim U[0, 30]$
BR14	P: 1 st year of population projection	1, 9	1940 (reference or base case level is 1848 or 1748 for stochastic trials). (see x below)
BR15	$MSYL_{1+}=0.9$	1, 9, 10	
BR16	B2: Different stochastic parameter	1 ^S 1 ^S 1 ^S , 9 ^S , 10 ^S 1 ^S 1 ^S , 9 ^S	a) Negative correlation in recruitment $\rho = -0.75$ b) High correlation in recruitment $\rho = 0.9$ c) High correlation in recruitment $\rho = 0.9$; + Episodic events d) Change σ_e^2 to give 3* variation in population size at equilibrium e) $\rho = 0.9$ + change σ_e^2 to give 3*equilibrium variation +episodic events

Table 8
The set of *Initial Exploration Trials* for fishery type 2.

Trial no.	$MSYR_{1+}$	$MSYL_{1+}$	Need		Data quality			
			Initial level	Final level	CV_{est}	$\gamma_{12,9}$	$\lambda_{12,9}$	B_A
B1	0.025	0.6	67	67	0.25	0	1	1
B3	0.04	0.6	67	201	0.25	0	1	1
B6	0.01	0.6	67	67	0.25	0	1	1
B7	0.01	0.6	67	201	0.25	0	1	1
B7a	0.01	0.6	67	201	0.125	4	2	1.5
B10	0.04	0.6	67	67	0.25	0	1	1
B11	U[0.01, 0.04]	0.6	67	67	0.25	0	1	1
B12	U[0.01, 0.04]	0.6	67	201	0.25	0	1	1
B13	U[0.01, 0.04]	0.6	67	201	0.125	4	2	1.5

this in the calculation of the strike limit for the five-year period starting in year t . If the strike limit based on data up to year $t-3$ or $t-2$ was 'acceptable', then conduct the next survey in year $t+11$.

(iii) Inertia population dynamics model

The inertia model is discussed more fully in Witting (2002). It assumes that density-dependent changes in life history parameters affect the probability of birth/calf survival for mature females. The model is only implemented for the deterministic case. In this model, the dynamics are governed by the equations given in Section A except that Equation (A2.1) which sets the number of births at the start of year $t+1$, B_{t+1} , is replaced by

$$B_{t+1} = \sum_a B_{t+1,a} \quad (\text{Diii.1})$$

where $B_{t+1,a}$ is the number of births in year $t+1$ from females of age a , and is given by;

$$B_{t+1,a} = b_{t+1,a} \max(0, N_{t+1,a}^f - B_{t,a-1} S_{a-1}) \quad a_m \leq a \leq x-1$$

$$B_{t+1,x} = b_{t+1,x} \max(0, N_{t+1,x}^f - B_{t,x} S_x - B_{t,x-1} S_{x-1}) \quad (\text{Diii.2})$$

$N_{t,a}^f$ is the number of mature females of age a at the start of year t :

$$N_{t,a}^f = R_{t,a}^f + U_{t,a}^f \quad \text{if } a > a_m \text{ and } 0 \text{ otherwise} \quad (\text{Diii.3})$$

$b_{t+1,a}$ is the probability of birth/calf survival for mature females of age a that did not calve in the previous year:

$$b_{t+1,a} = b'_{t+1,a} \{1 + A(1 - (D_{t+1} / D_{-\infty})^z)\} \quad \text{with the restriction that } 0 \leq b_{t+1,a} \leq 1 \quad (\text{Diii.4})$$

$b'_{t+1,a}$ is the 'intrinsic' birth rate for animals of age a (depends only upon when the animal was born):

$$b'_{t+1,a+1} = b'_{t,a} \quad 1 \leq a \leq x-2 \quad (\text{Diii.5})$$

$$b'_{t+1,x} = \frac{b'_{t,x} N_{t,x} S_x + b'_{t,x-1} N_{t,x-1} S_{x-1}}{N_{t,x} S_x + N_{t,x-1} S_{x-1}} \quad (\text{Diii.6})$$

$b'_{t+1,0}$ is the 'intrinsic' birth rate for the calves during year $t+1$ and is the average (population-weighted) 'intrinsic' birth rate for their parents, adjusted by a density-dependent inter-generation change (g) that may arise from a diversity of mechanisms including selection, maternal effects and other forms of environmental response:

$$b'_{t+1,0} = \frac{g_{t+1} \sum_a b'_{t,a} B_{t+1,a}}{B_{t+1}} \quad (\text{Diii.7})$$

$$g_{t+1} = \{1 + A_i(1 - (D_{t+1} / D_{-\infty})^z)\} \quad (\text{Diii.8})$$

In the pristine population, $g_{-\infty} = 1$ i.e. $b_{-\infty,a} = b_{-\infty}$ which is set as for the base case trials. A_i is a constant and is set such that $A_i / A = 0.5$.

(iv) Survey bias

In order to avoid a discontinuity in the value of the survey bias, if the historical survey bias in year 2002 is not equal to the value of the future bias, then the bias changes linearly between years 0 and 25 to the new value, and is constant thereafter.

(v) Historic catch bias

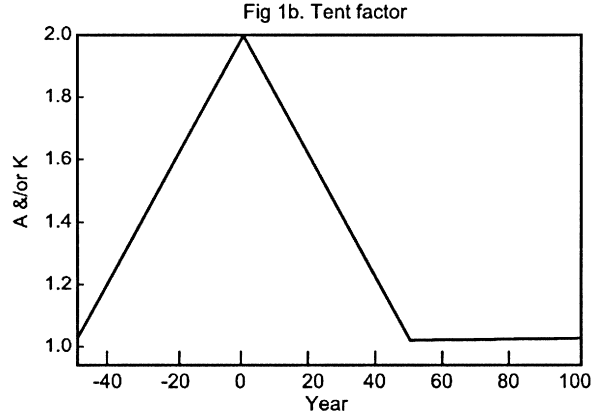
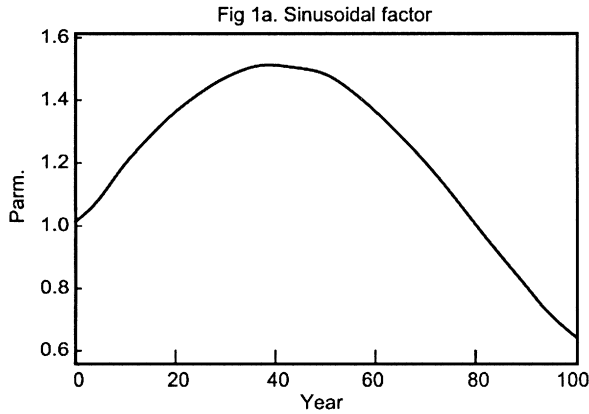
This factor involves applying a bias to the true historic catch, between 1848 and 1914, as used by the operating model. The SLA is given the same catch series as for the base case trial (see Table 1). These values are either over reported when the true catches are 0.5 times less, or under reported when the true catches are 1.5 times greater.

(vi) Varying K

$D_{-\infty}$ in Equation (2.3) is replaced by $D_{-\infty}(t)$ for trials in which K varies. The different forms of K are shown in Fig 1. The initial value of $D_{-\infty}$ is set as for the base case trials, and is held fixed until the start of management (year 0) or until year -50 in the case when K varies as a tent. The values of all other parameters (e.g. the resilience parameter A , the degree of compensation z and the fecundity $b_{-\infty}$) do not change (unless also specified for a particular trial). The value of the reference population level, P^* , used in generation of the

Table 9
'Strategic' Inter-Survey Period.

Year	Strike limit	Conduct Survey?
$t-4$	C_{t-5}	Yes
$t-3$	C_{t-5}	Only if $t-4$ survey leads to an 'unacceptable' strike limit
$t-2$	C_{t-5}	Only if $t-3$ survey leads to an 'unacceptable' strike limit
$t-1$	C_{t-5}	
t	C_t	
If C_t was 'acceptable':		
$t+1$	C_t	No (next in $t+11$)
$t+2$	C_t	Yes
$t+3$	C_t	Only if $t+1$ survey 'unacceptable'
$t+4$	C_t	Only if $t+2$ survey 'unacceptable'
$t+5$	C_{t+5}	
C_{t+5} 'acceptable':		
$t+6$	C_{t+5}	No (next in $t+16$)
$t+7$	C_{t+5}	Yes
$t+8$	C_{t+5}	If $t+6$ survey 'unacceptable'
$t+9$	C_{t+5}	If $t+7$ survey 'unacceptable'
$t+10$	C_{t+10}	
$t+11$	C_{t+10}	Yes
C_{t+5} 'unacceptable':		
$t+6$	C_{t+5}	Yes
$t+7$	C_{t+5}	If $t+6$ survey 'unacceptable'
$t+8$	C_{t+5}	If $t+7$ survey 'unacceptable'
$t+9$	C_{t+5}	
$t+10$	C_{t+10}	
$t+11$	C_{t+10}	Only if C_{t+10} 'unacceptable'



abundance estimates (equation (B1.1)) is also constant through out the entire trial. H (see section G) is not defined for trials with varying K .

(vii) Varying MSYR

The resilience, A , in equation (2.3) is replaced by $A(t)$ for trials in which $MSYR$ varies. The initial value of A is set as for the base case trials, and it is held fixed until the start of management (year 0). The values of all other parameters do not change (unless also specified for a particular trial).

(viii) Varying mortality rate

For trials in which the natural mortality rate M varies, Equations (A1.2) are replaced by $S_a(t) = e^{-M_a(t)}$ where the mortality at each age $a = 1, x$ varies as given in the trial definition. The calf survival rate is given by:

$$S_0(t) = S_{juv}(t) S_{adult}(t) \quad (Dviii.1)$$

In trial BR10d, the resilience and natural mortality vary in sync in years 33 and 66: A is reduced by a factor of 1/2.5 and M is halved in year 33; in year 66 they return to their initial values.

(ix) Episodic events

In episodic event trials, 2 events occur during the first 50 years of management in which 20% of the animals die. The deaths occur uniformly throughout the population i.e. the numbers in each age class, both recruited and unrecruited, are reduced by 20% in years when an event occurs. The 2 events occur in different years.

(x) Initial year of population projection

This option follows the method used in recent assessments of the eastern North Pacific stock of gray whales (e.g. Wade, 2002; Punt and Butterworth, 2002) for which a simple density-dependent population dynamics model is not consistent with the abundance estimates. The model starts population projections from a more recent year than that in which the first recorded catch occurred and are based on the assumption that the age-structure at the start of the projection (1940 in this case) is stable. Note that even though the operating model ignores the catch data from the years 1848-1939, these catches should nevertheless be provided to the *SLA*.

The determination of the age-structure at the start of 1940 involves specifying the effective 'rate of increase', γ , that applies to each age-class. Under the assumption in this paper of knife-edge recruitment to the fishery at age 1, the number

of animals of age a at the start of year τ ($= 1940$) relative to the number of births at that time, $N_{\tau,a}^*$, is given by the equation:

$$N_{\tau,a}^* = \begin{cases} 1 & \text{if } a = 0 \\ N_{\tau,a-1}^* S_{a-1} (1 - \gamma) & \text{if } 1 < a < x \\ N_{\tau,x-1}^* S_{x-1} (1 - \gamma) / (1 - S_x (1 - \gamma)) & \text{if } a = x \end{cases} \quad (Dx.1)$$

B_τ is the number of births in year τ (found rearranging equations (A2.1) and (2.3)):

$$B_\tau = \left[1 - \left(\frac{1}{\left(\max(0, N_\tau^f - B_\tau S_{adult}) / B_\tau \right) b_{-\infty}} - 1 \right) \frac{1}{A} \right]^{1/z} \frac{D_{-\infty}}{D_\tau^*} \quad (Dx.2)$$

D_τ^* is the number of whales in the density dependent component of the population in year τ relative to the number of births at that time.

In step (a) of the conditioning process, K^{1+} ($= D_{-\infty}$) is drawn from $U[7000, 31000]$ (IWC, 1998). The effective rate of increase, γ , is selected during conditioning (see section A.8) such that if the population dynamics model is projected from 1940 to 1993, the size of 1+ component of the population in 1993 equals the pre-specified value, P_{1993} .

(ix) Serial correlation

In trials in which the correlation in recruitment, ρ , (used in equations A2.7 and A2.8) is generated from a uniform distribution, the value of σ_ϵ^2 is set using the following equation:

$$\sigma_\epsilon^2 = \sqrt{0.05845467(1 - \rho^2)} \quad \text{Dix.1}$$

CROSS VALIDATION TRIALS

Table 10 lists the factors considered in the *Cross Validation* trials. The values of these factors are generated by selecting randomly from the ranges listed in Table 11. If the value for MSY_{1+} is inconsistent with the other parameters, it is re-generated until a satisfactory value is obtained. The value for the historical survey bias in 1978 is dependent on the $MSYR$ rate: the bias in 1978 is 1 for values for MSY_{1+} of 2.5% and larger, and declines linearly to a value of 0.67 as MSY_{1+} declines from 2.5% to 1%. The survey bias varies linearly its value in 1978 to a value of 1 in year 0 ($= 2003$).

It then varies linearly (from 1 in year 0) to the chosen value in year 25 and is constant thereafter.

The set of *Cross Validation* trials is given as Table 11.

Table 10

Factors and ranges for constructing *Cross-validation* trials for the Bering-Chukchi-Beaufort Seas stock of bowhead whales.

Factor	Range
$MSYR_{1+}$	1 – 4%
$MSYL_{1+}$	0.4 – 0.8
Final need	67 – 201
Survey bias in future year 25	0.67 – 1.5
Estimated survey CV	0.1 – 0.4
Time-lag	0 – 20

E. Tuning

The trial for *depletion tuning* is BE14. Tuning should be achieved to match the (1+) median final depletion achieved by H (see Section G) for this trial to within 0.005. Developers should also provide results for all trials for a range of tunings of their candidate *SLAs*. This range of tunings should be chosen so that the range of median final depletions for trial BE14 includes the value used for depletion tuning as specified above.

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_b^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 $t \geq 2003$ (defined as $t = 0$ below).

K^* is the population size in year t if there had never been any fishing.

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.

Statistics marked in bold face are considered the more important. All developers must report at least the 5% and median values for the D1 and N9 statistics. In addition, they should bring a machine readable copy of all the statistics to meetings so that these can be discussed if the SWG wishes.

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 (optional for trials BR9, 10 and 11). In trials with varying K this statistic is defined as P_T / K_t^* .

D2. Lowest depletion: $\min(P_t / K)$: $t = 0, 1, \dots, T$. In trials with varying K this statistic is defined as $\min(P_t / K_t^*)$: $t = 0, 1, \dots, T$.

D6. Plots for simulations 1 and 2 of $\{P_t : t = 0, 1, \dots, T\}$ and $\{P_t^* : t = 0, 1, \dots, T\}$

D7. Plots of $\{P_{t[x]} : t = 0, 1, \dots, T\}$ and $\{P_{t[x]}^* : t = 0, 1, \dots, T\}$ where $P_{t[x]}$ is the x th percentile of the distribution of P_t . Results are presented for $x = 5$ and $x = 50$.

D8. Rescaled final population: P_T / P_T^*

D9. Minimum population level (for trials BR9, 10 and 11) $\min(P_t)$: $t = 0, 1, \dots, T$

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 $C_t < Q_t$) / T

N4. Fraction of years in which $C_t = Q_t$

N5. Proportion of block need satisfaction: $\Gamma / (T - h + 1)$ where Γ is the number of blocks of h years in which the total catch equals the total need; h is 5 for these trials.

N7. Plot of $\{V_{t[x]} : t = 0, 1, \dots, T\}$ where $V_{t[x]}$ is the x th percentile of the distribution of $V_t = C_t / Q_t$

N8. Plots of V_t for simulations 1 and 2.

N9. Average need satisfaction: $\frac{1}{T} \sum_{t=0}^{T-1} \frac{C_t}{Q_t}$

N10. AAV (Average Annual Variation):

$$\sum_{t=-1}^{T-2} |C_{t+1} - C_t| / \sum_{t=-1}^{T-2} C_t$$

N11. Anti-curvature: $\frac{1}{T-1} \sum_{t=0}^{T-2} \left| \frac{C_t - M_t}{\max(10, M_t)} \right|$

$$\text{where } M_t = (C_{t+1} + C_{t-1}) / 2$$

N12. Mean downstep (or modified AAV):

$$\sum_{t=-1}^{T-2} \left| \min(C_{t+1} - C_t, 0) \right| / \sum_{t=-1}^{T-2} C_t$$

F.3 Recovery

R1. Relative recovery: $P_t^* / P_{t_r}^*$ 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 $\min(1, P_T / MSYL)$.

Table 11

The *CV* for the Bering-Chukchi-Beaufort Seas stock of bowhead whales.

Trial No.	Model	$MSYR_{1+}$	$MSYL_{1+}$	Final need	Historical survey bias	Future survey bias	Survey CV (true, est)	Age data	Other
BCV01	D	3.11%	73.8%	186	1	0.794	0.25,0.394	Good	Lag=15
BCV02	D	2.52%	40.9%	72	1	0.700	0.25,0.295	Good	Lag=4
BCV03	D	1.81%	41.2%	155	1	0.767	0.25,0.116	Good	Lag=7
BCV04	D	3.43%	76.4%	69	1	0.971	0.25,0.242	Good	Lag=0
BCV05	D	3.36%	68.8%	195	1	0.676	0.25,0.236	Good	Lag=2
BCV06	D	2.22%	68.5%	194	1	1.450	0.25,0.140	Good	Lag=1
BCV07	D	1.58%	71.0%	183	1	1.386	0.25,0.388	Good	Lag=8
BCV08	D	1.16%	70.5%	109	1	1.332	0.25,0.166	Good	Lag=15
BCV09	D	2.34%	53.2%	186	1	1.136	0.25,0.357	Good	Lag=4
BCV10	D	2.36%	79.6%	71	1	1.422	0.25,0.105	Good	Lag=17

- R3. Time frequency in recovered state = (the number of years for which $P_t > 0.9 MSYL$, given that $t \geq t_r$) / $(T - t_r + 1)$ where t_r is the first year in which the population reaches $MSYL$ (or T otherwise).
- R4. Relative time to recovery:

$$RTR = \begin{cases} 1 & \text{if } P_0 \geq MSYL \\ (T - t_r) / T & \text{if } P_0 < MSYL \text{ and } P_T \geq MSYL \\ \min(t | P_t^* \geq P_T) / T & \text{if } P_0 < MSYL \text{ and } P_T < MSYL \end{cases}$$

G. Optimisation

H is defined as a set of strike limits computed using a target SLA (detailed below) which has been given perfect and complete knowledge about the stock dynamics and the operating model parameter values. H is used in defining the median final depletion to be used for depletion tuning (see section E). For a given trial i and replicate j , H_t^{ij} is defined as:

$$H_t^{ij} = \min \left(Q_t, \begin{cases} 0 & \text{if } N_t^{1+} < 2000 \\ 0.8 RY_t & \text{if } 2000 \leq N_t^{1+} < MSYL^{1+} \\ 0.9 MSY & \text{if } N_t^{1+} > MSYL^{1+} \end{cases} \right) \quad (G.1)$$

MSY is defined in terms of uniform selectivity harvesting on the 1+ component of the population;

RY_t is the replacement yield for year t and is given by Equation (G.2) for the deterministic model and by Equation (G.2s) for the stochastic model:

$$RY_{t+1} = \frac{\sum_{a=0}^x \sum_{m/f} \{ (R_{t+1,a}^{m/f} + U_{t+1,a}^{m/f} \delta_{a+1}) S_a - R_{t+1,a}^{m/f} \}}{\sum_{a=0}^x \sum_{m/f} R_{t+1,a}^{m/f} S_a} \quad (G.2)$$

$$RY_{t+1} =$$

$$\frac{\sum_{a=0}^x \sum_{m/f} \{ Bin^*((R_{t+1,a}^{m/f} + U_{t+1,a}^{m/f} \delta_{a+1}), S_a) - R_{t+1,a}^{m/f} \}}{\sum_{a=0}^x \sum_{m/f} Bin^*(R_{t+1,a}^{m/f}, S_a)} \quad (G.2s)$$

Rearranging Equation (G.2s) gives (using the fact that $R_{t+1,0} = 0$ by definition):

$$RY_{t+1} = \frac{Bin^*(B_{t+1} \delta_1, S_0) + \sum_{a=1}^x \sum_{m/f} \{ Bin^*((R_{t+1,a}^{m/f} + U_{t+1,a}^{m/f} \delta_{a+1}), S_a) - R_{t+1,a}^{m/f} \}}{\sum_{a=1}^x \sum_{m/f} Bin^*(R_{t+1,a}^{m/f}, S_a)} \quad (G.2s)$$

The $Bin^*(B_{t+1} \delta_1, S_0)$ term is calculated at the start of year $t+1$, once the number of mature females and the expected probability of birth/calf survival has been set (Equations

(A2.2) and (A2.3)). Thus, environmental stochasticity (Equations (A2.7) and (A2.8)) is included in the calculation of RY .

The replacement yield for the stochastic trials is computed by averaging RY_{t+1} over 2000* Monte Carlo replicates. The Monte Carlo process therefore involves integrating over stochastic variation (demographic and environmental) in survival rates and fecundity (see Equations (A1.1s) and (A2.1s)).

The software also calculates a measure of similarity between the strike limits provided by the SLA and those provided by H in the ideal case (Givens *et al.*, 1999). For trial i this is:

$$Z_i = \frac{\sum_{j=1}^{100} \sum_{t=0}^{99} \{ H_t^{i,j}(C) - C_t^{i,j}(C) \}^2}{\sum_{j=1}^{100} \sum_{t=0}^{99} \{ H_t^{i,j}(C) \}^2} \quad (G.3)$$

where:

$H_t^{ij}(C)$ is the strike limit for replicate j of trial i in year t for a trial in which a catch equal to H_t^{ij} is removed each year; and

$C_t^{ij}(C)$ is the strike limit for replicate j of trial i in year t provided by the candidate SLA , for a trial in which removals up to year $t-1$ have been determined by the same candidate SLA .

H. References

- Angliss, R.P., Rugh, D.J., Withrow, D.E. and Hobbs, R.C. 1995. Evaluations of aerial photogrammetric length measurements of the Bering-Chukchi-Beaufort Seas stock of bowhead whales (*Balaena mysticetus*). *Rep. int. Whal. Commn* 45:313-24.
- Bockstoce, J.R. and Botkin, D.B. 1983. The historical status and reduction of the western Arctic bowhead whale (*Balaena mysticetus*) population by the pelagic whaling industry 1848-1914. *Rep. int. Whal. Commn* (special issue) 5:107-141.
- Butterworth, D.S. and Punt, A.E. 1995. On the Bayesian approach suggested for the assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales. *Rep. int. Whal. Commn* 45:303-11.
- Givens, G.H. and Thompson, S.E. 1996. Alternative Bayesian Synthesis approaches to Bering-Chukchi-Beaufort Seas bowhead whale stock assesment: uncertainty in historic catch and hitting with fixed MSYR. *Rep. int. Whal. Commn* 46:509-29.
- Givens, G.H., Punt, A.E. and Bernstein, A.O. 1999. Equivalence tuning of $SLAs$. *J. Cetacean Res. Manage.* 1 (3):289-95
- Givens, G.H., Zeh, J.E. and A.E. Raftery. 1995. Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales using the Baleen II model in a Bayesian synthesis framework. *Rep. int. Whal. Commn* 45:345-64.
- International Whaling Commission 1991. Report of the Scientific Committee. Annex D. Report of the sub-committee on management procedures, Appendix 4. Report of the *ad hoc* trials subgroup. *Rep. int. Whal. Commn* 41:108-112C
- International Whaling Commission 1998. Report of the Scientific Committee. Annex J, Appendix 2. Report of the *ad hoc* bowhead assessment subgroup. *Rep. int. Whal. Commn* 48:245-248.
- Poole, D. and Givens, G.H. 2000. An Exploratory Assessment of the Bering-Chukchi-Beaufort Seas Stock of bowhead whales using a stochastic population dynamics model. Paper SC/52/AS12 presented to the IWC Scientific Committee, Adelaide, Australia, June 2000 (unpublished). [Paper available from the Office of this Journal].
- Punt, A.E. 1999. A full description of the standard BALEEN II model and some variants thereof. *J. Cetacean Res. Manage.* 1 (Suppl.) 267-76.
- Punt, A.E. 2000. Calculations of A and z . *J. Cetacean Res. Manage.* 2 (suppl):150-2
- Punt, A.E. and Butterworth, D.S. 1999. On assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales (*Balaena*

* The number of Monte Carlo replicates was set by the Email correspondence group, such that RY is calculated accurate to 2 whales.

- mysticetus*) using a Bayesian approach. *J. Cetacean Res. Manage.* 1(1):53-71.
- Punt, A.E. and Butterworth, D.S. 2002. An examination of certain of the assumptions made in the Bayesian approach used to assess the eastern Pacific stock of gray whales (*Eschrichtius robustus*). *J. Cetacean Res. Manage.* 4(1):99-110.
- Wade, P.R. 2002. A Bayesian stock assessment of the eastern Pacific gray whale using abundance and harvest data from 1967-1996. *J. Cetacean Res. Manage.* 4(1):85-98.
- Witting, L. 2002. Report of the Third Workshop on the development of an aboriginal/subsistence whaling management procedure (AWMP). Annex E. Inertia model. *J. Cetacean Res. Manage.* 4 (suppl) 447-9.
- Zeh, J.E. Raftery, A.E. and Schaffner, A.A. 1995. Revised estimates of bowhead population size and rate of increase. Paper SC/47/AS10 presented to the IWC Scientific Committee, Dublin, Ireland, May 1995. (unpublished). [Paper available from the Office of this Journal].

Adjunct 1. List of notations used.

Symbol	Definition	Reference
Basic dynamics		A
$R_{t,a}^{m/f}$	The number of recruited males/females of age a at the start of year t	A1.1, 2.2, 2.5
$U_{t,a}^{m/f}$	The number of unrecruited males/females of age a at the start of year t	A1.1, 2.2, 2.5
$C_{t,a}^{m/f}$	The catch of males/females of age a during year t	A1.1, 3.1
S_a	The annual survival rate of animals of age a ($= \exp(-M_a)$ where M_a is the instantaneous natural mortality of animals of age a)	A1.1, 1.2
S_{juv}	The survival rate for 'juveniles' ($1 \leq a \leq a_{\text{adult}}$)	A1.1, 1.2
S_{adult}	The survival rate for adults ($a > a_{\text{adult}}$)	A1.1, 1.2
a_{adult}	The greatest age at which the 'juvenile' survival rate applies	A1.1, 1.2, 2.1
δ_a	The fraction of unrecruited animals of age $a-1$ which recruit at age a	A1.2
x	The maximum (lumped) age-class.	A1.1
Births		A.2
N_t^f	The number of mature females at the start of year t	A2.2, 2.1
N_t^{1+}	The 1+ population size at the start of year t	A2.5
K^{1+}	The pristine 1+ population size at the start of year t	A2.6
B_{t+1}	The number of births at the start of year $t+1$	A2.1, 2.4
B_t^f	Number of female births during year t	A2.4
R_t^m, R_t^f	The number of recruited male/female calves in year t	A2.4
U_t^m, U_t^f	The number of unrecruited male/females calves in year t	A2.4
b_{t+1}	The probability of birth/calf survival for mature females that did not calve in the previous year	A2.3
$\tilde{b}_{t+1}$	A realisation of a random process, equal to b_{t+1} in expectation, that generates annual birth/calf survival probabilities	A2.1
$b_{-\infty}$	The average number of live births per year per mature female that did not calve in the previous year in the pristine (pre-exploitation) population	A2.3
a_m	Age-at-first parturition (= age-at-maturity + 1 year)	A2.2
A	Resilience parameter	A2.3
z	The degree of compensation	A2.3
D_t	The size of the component of the population in year t upon which the density-dependence is assumed to act	A2.3
$D_{-\infty}$	The pristine size of the component of the population upon which the density-dependence is assumed to act	A2.3
α_0	The proportion of animals of age 0 which are recruited (0 in this model)	A2.4
q_t	A random variable; $q_t = \mu_t + \rho(q_{t-1} - \mu_{t-1}) + \varepsilon_t$ where $\varepsilon_t \sim N(0; \sigma_\varepsilon^2)$	A2
μ_t	A constant set each year to give the required value of $\tilde{b}_t$	A2
σ_q^2	Variance of q_t ($= \sigma_\varepsilon^2 / (1 - \rho^2)$)	A2
σ_ε^2	Variance of ε	A2
Catches		
$C_t^{m/f}$	The catch of males/females in year t	A3.1
Recruitment		A.4
α_a	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 1	A4.1
δ_{a+1}	The fraction of unrecruited animals of age a that survive to age $a+1$ which then recruit	A4.2

Symbol	Definition	Reference
Initial population vector		A.6
$R_{-\infty,a}^{m/f}$	The number of males/females of age a that would be recruited in the pristine population	A6.1
$U_{-\infty,a}^{m/f}$	The number of males/females of age a which would be unrecruited in the pristine population	A6.1
$N_{-\infty,0}$	The total number of animals of age 0 in the pristine population	A6.1
$f_{\max}$	Maximum theoretical pregnancy rate	Table 2
$c_{\min}$	$1/f_{\max}$	Table 2
$f(F)$	Fecundity (number of female births per mature female) when the exploitation rate is F	A7.1
n_y	Minimum possible interval between calvings (1 year in these trials)	A7.1
$P^D(F)$	Size of the component of the population on which density-dependence acts when the exploitation rate is F	A7.1
K^D	Pre-exploitation size of the component of the population on which density-dependence acts	A7.1
$P(F)$	Normalised equilibrium number of 'recruited' animals when the exploitation rate is fixed at F (either the number of animals which have reached the age at first parturition, or the number of age 1+ animals). The normalisation is provided by dividing by the number of births at pre-exploitation equilibrium.	A7
$\tilde{P}(F)$	Number of 'recruited' animals per birth when the exploitation rate is fixed at F .	A7
Basic dynamics		A
$\hat{S}$	The survey estimate	B1.1, 1.5
θ	A constant chosen to give the required value of CV_{est}	B1.7, 1.9
β	See definition of w	
α	See definition of Y	
B_A	The survey bias	B1.1
P	The 1+ population size in the area at the start of year t ($= N_t^{1+}$)	B1.1, 1.2, 1.5
P^*	The reference population level, equal to the pristine 1+ population	B1.1, 1.4
Y	A lognormal random variable	B1.1
W	A Poisson random variable, independent of Y , with $E(w) = \text{var}(w) = \mu = (P/P^*)/\beta^2$	B1.1
CV_{true}	True coefficient of variation (standard error as a fraction of the estimate) when $P = 0.6P^*$	B1.5
CV_{est}	(Approximately) the expectation of the estimate of the CV provided to the SLA	B1.7
Age-class data		
n_0	Number of calves	B.2
n_m	Number of mature animals	B.2
N	Total number of animals	B.2
L	Length of calves or mature animals	B2.1
$p(L)$	The proportion of whales larger than length L	B2.2
c	Specifies marginal variance of age/length class proportion data	B2.1
$a_{\min}(L)$	The last age at which no whales may exceed length L	B2.3
$a_{\max}(L)$	The age at which all whales exceed length L	B2.3
$a_{50}(L)$	The age at which the length of 50% of whales of that age exceed length L	B2.3
σ_L	A dispersion parameter	B2.3
γ_L	A bias term to account for error in $a_{50}(L)$	B2.3
λ_L	A term to account for error in σ_L	B2.3
Need		
Q_t	Level of need in year t	C
Robustness Trials		A
t_l	The density-dependent time lag ($= 0$ in base-case trials)	Di.1
$B_{t+1,a}$	The number of births in year $t+1$ from females of age a	Dii.1
$N_{t,a}^f$	The number of mature females of age a at the start of year $t = R_{t,a}^f + U_{t,a}^f$	Dii.3
$b_{t+1,a}$	The probability of birth/calf survival for mature females of age a that did not calve in the previous year	Dii.4
$b'_{t+1,a}$	The 'intrinsic' birth rate for animals of age a (depends only on when the animal was born)	Dii.5 and 6
$b'_{t+1,0}$	The 'intrinsic' birth rate for the calves during year $t+1$ and is the average (population-weighted) 'intrinsic' birth rate for their parents, adjusted by a density-dependent inter-generation change (g).	Dii.7
g_{t+1}	The density-dependent inter-generation change to the birth rate. In the pristine population, $g_{\infty} = 1$	Diii.8
A_i	Constant ($=$ the resilience $A/2$).	Diii.8
$D_{-\infty}(t)$	$D_{-\infty}$ in Equation (2.3) is replaced by $D_{-\infty}(t)$ for trials in which K varies	Dvi
$A(t)$	The resilience, A , in equation (2.3) is replaced by $A(t)$ for trials in which $MSYR$ varies	Dvii
$S_a(t)$	$S_a(t) = e^{-M_a(t)}$	Dviii
τ	Starting year ($= 1940$) for population projections starting after the first catches.	Dx
$N_{\tau,a}^*$	The number of animals of age a at the start of year τ relative to the number of births at that time	Dx.1
B_{τ}	The number of births in year τ	Dx.2
D_{τ}^*	The number of whales in the density dependent component of the population in year τ relative to the number of births at that time	Dx.2

Appendix 3ii

FISHERY TYPE 2: IMPLEMENTATION FOR EASTERN NORTH PACIFIC GRAY WHALES

This document outlines a set of trials for the eastern North Pacific (ENP) stock of gray whales for the case in which stock identity is not an issue. The trials are based on those for Bering-Chukchi-Beaufort (BCB) Seas stock of bowhead whales because the ENP gray whale appears to be an example of a type 2 fishery (no obvious stock identity problems, considerable information, and where the Scientific Committee has not had major problems providing advice under paragraph 13(a) of the Schedule). The specifications below provide the equations needed to implement the suggestions of Punt and Givens (2000).

A. The population dynamics model

The underlying dynamics model is deterministic and is age- and sex-structured and is based on the Baleen II program (Punt, 1999).

A.1 Basic dynamics

Equations A1.1 provide the underlying 1+ dynamics.

$$\begin{aligned} R_{t+1,a+1}^{m/f} &= (R_{t,a}^{m/f} - C_{t,a}^{m/f}) S_a + U_{t,a}^{m/f} S_a \delta_{a+1} & 0 \leq a \leq x-2 \\ R_{t+1,x}^{m/f} &= (R_{t,x}^{m/f} - C_{t,x}^{m/f}) S_x + (R_{t,x-1}^{m/f} - C_{t,x-1}^{m/f}) S_{x-1} & (A1.1) \\ U_{t+1,a+1}^{m/f} &= U_{t,a}^{m/f} S_a (1 - \delta_{a+1}) & 0 \leq a \leq x-2 \end{aligned}$$

$R_{t,a}^{m/f}$ is the number of recruited males/females of age a at the start of year t ;

$U_{t,a}^{m/f}$ is the number of unrecruited males/females of age a at the start of year t ;

$C_{t,a}^{m/f}$ 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);

S_0 is the annual survival rate of animals of age a :

$$S_a = \begin{cases} S_0 & \text{if } a = 0 \\ S_{1+} & \text{if } a > 0 \end{cases} \quad (A1.2)$$

S_0 is the calf survival rate;

S_{1+} is the survival rate for animals aged 1 and older;

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). $\times$ is taken to be 15 for these trials.

A.2 Births

The number of births at the start of year $t+1$, B_{t+1} , is given by Equation A2.1a:

$$B_{t+1} = b_{t+1} N_{t+1}^f \quad (A2.1)$$

N_t^f is the number of mature females at the start of year t :

$$N_t^f = \sum_{a=a_m}^x (R_{t,a}^f + U_{t,a}^f) \quad (A2.2)$$

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);

a_{t+} is the probability of birth/calf survival for mature females:

$$b_{t+1} = b_{-\infty} \{1 + A(1 - (D_{t+1} / D_{-\infty})^z)\} \quad (A2.3)$$

a_m is the average number of live births per year per mature female in the pristine (pre-exploitation) population;

A is the resilience parameter;

z is the degree of compensation;

D_t is the size of the component of the population in year t upon which the density-dependence is assumed to act; and

$D_{-\infty}$ is the pristine size of the component of the population upon which the density-dependence is assumed to act.

The number of female births, B_t^f , is computed from the total number of the births during year t using Equation A2.4:

$$B_t^f = 0.5 B_t \quad (A2.4)$$

The numbers of recruited/unrecruited calves is given by:

$$\begin{aligned} R_{t,0}^f &= \alpha_0 B_t^f & R_{t,0}^m &= \alpha_0 (B_t - B_t^f) \\ U_{t,0}^f &= (1 - \alpha_0) B_t^f & U_{t,0}^m &= (1 - \alpha_0) (B_t - B_t^f) \end{aligned} \quad (A2.5)$$

α_0 is the proportion of animals of age 0 which are recruited.

In these trials $D_t = N_t^{1+}$ and $D_{-\infty} = K^{1+}$ because density-dependence is assumed to act on the 1+ component of the population and affects fecundity and infant survival. N_t^{1+} and K^{1+} are defined according to the equations:

$$N_t^{1+} = \sum_{a=1}^x (R_{t,a}^f + U_{t,a}^f + R_{t,a}^m + U_{t,a}^m) \quad (A2.6)$$

$$K^{1+} = \sum_{a=1}^x (R_{-\infty,a}^f + U_{-\infty,a}^f + R_{-\infty,a}^m + U_{-\infty,a}^m)$$

The common control program maintains the option for density dependence to act on the mature component of the population i.e. $D_t = N_t^f$ and $D_{-\infty} = K_{-\infty}^f$, to implement some of the robustness trials.

A.3 Catches

The historical ($t < 2003$) catches are taken to be equal to the reported catches (Table 1). The sex-ratio of future catches is assumed to be 50:50. Catches are taken uniformly from the recruited component of the population:

$$C_{t,a}^{m/f} = C_t^{m/f} R_{t,a}^{m/f} / \sum_a R_{t,a}^{m/f} \quad (A3.1)$$

$C_t^{m/f}$ is the catch of males/females in year t . The total catch in a given future year is taken to be the minimum of the need for that year, Q_t , and the corresponding strike limit, $C_t = C_t^m + C_t^f$.

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 5, i.e.:

Table 1a
Commercial and recent aboriginal (post 1943) catches from the eastern North Pacific stock of gray whales.

Year	Male	Female	Year	Male	Female	Year	Male	Female	Year	Male	Female
1846	23	45	1885	21	41	1924	0	1	1963	60	120
1847	23	45	1886	17	33	1925	63	70	1964	73	146
1848	23	45	1887	7	13	1926	25	17	1965	70	111
1849	23	45	1888	7	13	1927	7	25	1966	123	97
1850	23	45	1889	7	13	1928	4	8	1967	135	239
1851	23	45	1890	7	13	1929	0	3	1968	67	134
1852	23	45	1891	7	13	1930	0	0	1969	59	155
1853	23	45	1892	7	13	1931	0	0	1970	26	125
1854	23	45	1893	0	0	1932	0	0	1971	51	102
1855	162	324	1894	0	0	1933	2	3	1972	22	160
1856	162	324	1895	0	0	1934	30	24	1973	97	81
1857	162	324	1896	0	0	1935	11	23	1974	94	90
1858	162	324	1897	0	0	1936	45	57	1975	58	113
1859	162	324	1898	0	0	1937	5	9	1976	69	96
1860	162	324	1899	0	0	1938	18	36	1977	86	101
1861	162	324	1900	0	0	1939	10	19	1978	94	90
1862	162	324	1901	0	0	1940	39	66	1979	57	126
1863	162	324	1902	0	0	1941	19	38	1980	53	128
1864	162	324	1903	0	0	1942	34	67	1981	36	100
1865	162	324	1904	0	0	1943	33	66	1982	56	112
1866	79	159	1905	0	0	1944	0	0	1983	46	125
1867	79	159	1906	0	0	1945	10	20	1984	59	110
1868	79	159	1907	0	0	1946	7	15	1985	55	115
1869	79	159	1908	0	0	1947	0	1	1986	46	125
1870	79	159	1909	0	0	1948	6	13	1987	47	112
1871	79	159	1910	0	1	1949	9	17	1988	43	107
1872	79	159	1911	0	0	1950	4	7	1989	61	119
1873	79	159	1912	0	0	1951	5	9	1990	67	96
1874	79	159	1913	0	1	1952	15	29	1991	57	113
1875	17	33	1914	6	13	1953	19	29	1992	0	0
1876	17	33	1915	0	0	1954	13	26	1993	0	0
1877	17	33	1916	0	0	1955	20	39	1994	25	19
1878	17	33	1917	0	0	1956	41	81	1995	49	43
1879	21	42	1918	0	0	1957	33	65	1996	19	24
1880	17	34	1919	0	0	1958	49	99	1997	48	31
1881	17	33	1920	1	1	1959	65	130	1998	63	60
1882	17	33	1921	11	22	1960	58	115	1999	69	53
1883	19	39	1922	6	4	1961	71	141	2000	62	51
1884	23	45	1923	0	0	1962	53	98			

Sources: 1846 - 1854 : IWC (1993) p.243 & 257.

1855 - 1910 : Lankester and Beddington (1986).

1910 – 2000 Based on Donahue and Brownell (2001) with corrections by C. Allison.

Sex ratio: 1846-1964 Ratio of 2:1 females to males used IWC (1993) p.257 except where actual values known

1965-1972 Animals of unknown sex allocated in the ratio 195:290 = ratio of the known USSR catch in this period (Zimushiko and Ivashin (1980).

1973-1988 Sex ratio of animals of unknown sex is assumed to be the same as that of animals of known sex in the catch that year.

1991 Animals allocated in the ratio 319:675 = 1:2.2 = ratio of catches from 1985-1990.

1994 on: Animals allocated in the ratio 341:252 = ratio of known catches from 1995-2000 (note: the catching methods changed when catching resumed in 1994).

$$\alpha_a = \begin{cases} 0 & \text{if } a < 5 \\ 1 & \text{otherwise} \end{cases} \quad (\text{A4.1})$$

Table 1b

Historical (pre-1944) aboriginal catches from the eastern north Pacific stock of gray whales. The numbers are taken from Mitchell and Reeves (1990). The sex-ratio of these catches is assumed to be 1:1 (source: IWC, 1993).

Years	Annual catch (both sexes)
1600 - 1750	180
1751 - 1840	200
1841 - 1860	190
1861 - 1890	110
1891 - 1915	60
1916 - 1930	50
1931 - 1939	10
1940 - 1943	20

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:

$$\delta_{a+1} = \begin{cases} [\alpha_{a+1} - \alpha_a] / [1 - \alpha_a] & \text{if } \alpha_a < 1 \\ 1 & \text{otherwise} \end{cases} \quad (\text{A4.2})$$

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:

$$\begin{aligned} R_{-\infty,a}^{mf} &= 0.5 N_{-\infty,0} \alpha_a \prod_{a'=0}^{a-1} S_{a'} & \text{if } a < x \\ U_{-\infty,a}^{mf} &= 0.5 N_{-\infty,0} (1-\alpha_a) \prod_{a'=0}^{a-1} S_{a'} & \text{if } a < x \\ R_{-\infty,x}^{mf} &= 0.5 N_{-\infty,0} \prod_{a'=0}^{x-1} \frac{S_{a'}}{(1-S_x)} & \text{if } a = x \end{aligned} \quad (\text{A6.1})$$

$R_{-\infty,a}^{mf}$ is the number of animals of age a that would be recruited in the pristine population;

$U_{-\infty,a}^{mf}$ 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:

$$N_{-\infty,0} = K^{1+} / \left(\sum_{a=1}^{x-1} \left(\prod_{a'=0}^{a-1} S_{a'} \right) + \frac{1}{1-S_x} \prod_{a'=0}^{x-1} S_{a'} \right) \quad (\text{A6.2})$$

It is well-known that it is not possible to make a simple density-dependent population dynamics model consistent with the abundance estimates for the eastern north Pacific stock of gray whales (Reilly, 1981; 1984; Cooke, 1986; Lankester and Beddington, 1986; Butterworth *et al.*, 2002). This is why recent assessments of this stock (e.g. Wade, 2002; Punt and Butterworth, 2002) have been based on starting population projections from a more recent year (denoted as τ) than that in which the first recorded catch occurred. The trials are therefore based on the assumption that the age-structure at the start of $\tau = 1930$ is stable rather than that the population was at its pre-exploitation equilibrium size at the start of 1600. The choice of 1930 for the first year of the simulation is motivated by the fact that the key assessment results are not sensitive to a choice for this year from 1930-1968 (Punt and Butterworth, 2002). Note that even though the operating model ignores the catch data from the years 1600-1929, these catches are nevertheless provided to the *SLA*.

The determination of the age-structure at the start of 1930 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 5, only the γ^+ component (assumed to be zero following Punt and Butterworth, 2002) applies to ages a of 4 or less. The number of animals of age a at the start of $\tau = 1930$ relative to the number of calves at that time, $N_{\tau,a}^*$, is therefore given by the equation:

$$N_{\tau,a}^* = \begin{cases} 1 & \text{if } a = 0 \\ N_{\tau,a-1}^* S_{a-1} (1-\gamma^+) & \text{if } a \leq 5 \\ N_{\tau,a-1}^* S_{a-1} (1-\gamma) & \text{if } 5 < a < x \\ N_{\tau,x-1}^* S_{x-1} (1-\gamma) / (1-S_x (1-\gamma)) & \text{if } a = x \end{cases} \quad (\text{A6.3})$$

B_τ is the number of calves in year $\tau (= 1930)$ and is derived directly from equations 2.1 and 2.3 (for further details see Punt, 1999)

$$B_\tau = \left(1 - \left[1 / (N_\tau^f b_{-\infty}) - 1 \right] / A \right)^{1/z} \frac{D_{-\infty}}{D_\tau^*} \quad (\text{A6.4})$$

D_τ^* is the number of animals in the density dependent component of the population relative to the number of births at that time (see equation A2.6).

The effective rate of increase, γ , is selected so that if the population dynamics model is projected from 1930 to 1968, the size of the 1+ component of the population in 1968 equals a pre-specified value, P_{1968} .

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.. The method is the same as for the BCB bowhead whale with $n_y = 0$ (no minimum calving interval) – see Section A.7 of Appendix 3b (bowhead specifications)

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 of the eastern North Pacific stock of gray whales (Punt and Butterworth, 2002; Wade, 2002). The algorithm for conducting the Bayesian assessment is as follows:

- Draw values for the parameters S_{1+} , $f_{\max}$, a_m , $MSYR_{1+}$, $MSYL_{1+}$, K^{1+} , P_{1968} , CV_{sch} (the CV associated the mean school size estimation error in 1968) and CV_{add} (the CV associated with the additional variance in 1968) from the priors in Table 2. For most trials, 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.

Table 2

The prior distributions for the eastern North Pacific stock of gray whales.

Parameter	Prior distribution
Non-calf survival rate, S_{1+}	U[0.95, 0.999]
Age-at-maturity, a_m	U[5, 9]
K^{1+}	U[0, 70,000]
$MSYL_{1+}$	U[0.4, 0.8]
$MSYR_{1+}$	U[0.01, 0.1]
Maximum pregnancy rate, $f_{\max}$	U[0.3, 0.6]
Additional variation, CV_{add}	U[0, 0.35]
School size variation, CV_{sch}^{1+}	$U[\max(CV_{sch}^{obs}) / 6, 1.5 * \max(CV_{sch}^{obs})]$
1968 abundance, $\ell n P_{1968}$	$N(\ell n 13,012; ((893/12013)^2 + CV_{add}^2))$

¹ NB on implementation it should be confirmed that the posterior for this parameter does not have appreciable probability near the boundary for CV_{sch} .

- 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 .
- Calculate the likelihood of the projection which is given by:

$L = L_1 + L_2$ where

$$L_1 = \prod_y \frac{1}{\sqrt{\sigma_y^2 + E(CV_{add,y}^2) + E(CV_{sch,y}^2)}} \exp\left(-\frac{(\ell n N_y^{obs} - \ell n \hat{N}_y)^2}{2(\sigma_y^2 + E(CV_{add,y}^2) + E(CV_{sch,y}^2))}\right) \quad (A8.1)$$

$$L_2 = \frac{(n_{sch}(CV_{sch,y}^{obs})^2 / E(CV_{sch,y}^2))^{0.5n_{sch}-1}}{\exp\left(\frac{n_{sch}(CV_{sch,y}^{obs})^2}{2E(CV_{sch,y}^2)}\right)}$$

N_y^{obs} is the shore-count-based estimate of the (1+) abundance at the start of year y (Table 3);
 $\hat{N}_y$ is the model-estimate of the (1+) abundance at the start of year y ;
 α_y is the (sampling) standard deviation of the logarithm of N_y^{obs} (approximated by its (sampling) coefficient of variation, $CV_{est,y}^{obs}$);
 $E(CV_{add,y}^2)$ is the square of the actual CV of the additional variation for year y :

$$E(CV_{add,y}^2) = \eta(0.1 + 0.013P^* / P_y) = CV_{add}^2 \frac{0.1 + 0.013P^* / P_y}{0.1 + 0.013P^* / P_{1968}} \quad (A8.2)$$

$E(CV_{sch,y}^2)$ is the square of the actual CV associated with the mean school size estimation error in year y :

$$E(CV_{sch,y}^2) = CV_{sch}^2 \frac{0.02 + 0.012P^* / P_y}{0.02 + 0.012P^* / P_{1968}} \quad (A8.3)$$

n_{sch} is the number of degrees of freedom for the estimate of the CV of the error in mean school size. n_{sch} is taken to = 35 and is calculated from the

$$CV \text{ of } (CV_{sch}^{obs})^2 = \sqrt{2/n_{sch}}$$

$CV_{sch,y}^{obs}$ is the (observed) CV associated with the mean school size estimation error in year y .

- (d) Steps (a) – (c) are repeated a large number (typically 100,000) of times.
 (e) 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 will be chosen to ensure that each of the 100 parameter vectors are unique.

The population model estimates are divided by the bias factor when conditioning the trials that involve the assumption that the abundance estimates are biased.

B. Data generation

B.1 Absolute Abundance Estimates

The historic ($t < 2000$) abundance estimates (and their CVs) are provided to the *SLA* and are taken to be those in Table 3. An estimate of absolute abundance together with an estimate of its CV is generated, and is provided to the *SLA*, for the year $t=2001$ and then once every F years during the management period (where $F=10$). 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:

$$\hat{S} = B_A P Y w / \mu = B_A P^* \beta^2 Y w \quad (B1.1)$$

B_A is the bias;

P is the current 1+ population size ($= N_t^{1+}$); (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 1+ population, $= K^{1+}$).

Note that under the approximation $CV^2(ab) = CV^2(a) + CV^2(b)$, $E(\hat{S}) = B_A P_t$ and $CV_{true}^2(\hat{S}) = \alpha^2 + \beta^2 P^* / P$ (B1.5)

The steps¹ used in the program to generate the abundance estimates and their CVs are given below.

The *SLA* is provided with estimates of CV_{est} and CV_{sch} for each sightings estimate.

¹ 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} ($= 0.075$ = value used to generate the 1968 abundance). Generate values of CV_{add}^2 and CV_{sch}^2 for 1968.
 - (ii) Set η using equation B1.8b and the value of CV_{add} generated in step (i).
 - (iii) Set θ^2 using equation B1.7a and the values for CV_{est} and CV_{sch} from step (i) and $w\beta^2 = P / P^* = P_{1968} / P^*$. Set α^2 and β^2 using equation B1.9.
 - (iv) Generate ω (Poisson random variable – see equation B1.4) and ϕ (lognormal random variable – see equation B1.3).
 - (v) Set abundance estimate $\hat{S}$ using equation B1.1.
 - (vi) Set $E(CV_{est,y}^2) + E(CV_{sch,y}^2)$ using eqn B1.7a and $E(CV_{sch,y}^2)$ using eqn B1.7b.
 - (vii) Generate $\hat{CV}_{sch,y}$ from a $\chi_{n_{sch}}^2$ distribution using equation B1.6b.
- Generate $\hat{CV}_{est,y}$ from a χ_n^2 distribution using equation B1.6a. If this is negative then repeat steps (vii)–(viii).

Table 3

Estimates of absolute abundance (with associated standard errors) for the eastern North Pacific stock of gray whales based on shore counts (source: J. Breiwick, pers. comm.).

Year	Estimate	CV_{est}	CV_{sch}	Year	Estimate	CV_{est}	CV_{sch}	$CV_{combined}$
1967/68	12,921	0.07461	-	1977/78	16,879	0.06487	-	-
1968/69	12,070	0.04921	-	1978/79	13,104	0.04800	-	-
1969/70	12,597	0.05081	-	1979/80	16,364	0.05084	-	-
1970/71	10,707	0.04548	-	1984/85	21,443	0.05512	-	-
1971/72	9,760	0.05369	-	1985/86	20,113	0.04609	-	-
1972/73	15,099	0.04557	-	1987/88	20,869	0.04375	-	-
1973/74	14,696	0.04974	-	1992/93	17,674	0.05822	-	-
1974/75	12,955	0.05087	-	1993/94	23,109	0.05461	-	-
1975/76	14,520	0.05482	-	1995/96	22,263	0.07621	0.0524	0.07621
1976/77	15,304	0.04371	-	1997/98	26,635	0.09035	0.0442	0.09035

The estimate of $CV_{est,y}$ is given by:

$$\hat{CV}_{est,y} = \sqrt{\sigma_y^2 (\chi_n^2 / n) - \hat{CV}_{sch,y}^2}$$

$$\sigma_y^2 = \ell n(1 + E(CV_{est,y}^2) + E(CV_{sch,y}^2)) \quad (B1.6a)$$

$E(CV_{est,y}^2) + E(CV_{sch,y}^2)$ is the sum of the squares of the actual CVs due to estimation error:

$$E(CV_{est,y}^2) + E(CV_{sch,y}^2) = \theta^2 (a^2 + b^2 / w\beta^2) \quad (B1.7a)$$

χ_n^2 is a random number from a χ^2 distribution with n ($= 19$; the value assumed for the single stock trials wfor the RMP) degrees of freedom;

a^2, b^2 are constants and equal to 0.02 and 0.012 respectively;

$\hat{CV}_{sch,y}$ is the estimate of $CV_{sch,y}$ and is given by:

$$\hat{CV}_{sch,y} = \sigma_{sch,y} \sqrt{(\chi_{n_{sch}}^2 / n_{sch})} \quad \sigma_{sch,y}^2 = \ell n(1 + E(CV_{sch,y}^2)) \quad (B1.6b)$$

where $\chi_{n_{sch}}^2$ is a random number from a χ^2 distribution with n_{sch} ($= 35$) degrees of freedom and

$E(CV_{sch,y})$ is the actual CV associated with the mean school size estimation error in year y (set using equation B1.7a after assuming the split of the CV_{sch}^2 and CV_{est}^2 is constant from one year to the next):

$$E(CV_{sch,y}^2) = \frac{\theta^2 (a^2 + b^2 / w\beta^2)}{1 + CV_{est}^2 / CV_{sch}^2} = CV_{sch}^2 \frac{a^2 + b^2 / w\beta^2}{a^2 + b^2 P^* / P_{1968}} \quad (B1.7b)$$

The relationship between CV_{est} and CV_{true} is given by:

$$\eta = [E(CV_{true}^2) - E(CV_{est}^2) - E(CV_{sch}^2)] / (0.1 + 0.013P^* / P) \quad (B1.8a)$$

where η is a constant known as the additional variance factor. The value of η is based on the population size and CVs for 1968 (for consistency with the way the CV for P_{1968} is generated in Table 2):

$$\eta = CV_{add}^2 / (0.1 + 0.013P^* / P_{1968}) \quad (B1.8b)$$

The values of α and β are then computed as:

$$a^2 = \theta^2 a^2 + \eta \cdot 0.1, \quad \beta^2 = \theta^2 b^2 + \eta \cdot 0.013 \quad (B1.9)$$

C. Need

The level of need in each year, Q_t , will be supplied to the SLA. The need is given by

$$Q_t = Q_{2003} + \frac{t-2003}{100} (Q_{2103} - Q_{2003}) \quad \text{where } Q_{2003} (= 150) \text{ is}$$

the need at the start of the first year in which the AWMP is applied and Q_{2103} is the value 100 years later. The level of need supplied to the SLA is the total need for the 5-year period for which strike limits are to be set.

D. Trials

The set of evaluation trials is given as Table 4 and the robustness trials as Table 5.

DETAILS OF FACTORS

The factors used in the trials are shown in Tables 6 and 7 and further details are given below where necessary.

(i) Time lag in density-dependent response

For trials with a time lag in the density-dependent response, Equation (A2.3) is replaced by

$$b_{t+1} = b_{-\infty} \{1 + A(1 - (D_{t+1-t_l} / D_{-\infty})^z)\} \quad (Di.1)$$

where t_l is the density-dependent time lag ($= 0$ in base-case trials).

(ii) 'Strategic' inter-survey period

See Section Dii of Appendix 3(i) (bowhead specifications).

Table 4

GE trials (Note: trial numbers are chosen to match equivalent BE trials). Values given in bold type show differences from the base case trial. See items (i) and (iii) for further details of the factors involving strategic surveys and the inertia model).

Trial	Description	Model	MSYR ₁₊	MSYL ₁₊	Final Need	Survey frequency	Historical survey bias	Future survey bias	Future Survey CV
GE01	Base case	D	3.5%	0.6	340	10	1	1	Base
GE02	Low need i.e. constant	D	3.5%	0.6	150	10	1	1	Base
GE03	Future +ve bias	D	3.5%	0.6	340	6	1	1→1.5 in yr 25	Base
GE04	Future -ve bias	D	3.5%	0.6	340	6	1	1→0.5 in yr 25	Base
GE05	Underestimated CVs	D	3.5%	0.6	340	10	1	1	$\frac{1}{2} CV_{est}$
GE07	MSYL ₁₊ = 0.8	D	3.5%	0.8	340	10	1	1	Base
GE08	6 year surveys	D	3.5%	0.6	340	6	1	1	Base
GE09	MSYR ₁₊ = 1.5%	D	1.5%	0.6	340	10	0.5 → 1	1	Base
GE10	MSYR ₁₊ = 5.5%	D	5.5%	0.6	340	10	1	1	Base
GE11	Bad data	D	3.5%	0.6	340	10	1	1→1.5 in yr 25	$\frac{1}{2} CV_{est}$
GE12	Difficult 1.5%	D	1.5%	0.6	340	10	0.5 → 1	1→1.5 in yr 25	$\frac{1}{2} CV_{est}$
GE12a	Difficult 1.5%	D	1.5%	0.6	340	6	0.5 → 1	1→1.5 in yr 25	$\frac{1}{2} CV_{est}$
GE14	High need	D	3.5%	0.6	530	10	1	1	Base
GE14a	High need	D	3.5%	0.6	530	6	1	1	Base
GE16	MSYR ₁₊ = 1.5%; high need	D	1.5%	0.6	530	10	0.5 → 1	1	Base
GE20	MSYR ₁₊ = 5.5%; high need	D	5.5%	0.6	530	6	1	1	Base
GE21	Integrated	D	U[1.5,5.5%]	U[.4-.8]	340	10	1	1	Base
GE21a	Integrated	D	U[1.5,5.5%]	U[.4-.8]	340	6	1	1	Base
GE23	Strategic surveys; high need	D	3.5%	0.6	530	Strategic	1	1	CV_{true} = 0.1 + base case value
GE24	Inertia Model – medium	I		0.6	340	10	1	1	Base
GE25	Inertia Model – slow	I		0.6	340	10	1	1	Base
GE26	Inertia Model – fast	I		0.6	340	10	1	1	Base

Table 5
The robustness trials.

Trial No.	Factor	Basic trials (Table 4)	Factor Level
GR01	A: Density dependence	1, 9, 10	Density dependence on mature (GE trials use 1+)
GR04	E: Survey frequency	9, 14, 16, 20	a) 15 yrs b) 5 yrs c) 10 yrs
GR05	F: Strategic surveys (see ii)	1, 9 1, 9	a) Yes + CV = base case value b) Yes + CV _{true} =0.1+ base case value
GR06	G: Survey bias time dependence (see iv)	1 1 9 12 14	a) Historic bias: 1.5 constant; Future bias: decreasing (1.5→1) b) Historic bias: 0.5 constant; Future bias: increasing (0.5→1) c) Future bias: sinusoidal from base value in yr 0 to maximum of 150% in yr 40 (Fig1a) d) Future bias: decreasing (1.5→1) from year 0 to 100 e) Future bias: increasing from 1→1.5 in year 25 and constant thereafter
GR07	H: Future survey CV	1 1	a) CV _{est} = 1/2 base case value and CV _{true} has the same CV _{add} b) CV _{true} =0.1+ base case value
GR08	I: Historic catch bias (see v)	14, 16, 20	0.5 (1940-70 catches under-reported) + survey bias adjustment as necessary
GR09	K: Time dependence in K (see vi)	1, 2, 9, 10 1, 2, 9, 10 1 1, 21 1, 9	a) K halves linearly over 100 years b) K doubles linearly over 100 years c) K sinusoidal from base value in year 0 to maximum of 150% in year 40 (Fig 1a) d) Tent K: K doubles linearly from years-50 to 0 and halves from years 0 to 50 (Fig1b) e) K halves linearly over 100 years + strategic surveys
GR10	L: Time dependence in MSYR (see vii)	10 9 1, 2, 8 1, 2, 8 1 1, 21	a) Resilience (A) halves linearly over 100 years b) Resilience (A) doubles linearly over 100 years c) Resilience steps 2½%→1%→2½% every 33 yrs over 100 years d) Resilience steps 2½%→1%→2½% every 33 yrs over 100 years in sync with M (compute MSYR first) – if it is practical halve M for each age class e) K and A halve linearly over 100 years f) K and A vary as tent (see GR09(d))
GR11	M: Time dependence in M (see viii)	1, 2, 9, 10 1, 2, 9, 10	a) Natural mortality M halves linearly over 100 years b) M doubles linearly over 100 years
GR12	N: Episodic events (see ix)	1, 2, 9, 10	2 events in which 20% of animals die occur between years 1-50
GR13	O: Integrated.	1, 11, 14 11, 14	MSYR ₁₊ ~U[1.5, 5.5%]; fixed MSY _{L1+} =0.6 MSYR ₁₊ ~U[1.5, 5.5%]; MSY _{L1+} ~U[0.4, 0.8]
GR15	MSY _{L1+} =0.9	1, 9, 10	
GR17	Q: 20 year time lag (see i)	9	20 year time lag

(iii) Inertia population dynamics model

The inertia model is discussed more fully in Witting (2001) and Witting (2002). It assumes that density-dependent changes in life history parameters affect the probability of birth/calf survival for mature females. The model is only implemented for the deterministic case. In this model, the dynamics are governed by the equations given in Section A except that Equation (A2.1) which sets the number of births at the start of year $t+1$, B_{t+1} , is replaced by

$$B_{t+1} = \sum_a B_{t+1,a} \quad (\text{Diii.1})$$

where $B_{t+1,a}$ is the number of births in year $t+1$ from females of age a , and is given by;

$$B_{t+1,a} = b_{t+1,a} N_{t+1,a}^f \quad a_m \leq a \leq x \quad (\text{Diii.2})$$

$N_{t,a}^f$ is the number of mature females of age a at the start of year t :

$$N_{t,a}^f = R_{t,a}^f + U_{t,a}^f \quad \text{if } a > a_m \text{ and } 0 \text{ otherwise} \quad (\text{Diii.3})$$

$b_{t+1,a}$ is the probability of birth / calf survival for mature females of age a :

$$b_{t+1,a} = b'_{t+1,a} \{1 + A(1 - (D_{t+1} / D_{-\infty})^f)\} \quad \text{with the restriction that } 0 \leq b_{t+1,a} \leq 1 \quad (\text{Diii.4})$$

$b'_{t+1,a}$ is the 'intrinsic' birth rate for animals of age a (depends only on when the animal was born):

$$b'_{t+1,a+1} = b'_{t,a} \quad 1 \leq a \leq x-2 \quad (\text{Diii.5})$$

$$b'_{t+1,x} = \frac{b'_{t,x} N_{t,x} S_x + b'_{t,x-1} N_{t,x-1} S_{x-1}}{N_{t,x} S_x + N_{t,x-1} S_{x-1}} \quad (\text{Diii.6})$$

$b'_{t+1,0}$ is the 'intrinsic' birth rate for the calves during year $t+1$ and is the average (population-weighted) 'intrinsic' birth rate for their parents, adjusted by a density-dependent inter-generation change (g) that may arise from a diversity of mechanisms including selection, maternal effects and other forms of environmental response:

$$b'_{t+1,0} = \frac{g_{t+1} \sum_a b'_{t,a} B_{t+1,a}}{B_{t+1}} \quad (\text{Diii.7})$$

$$g_{t+1} = \{1 + A_i(1 - (D_{t+1} / D_{-\infty})^f)\} \quad (\text{Diii.8})$$

In the pristine population, $g_{-\infty} = 1$ i.e. $b_{-\infty} = b_{-\infty}$ which is set as for the base case trials. A_i is a constant and is set such that $A_i / A = 0.5$.

The above implementation uses the traditional Pella-Tomlinson form of density dependence in combination with the inertia model with an added restriction on the birth

rate at population levels above K (without this restriction the model can exhibit rapid short-term fluctuations in the population size time trajectories). Another constraint is also added to ensure that the population between 1880 and 1920 is less than 5000 (without this constraint it is possible to obtain good fits to the recent abundance data, but with population trajectories that are at very high levels in the late 1800s).

The set of GE trials include three trials using the inertia model, which are classified as having fast, medium and slow dynamics. There is no obvious definition of the dynamics so analyses are to be conducted based on defining 'fast, medium and slow' according to five alternatives:

- (i) Slope – the slope from the first maximum population size after year 0 (= actual year 2003) to the first minimum population size or the slope from year 0 to year 50 if the population size increases monotonically over the entire 50 year period.
- (ii) F_{MSY} – the constant exploitation rate, that over the next 1000 years, maximizes the average future catch (range 0 to 10% in steps of 0.5%).
- (iii) F_{ext} – the constant exploitation rate that, over the next 1000 years, keeps the 1+ population size above 1000 animals.
- (iv) Population change: the ratio of the population size in year 50 to that in year 0.
- (v) High Low ratio: the ratio of the lowest to the highest population size over years 0 to 50.

The 'slope', 'population change' and 'high low ratio' statistics are based on population projections after 2003 in which the catch is assumed to be zero. To select parameters sets for a simulation trial, the draws from the prior distributions will be divided into three groups based on the values for each of these statistics, a subset of draws for each group will be selected by sampling with replacement and proportional to the likelihood within each group, and the resulting trajectories will be plotted for each group. The E-mail correspondence group will examine the trajectory plots to see which of the five statistics can be best used to define 'fast, medium and slow' dynamics.

(iv) Survey bias

In order to avoid a discontinuity in the value of the survey bias, if the historical survey bias in year 2002 is not equal to the value of the future bias, then the bias changes linearly between years 0 and 25 to the new value, and is constant thereafter.

(v) Historic catch bias

This factor involves applying a bias to the true historic catch, between 1848 and 1914, as used by the operating model. The SLA is given the same catch series as for the base case trial (see Table 1). These values are either over reported when the true catches are 0.5 times less, or under reported when the true catches are 1.5 times greater.

(vi) Varying K

D_{∞} in Equation (2.3) is replaced by $D_{\infty}(t)$ for trials in which K varies. The different forms of K are shown in Fig 1. The initial value of D_{∞} is set as for the base case trials, and is held fixed until the start of management (year 0) or until year -50 in the case when K varies as a tent. The values of all other parameters (e.g. the resilience parameter A , the degree of compensation z and the fecundity b_{∞}) do not change (unless also specified for a particular trial). The value of the reference population level, P^* , used in generation of the abundance estimates (equation (B1.1)) is also constant through out the entire trial. H (see section G) is not defined for trials with varying K .

(vii) Varying $MSYR$

The resilience, A , in equation (2.3) is replaced by $A(t)$ for trials in which $MSYR$ varies. The initial value of A is set as for the base case trials, and it is held fixed until the start of management (year 0). The values of all other parameters do not change (unless also specified for a particular trial).

(viii) Varying mortality rate

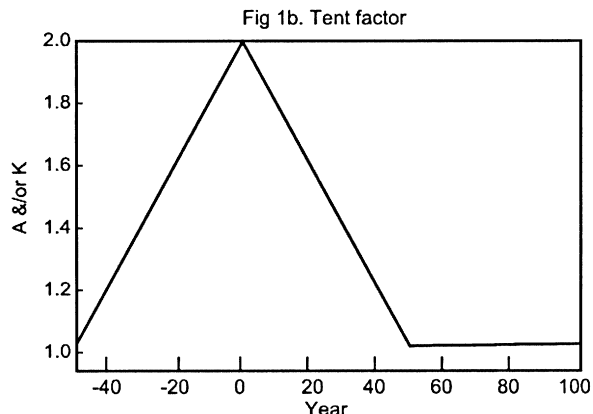
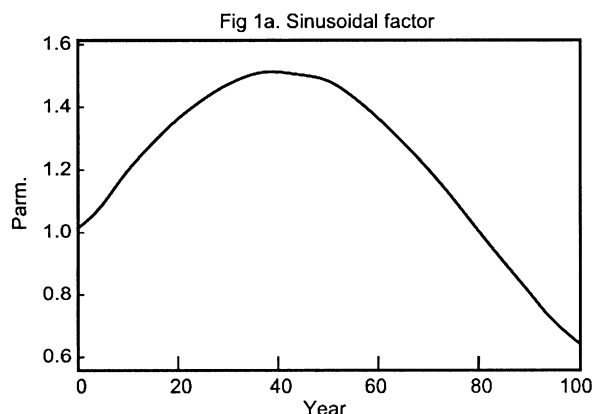
For trials in which the natural mortality rate M varies, Equations (A1.2) are replaced by $S_a(t) = e^{-M_a(t)}$ where the mortality at each age $a=1, x$ varies as given in the trial definition. The calf survival rate is given by:

$$S_0(t) = S_{juv}(t) S_{adult}(t) \quad (Dviii.1)$$

In trial BR10d, the resilience and natural mortality vary in sync in years 33 and 66: A is reduced by a factor of 1/2.5 and M is halved in year 33; in year 66 they return to their initial values.

(ix) Episodic events

In episodic event trials, 2 events occur during the first 50 years of management in which 20% of the animals die. The deaths occur uniformly throughout the population i.e. the



numbers in each age class, both recruited and unrecruited, are reduced by 20% in years when an event occurs. The 2 events occur in different years.

CROSS VALIDATION TRIALS

Not yet set for Gray whales.

E. Tuning

The trial for *depletion tuning* is to be decided later. Tuning should be achieved to match the median final depletion achieved by *H* (see Section G) for this trial to within 0.02. Developers should also provide results for all trials for a range of tunings of their candidate SLAs.

F. Statistics and G. Optimisation

See Sections F and G of Appendix 3(i) (bowhead specifications).

H. References

- Butterworth, D.S., Korrubel, J.L. and Punt, A.E. 2002. What is needed to make a simple density-dependent response population model consistent with data for the eastern Pacific gray whales? *J. Cetacean Res. Manage.* 4(1):63-76.
- Cooke, J.G. 1986. On the net recruitment rate of gray whales with reference to inter-specific comparisons. *Rep. int. Whal. Commn* 36:363-6.
- Donahue, M. and Brownell, R.L. 2001. Twentieth century whaling statistics for eastern Pacific gray whales. Paper SC/53/BRG16 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- International Whaling Commission. 1993. Report of the Special Meeting of the Scientific Committee on the assessment of gray whales, Seattle, 23-27 April 1990. *Rep. int. Whal. Commn* 43:241-259.
- Lankester, K. and Beddington, J.R. 1986. An age structured population model applied to the gray whale (*Eschrichtius robustus*). *Rep. int. Whal. Commn* 36:353-8.
- Mitchell, E.D. and Reeves, R.R. 1990. Aboriginal whaling for gray whales in the eastern North Pacific Ocean. Paper SC/A90/G7 presented to the IWC Scientific Committee Special Meeting on the assessment of gray whales, April 1990, Seattle, USA (unpublished). [Paper available from the Office of this Journal].
- Punt, A.E. 1999. A full description of the standard Baleen II model and some variants thereof. *J. Cetacean Res. Manage.* 1(Suppl.): 267-76.
- Punt, A.E. and Butterworth, D.S. 2002. An examination of certain of the assumptions made in the Bayesian approach used to assess the eastern Pacific stock of gray whales (*Eschrichtius robustus*). *J. Cetacean Res. Manage.* 4(1):99-110.
- Punt, A.E. and Givens, G.H. 2000. Issues related to the specification of trials for the eastern north Pacific stock of gray whales. *J. Cetacean Res. Manage.* 2 (Suppl.): 153-154.
- Reilly, S.B. 1981. Gray whale population history: an age structured simulation. Paper SC/33/PS8 presented to the IWC Scientific Committee, June 1981 (unpublished). 24 pp. [Paper available from the Office of this Journal].
- Reilly, S.B. 1984. Observed and maximum rates of increase of gray whales, *Eschrichtius robustus*. *Rep. int. Whal. Commn* (Spec. Iss.) 6: 389-99.
- Wade, P.R. 2002. A Bayesian stock assessment of the eastern Pacific gray whale using abundance and harvest data from 1967-1996. *J. Cetacean Res. Manage.* 4(1): 85-98.
- Witting, L. 2001. On inertial dynamics in whale populations. The case of the eastern North Pacific gray whale. Paper SC/53/AWMP6 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Witting, L. 2002. Report of the Third Workshop on the development of an aboriginal/subsistence whaling management procedure (AWMP). Annex E. Inertia model. *J. Cetacean Res. Manage.* 4 (suppl) 447-9.
- Zimushiko, V.V. and Ivashin M.V. 1980. Some results of Soviet Investigations and whaling of gray whales *Rep. int. Whal. Commn* 30: 243.

Appendix 3iii

CHANGES TO THE GRAY WHALE TRIAL SPECIFICATIONS DETAILED IN APPENDIX 3ii.

The modifications to the gray whale trials were agreed by the SWG with the details being finalised by a small group consisting of Allison, Butterworth, Givens and Witting.

1. Incorporation of the 2000/01 and 2001/02 abundance estimates.

The 2000/01 and 2001/02 abundance estimates for ENP gray whales presented at this meeting (see Annex F) were notably lower than the last previous estimate (1997/98) (see Table 1). The SWG **agreed** that the recent variations in surveyed abundance must be taken into account in its trial structure. Three plausible explanations for the recent surveys are:

- (1) The 2000/01 and 2000/02 surveys are biased due to variations in migration patterns or some unknown reason.
- (2) These two surveys are no different than the other recent ones, and the apparent differences in abundance are merely the result of natural variability.
- (3) The drop in abundance in these two surveys is attributable to a distinct mortality/productivity event.

The SWG **agreed** that trials should cover all three possible explanations, and noted that (2) and (3) would require reconditioning. Of these three options, the SWG considered that (1) should be investigated by only a very small number of sensitivity tests. Option (3) should be investigated more thoroughly, although the extent to which this was primarily an evaluation or robustness scenario will be decided at the next meeting. Option (2) should be treated as a very plausible explanation and investigated thoroughly with trials.

Three options were agreed by the small group:

- (i) Run the existing model. The estimated additional variance will be increased as a result of including the 2 new estimates (note: the estimates are assumed to be uncorrelated).
- (ii) Ignore the 2 new abundance estimates (and calf counts) in the conditioning (the SLA will however still be given all the estimates including those for 2000/01 and 2001/02).
- (iii) Let an episodic event occur in 1999/2000, in which x % of each age class die. x is to be included an extra

parameter in the conditioning process, and is drawn from a uniform prior $U[0,40\%]$.

[Punt recommended that the trials rather be based on a pre-specified value (40%) for the size of the episodic event (to prevent this trial becoming an 'apples and oranges' trial)].

(i) is the baseline option. Options (ii) and (iii) will be run for trials GE01, 4, 9, 12, 16 and 20 (these trials being the primary BE trial equivalents used by developers of the bowhead

SLA, together with one trial with a higher MSYR). The revised set of BE trials is listed in Table 2. The effects of these options will be looked at by correspondence.

2. Episodic Events trials

The SWG **agreed** that trials with episodic events should play a substantial role in GE/GR trials, to model a plausible biological possibility and as a surrogate for stochastic dynamics (see Annex E, item 3.2). If the recent reduction in surveyed abundance of ENP gray whales was due to a mortality event, calf counts suggest that this event was

Table 1

Estimates of absolute abundance (with associated standard errors) for the eastern north Pacific stock of gray whales based on shore counts (source: J. Breiwick, pers. comm.).

Year	Estimate	CV_{est}	CV_{sch}	Year	Estimate	CV_{est}	CV_{sch}	$CV_{combined}$
1967/68	12,921	0.07461	-	1978/79	13,104	0.04800	-	-
1968/69	12,070	0.04921	-	1979/80	16,364	0.05084	-	-
1969/70	12,597	0.05081	-	1984/85	21,443	0.05512	-	-
1970/71	10,707	0.04548	-	1985/86	20,113	0.04609	-	-
1971/72	9,760	0.05369	-	1987/88	20,869	0.04375	-	-
1972/73	15,099	0.04557	-	1992/93	17,674	0.05822	-	-
1973/74	14,696	0.04974	-	1993/94	23,109	0.05461	-	-
1974/75	12,955	0.05087	-	1995/96	22,263	0.07621	0.0524	0.07621
1975/76	14,520	0.05482	-	1997/98	26,635	0.09035	0.0442	0.09035
1976/77	15,304	0.04371	-	2000/01	18,761	0.09035	0.0442	0.09035
1977/78	16,879	0.06487	-	2001/02	17,414	0.09035	0.0442	0.09035

Table 4

GE trials (Note: trial numbers are chosen to match equivalent BE trials). Values in **bold** type show differences from the base case trial.

Trial	Description	Model	$MSYR_{1+}$	$MSYL_{1+}$	Final need	Survey freq.	Survey bias		Future survey CV	Conditioning option
							Historic	Future		
GE01	Base case	D	3.5%	0.6	340	10	1	1	Base	i
GE01b	Base case, ignore low est.	D	3.5%	0.6	340	10	1	1	Base	ii
GE01c	Base case, episodic event	D	3.5%	0.6	340	10	1	1	Base	iii
GE02	Low need i.e. constant need	D	3.5%	0.6	150	10	1	1	Base	i
GE03	Future +ve bias	D	3.5%	0.6	340	5	1	1→1.5 in yr 25	Base	i
GE04	Future -ve bias	D	3.5%	0.6	340	5	1	1→0.5 in yr 25	Base	i
GE04b	Future -ve bias	D	3.5%	0.6	340	5	1	1→0.5 in yr 25	Base	ii
GE04c	Future -ve bias	D	3.5%	0.6	340	5	1	1→0.5 in yr 25	Base	iii
GE05	Underestimated CVs	D	3.5%	0.6	340	10	1	1	$\frac{1}{2} CV_{est}$	i
GE07	$MSYL_{1+} = 0.8$	D	3.5%	0.8	340	10	1	1	Base	i
GE08	5 year surveys	D	3.5%	0.6	340	5	1	1	Base	i
GE09	$MSYR_{1+} = 1.5\%$	D	1.5%	0.6	340	10	0.5→1	1	Base	i
GE09b	$MSYR_{1+} = 1.5\%$	D	1.5%	0.6	340	10	0.5→1	1	Base	ii
GE09c	$MSYR_{1+} = 1.5\%$	D	1.5%	0.6	340	10	0.5→1	1	Base	iii
GE10	$MSYR_{1+} = 5.5\%$	D	5.5%	0.6	340	10	1	1	Base	i
GE11	Bad data	D	3.5%	0.6	340	10	1	1→1.5 in yr 25	$\frac{1}{2} CV_{est}$	i
GE12	Difficult 1.5%	D	1.5%	0.6	340	10	0.5→1	1→1.5 in yr 25	$\frac{1}{2} CV_{est}$	i
GE12a	Difficult 1.5%+5yr surveys	D	1.5%	0.6	340	5	0.5→1	1→1.5 in yr 25	$\frac{1}{2} CV_{est}$	i
GE12b	Difficult 1.5%	D	1.5%	0.6	340	10	0.5→1	1→1.5 in yr 25	$\frac{1}{2} CV_{est}$	ii
GE12c	Difficult 1.5%	D	1.5%	0.6	340	10	0.5→1	1→1.5 in yr 25	$\frac{1}{2} CV_{est}$	iii
GE14	High need	D	3.5%	0.6	530	10	1	1	Base	i
GE14a	High need + 5yr surveys	D	3.5%	0.6	530	5	1	1	Base	i
GE16	$MSYR_{1+} = 1.5\%$; high need	D	1.5%	0.6	530	10	0.5→1	1	Base	i
GE16b	$MSYR_{1+} = 1.5\%$; high need	D	1.5%	0.6	530	10	0.5→1	1	Base	ii
GE16c	$MSYR_{1+} = 1.5\%$; high need	D	1.5%	0.6	530	10	0.5→1	1	Base	iii
GE20	$MSYR_{1+} = 5.5\%$; high need	D	5.5%	0.6	530	5	1	1	Base	i
GE21	Integrated	D	U[1.5,5.5%]	U[.4-.8]	340	10	1	1	Base	i
GE21a	Integrated + 5yr surveys	D	U[1.5,5.5%]	U[.4-.8]	340	strategic	1	1	Base	i
GE23	Strategic surveys; high need	D	3.5%	0.6	530	5	1	1	$CV_{true}=0.1$ + base case value	i
GE24	Inertia Model – medium	I		0.6	340	10	1	1	Base	i
GE25	Inertia Model – slow	I		0.6	340	10	1	1	Base	i
GE26	Inertia Model – fast	I		0.6	340	10	1	1	Base	i

manifested (at least in part) by neonatal mortality. Therefore, the SWG **agreed** that episodic event trials should consider episodic changes in both mortality rates and/or productivity.

The group considered that the concerns of the sub-committee would be captured by the following three options:

- (i) The existing Episodic Events trial: 2 events occur between years 1-50, in which 20% of animals from every age class die.
- (ii) 2 events occur between years 1-50, in which 20% of animals die, taking from the youngest end of the population first. This option is to implement the suggestion that recent reductions in abundance may be due (at least in part) to neonatal mortality. The population trajectory should be circulated to examine the effect of this change and to judge whether its effect is sufficient to incorporate as an additional trial.
- (iii) In the future, draw the value of M (the natural mortality rate) at random every year [from 1-100], from 3 values: the historic value M_h and $M_h \pm 50\%$ (with the added restriction that there are as many ups as downs, so the

mean natural mortality rate is unchanged).

[Punt's comment: the variation in M is temporally-independent which, given that M is $\sim 5\%$, is a minor issue. He suggests temporally-correlated deviations in M].

3. Other changes to trials agreed by the SWG

At the last meeting, the SWG had changed survey frequency in the GE/GR trials from 5 years to 10 years, with some sensitivity tests set with 6 year intervals. To avoid the mismatch between 6 year survey intervals and 5 year block quotas, the SWG agreed that the 6 year intervals should be changed back to 5 years.

The SWG agreed that conditioning should use all available data if possible, in particular the existing calf count data although this increases the computing time required. To address practical computational issues, it agreed that *Evaluation Trials* should be conditioned on the calf count data, whereas *Robustness Trials* should provisionally ignore the calf count data at this stage. If changes in software or hardware speeded the conditioning process, then Allison would review this decision with a view towards conditioning all trials on the calf count data.

Appendix 4

[Tables follow]

Table of results of the Bowhead Evaluation trials. 5th, Median and 96th percentiles of a sub-set of the mandatory performance statistics are shown for the 5 candidate SLAs together with catch = Need, catch = H (perfect information) and the Catch Limit Algorithm. The statistics are listed in Table 1 of the Annex and full specifications are given in Appendix 3(i) section F. The trials are listed in table 6 of Appendix 3(i).

SLA	D1: Final 1+Depln			D10: 1+ Rel. Incr			N9: Need Satfn (20)			N9 Need Satfn (100)			N12: Mn Down Step		
	5%	Med	96%	5%	Med	96%	5%	Med	96%	5%	Med	96%	5%	Med	96%
BE01 Base Case: 2.5%, Need=67→134															
NEED	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.860	.862	.907	1.15	1.23	1.34	.95	1.00	1.00	.86	1.00	1.00	.000	.000	.024
GUP	.861	.867	.903	1.16	1.23	1.33	.99	1.00	1.00	.88	.99	1.00	.000	.003	.019
G-G	.861	.872	.902	1.17	1.23	1.33	1.00	1.00	1.00	.88	.98	1.00	.000	.007	.018
D-M-L	.860	.863	.909	1.15	1.23	1.35	.86	.98	1.00	.84	.99	1.00	.000	.002	.027
G-G-L	.874	.894	.911	1.19	1.26	1.36	1.00	1.00	1.00	.86	.93	.98	.003	.009	.016
CLA	.979	.987	.993	1.32	1.39	1.50	.00	.00	.00	.03	.06	.12	.244	.376	.551
BE01-SE Base Case: 2.5%, Need=67→134															
NEED	.831	.866	.907	1.10	1.22	1.33	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.831	.866	.907	1.10	1.22	1.33	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.834	.873	.925	1.10	1.23	1.38	.96	1.00	1.00	.86	1.00	1.00	.000	.000	.023
GUP	.834	.875	.925	1.10	1.23	1.37	.99	1.00	1.00	.87	.99	1.00	.000	.003	.019
G-G	.834	.877	.926	1.11	1.24	1.37	1.00	1.00	1.00	.88	.98	1.00	.000	.006	.018
D-M-L	.834	.873	.927	1.10	1.23	1.38	.86	.98	1.00	.82	.99	1.00	.000	.002	.030
G-G-L	.857	.896	.937	1.13	1.27	1.40	1.00	1.00	1.00	.85	.93	1.00	.002	.009	.016
CLA	.961	.987	1.011	1.27	1.40	1.52	.00	.00	.00	.02	.06	.11	.253	.370	.617
BE02 2.5%, Need=67															
NEED	.934	.935	.936	1.25	1.32	1.42	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.934	.935	.936	1.25	1.32	1.42	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.934	.935	.936	1.25	1.32	1.42	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
GUP	.934	.935	.936	1.25	1.32	1.42	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
G-G	.934	.935	.936	1.25	1.32	1.42	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M-L	.934	.935	.936	1.25	1.32	1.42	.95	1.00	1.00	.99	1.00	1.00	.000	.000	.007
G-G-L	.934	.935	.936	1.25	1.32	1.42	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
CLA	.979	.987	.993	1.32	1.39	1.50	.00	.00	.00	.05	.11	.20	.244	.376	.551
BE03 2.5%, Need=67→134, Bias=1, 1.5															
NEED	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.860	.862	.874	1.15	1.21	1.31	.96	1.00	1.00	.98	1.00	1.00	.000	.000	.007
GUP	.860	.862	.868	1.15	1.21	1.31	1.00	1.00	1.00	.99	1.00	1.00	.000	.000	.003
G-G	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M-L	.860	.862	.874	1.15	1.21	1.31	.88	.99	1.00	.97	1.00	1.00	.000	.001	.007
G-G-L	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
CLA	.955	.963	.974	1.29	1.35	1.47	.00	.00	.00	.11	.17	.24	.142	.183	.256
BE03-SE 2.5%, Need=67→134, Bias=1, 1.5															
NEED	.831	.866	.907	1.10	1.22	1.33	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.831	.866	.907	1.10	1.22	1.33	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.831	.868	.907	1.10	1.22	1.34	.98	1.00	1.00	.98	1.00	1.00	.000	.000	.006
GUP	.831	.867	.907	1.10	1.22	1.33	1.00	1.00	1.00	.99	1.00	1.00	.000	.000	.003
G-G	.831	.866	.907	1.10	1.22	1.33	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M-L	.831	.869	.907	1.10	1.22	1.34	.87	.99	1.00	.97	1.00	1.00	.000	.001	.008
G-G-L	.831	.866	.907	1.10	1.22	1.33	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
CLA	.936	.964	.992	1.23	1.36	1.49	.00	.00	.00	.11	.17	.24	.140	.180	.268
BE04 2.5%, Need=67→134, Bias=1,0.67															
NEED	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.915	.926	.937	1.24	1.30	1.41	.94	1.00	1.00	.72	.77	.83	.012	.018	.028
GUP	.918	.941	.955	1.25	1.32	1.43	.97	1.00	1.00	.67	.75	.84	.016	.027	.036
G-G	.921	.949	.962	1.26	1.33	1.44	1.00	1.00	1.00	.66	.74	.84	.023	.041	.051
D-M-L	.917	.931	.944	1.25	1.31	1.42	.85	.96	1.00	.65	.73	.81	.017	.028	.040
G-G-L	.920	.942	.953	1.25	1.33	1.43	1.00	1.00	1.00	.70	.78	.84	.012	.032	.041
CLA	.998	1.000	1.000	1.33	1.41	1.52	.00	.00	.00	.00	.00	.02	.716	1.000	1.000
BE04a 2.5%, Need=67→134, Bias=1,0.67, Survey=5yrs															
NEED	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.920	.927	.935	1.24	1.31	1.42	.96	1.00	1.00	.71	.77	.81	.015	.023	.031
GUP	.930	.943	.956	1.26	1.33	1.44	.98	1.00	1.00	.63	.73	.79	.020	.027	.036
G-G	.941	.953	.963	1.27	1.35	1.45	1.00	1.00	1.00	.61	.71	.78	.033	.043	.059
D-M-L	.924	.934	.944	1.25	1.32	1.43	.88	.96	1.00	.64	.72	.76	.024	.034	.046
G-G-L	.934	.948	.954	1.26	1.34	1.44	1.00	1.00	1.00	.65	.74	.80	.028	.035	.041
CLA	.999	1.000	1.000	1.34	1.41	1.52	.00	.00	.00	.00	.00	.01	.881	1.000	1.000

cont.

SLA	D1: Final 1+Depln			D10: 1+ Rel. Incr			N9: Need Satfn (20)			N9 Need Satfn (100)			N12: Mn Down Step		
	5%	Med	96%	5%	Med	96%	5%	Med	96%	5%	Med	96%	5%	Med	96%
BE05 2.5%, Need=67→134, CV=(.25,.1)															
NEED	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.860	.863	.905	1.16	1.23	1.34	.91	1.00	1.00	.86	.98	1.00	.000	.005	.031
GUP	.861	.873	.904	1.17	1.24	1.34	.96	1.00	1.00	.85	.97	1.00	.000	.007	.024
G-G	.861	.874	.903	1.17	1.23	1.34	1.00	1.00	1.00	.84	.96	1.00	.000	.012	.024
D-M-L	.861	.864	.906	1.16	1.24	1.35	.82	.98	1.00	.83	.97	1.00	.000	.011	.037
G-G-L	.875	.898	.913	1.20	1.26	1.37	1.00	1.00	1.00	.82	.91	.98	.005	.012	.025
CLA	.962	.982	.992	1.31	1.38	1.50	.00	.00	.02	.06	.13	.23	.165	.257	.427
BE07 2.5%, MSYL=80%, Need=67→134															
NEED	.964	.964	.965	1.14	1.21	1.34	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.964	.964	.965	1.14	1.21	1.34	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.964	.964	.965	1.14	1.21	1.34	.98	1.00	1.00	.98	1.00	1.00	.000	.000	.002
GUP	.964	.964	.969	1.14	1.21	1.34	1.00	1.00	1.00	.97	1.00	1.00	.000	.000	.006
G-G	.964	.964	.973	1.14	1.21	1.34	1.00	1.00	1.00	.95	1.00	1.00	.000	.000	.013
D-M-L	.964	.964	.965	1.14	1.21	1.34	.90	1.00	1.00	.96	1.00	1.00	.000	.000	.005
G-G-L	.964	.971	.978	1.15	1.22	1.34	1.00	1.00	1.00	.90	.97	1.00	.000	.007	.013
CLA	.994	.997	.998	1.18	1.25	1.38	.00	.00	.00	.04	.08	.13	.238	.353	.522
BE07-SE 2.5%, MSYL=80%, Need=67→134															
NEED	.946	.964	.981	1.08	1.21	1.36	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.946	.964	.981	1.08	1.21	1.36	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.946	.964	.981	1.08	1.21	1.36	.97	1.00	1.00	.95	1.00	1.00	.000	.000	.007
GUP	.948	.964	.981	1.08	1.21	1.36	1.00	1.00	1.00	.97	1.00	1.00	.000	.000	.007
G-G	.949	.965	.981	1.09	1.21	1.36	1.00	1.00	1.00	.95	1.00	1.00	.000	.000	.013
D-M-L	.946	.964	.981	1.08	1.21	1.36	.89	1.00	1.00	.93	1.00	1.00	.000	.000	.012
G-G-L	.956	.970	.987	1.09	1.21	1.37	1.00	1.00	1.00	.90	.96	1.00	.000	.007	.014
CLA	.986	.996	1.005	1.13	1.24	1.40	.00	.00	.00	.03	.07	.14	.240	.358	.515
BE08 2.5%, Need=67→134, Survey=5yrs															
NEED	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.860	.862	.905	1.15	1.22	1.34	.97	1.00	1.00	.87	1.00	1.00	.000	.000	.029
GUP	.861	.865	.899	1.16	1.23	1.33	.99	1.00	1.00	.90	.99	1.00	.000	.003	.022
G-G	.861	.871	.892	1.16	1.23	1.33	1.00	1.00	1.00	.91	.98	1.00	.000	.007	.017
D-M-L	.860	.862	.906	1.15	1.22	1.34	.90	.98	1.00	.84	.99	1.00	.000	.003	.034
G-G-L	.880	.896	.907	1.20	1.27	1.36	1.00	1.00	1.00	.87	.92	.96	.005	.011	.016
CLA	.974	.983	.991	1.31	1.39	1.50	.00	.00	.00	.04	.09	.14	.220	.309	.461
BE09 1%, Need=67→134, Bias=0.67→1, 1															
NEED	.450	.512	.565	1.00	1.05	1.08	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.571	.610	.630	1.19	1.24	1.26	1.00	1.00	1.00	.82	.85	.90	.000	.000	.000
D-M	.495	.570	.624	1.04	1.17	1.30	.95	1.00	1.00	.80	.90	1.00	.000	.012	.028
GUP	.505	.564	.627	1.05	1.15	1.32	.98	1.00	1.00	.78	.93	1.00	.000	.011	.026
G-G	.514	.562	.629	1.07	1.14	1.34	1.00	1.00	1.00	.78	.94	1.00	.000	.014	.033
D-M-L	.498	.578	.641	1.04	1.19	1.35	.85	.96	1.00	.75	.89	1.00	.000	.015	.033
G-G-L	.538	.586	.636	1.11	1.18	1.30	1.00	1.00	1.00	.80	.90	.96	.006	.012	.032
CLA	.878	.899	.912	1.71	1.83	1.97	.00	.00	.00	.03	.07	.13	.214	.343	.548
BE09a 1%, Need=67→134, Bias=0.67→1, 1, Survey=5yrs															
NEED	.450	.512	.565	1.00	1.05	1.08	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.571	.610	.630	1.19	1.24	1.26	1.00	1.00	1.00	.82	.85	.90	.000	.000	.000
D-M	.514	.568	.625	1.06	1.18	1.28	.96	1.00	1.00	.81	.89	1.00	.000	.016	.029
GUP	.520	.568	.624	1.06	1.16	1.33	.99	1.00	1.00	.78	.91	1.00	.000	.017	.028
G-G	.517	.570	.638	1.07	1.14	1.36	1.00	1.00	1.00	.75	.93	1.00	.003	.017	.036
D-M-L	.521	.575	.637	1.06	1.20	1.31	.88	.97	1.00	.78	.87	1.00	.000	.022	.038
G-G-L	.549	.593	.637	1.14	1.21	1.32	1.00	1.00	1.00	.78	.88	.94	.007	.013	.029
CLA	.867	.885	.903	1.67	1.80	1.95	.00	.00	.00	.05	.10	.17	.187	.269	.402
BE09-SE 1%, Need=67→134, Bias=0.67→1, 1															
NEED	.417	.526	.605	.87	1.04	1.19	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.542	.622	.696	1.14	1.25	1.39	.85	.97	1.00	.76	.85	.89	.013	.058	.121
D-M	.499	.578	.668	.99	1.15	1.34	.95	1.00	1.00	.80	.90	1.00	.000	.010	.030
GUP	.506	.575	.665	1.01	1.15	1.33	.99	1.00	1.00	.79	.92	1.00	.000	.011	.028
G-G	.506	.575	.666	1.02	1.15	1.32	1.00	1.00	1.00	.79	.93	1.00	.000	.014	.037
D-M-L	.502	.587	.677	.99	1.18	1.37	.85	.96	1.00	.76	.88	1.00	.000	.014	.035
G-G-L	.516	.591	.670	1.06	1.19	1.33	1.00	1.00	1.00	.81	.89	.97	.005	.012	.028
CLA	.842	.900	.961	1.65	1.80	2.02	.00	.00	.00	.03	.07	.13	.220	.349	.503
BE10 4%, MSYL=80%, Need=67→134															
NEED	.976	.977	.977	1.00	1.01	1.02	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.976	.977	.977	1.00	1.01	1.02	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.976	.985	.988	1.00	1.01	1.03	.97	1.00	1.00	.82	.93	1.00	.000	.013	.029
GUP	.977	.984	.988	1.00	1.01	1.03	1.00	1.00	1.00	.82	.93	1.00	.001	.014	.026
G-G	.977	.984	.988	1.00	1.01	1.03	1.00	1.00	1.00	.81	.93	.99	.002	.014	.027
D-M-L	.976	.985	.988	1.00	1.01	1.03	.89	1.00	1.00	.78	.91	1.00	.000	.018	.033
G-G-L	.983	.986	.988	1.00	1.02	1.03	1.00	1.00	1.00	.83	.89	.95	.006	.012	.019
CLA	.998	.999	1.000	1.02	1.03	1.05	.00	.00	.00	.00	.02	.07	.385	.623	.993

cont.

SLA	D1: Final 1+Depln			D10: 1+ Rel. Incr			N9: Need Satfn (20)			N9 Need Satfn (100)			N12: Mn Down Step		
	5%	Med	96%	5%	Med	96%	5%	Med	96%	5%	Med	96%	5%	Med	96%
BE10a 4%, MSYL=80%, Need=67→134, Survey=5yrs															
NEED	.976	.977	.977	1.00	1.01	1.02	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.976	.977	.977	1.00	1.01	1.02	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.976	.985	.988	1.00	1.01	1.03	.99	1.00	1.00	.83	.93	1.00	.000	.018	.040
GUP	.978	.984	.989	1.00	1.01	1.03	1.00	1.00	1.00	.81	.92	.99	.002	.018	.030
G-G	.980	.984	.990	1.00	1.01	1.03	1.00	1.00	1.00	.79	.92	.98	.005	.017	.033
D-M-L	.976	.985	.989	1.00	1.01	1.03	.93	1.00	1.00	.79	.91	1.00	.000	.024	.048
G-G-L	.985	.986	.988	1.00	1.02	1.03	1.00	1.00	1.00	.82	.87	.92	.008	.013	.016
CLA	.998	.999	1.000	1.02	1.03	1.05	.00	.00	.00	.00	.03	.07	.371	.575	.995
BE11 Bad Data: 2.5%, Need=67→134, Bias=1, 1.5, CV=(.25,.1)															
NEED	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.861	.863	.884	1.15	1.22	1.32	.93	1.00	1.00	.96	.99	1.00	.000	.001	.011
GUP	.860	.862	.872	1.15	1.22	1.32	.96	1.00	1.00	.98	1.00	1.00	.000	.000	.004
G-G	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M-L	.861	.863	.884	1.15	1.22	1.32	.85	.99	1.00	.94	.98	1.00	.000	.003	.013
G-G-L	.860	.862	.863	1.15	1.21	1.31	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
CLA	.911	.927	.951	1.24	1.31	1.43	.00	.00	.04	.28	.37	.47	.091	.119	.147
BE12 1%, Need=67→134, Bias=1→1.5, 1.5, CV=(.25,.1)															
NEED	.069	.148	.266	.23	.45	.72	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.398	.428	.475	1.28	1.29	1.30	.80	.85	.93	.65	.69	.74	.000	.004	.007
D-M	.241	.317	.393	.75	.95	1.14	.87	1.00	1.00	.74	.82	.96	.013	.027	.045
GUP	.227	.337	.421	.71	1.03	1.27	.94	1.00	1.00	.68	.80	.94	.013	.028	.040
G-G	.229	.356	.440	.71	1.08	1.34	1.00	1.00	1.00	.65	.78	.92	.016	.035	.056
D-M-L	.248	.337	.421	.80	1.03	1.23	.75	.95	1.00	.70	.80	.95	.017	.038	.055
G-G-L	.255	.343	.437	.78	1.00	1.28	1.00	1.00	1.00	.67	.80	.88	.013	.027	.042
CLA	.682	.733	.783	1.95	2.20	2.43	.00	.00	.01	.11	.20	.31	.117	.170	.268
BE12-SE 1%, Need=67→134, Bias=1→1.5, 1.5, CV=(.25,.1)															
NEED	.016	.182	.312	.05	.53	.83	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.373	.434	.506	1.15	1.28	1.44	.72	.88	.98	.64	.71	.78	.060	.100	.155
D-M	.224	.326	.428	.71	.99	1.22	.86	1.00	1.00	.73	.82	.97	.006	.027	.042
GUP	.237	.358	.467	.71	1.06	1.34	.93	1.00	1.00	.66	.80	.97	.009	.025	.043
G-G	.226	.369	.477	.68	1.09	1.41	1.00	1.00	1.00	.62	.79	.96	.013	.035	.059
D-M-L	.236	.352	.458	.73	1.05	1.29	.74	.96	1.00	.70	.80	.97	.009	.035	.054
G-G-L	.231	.367	.467	.73	1.10	1.37	1.00	1.00	1.00	.65	.80	.92	.012	.026	.044
CLA	.655	.744	.823	1.91	2.20	2.59	.00	.00	.01	.11	.20	.33	.105	.169	.262
BE12a 1%, Need=67→134, Bias=1→1.5, 1.5, CV=(.25,.1), Survey=5yrs															
NEED	.069	.148	.266	.23	.45	.72	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.398	.428	.475	1.28	1.29	1.30	.80	.85	.93	.65	.69	.74	.000	.004	.007
D-M	.273	.321	.388	.80	.97	1.11	.92	1.00	1.00	.74	.82	.91	.023	.038	.055
GUP	.285	.348	.409	.81	1.05	1.25	.97	1.00	1.00	.67	.78	.92	.019	.031	.045
G-G	.280	.371	.438	.81	1.13	1.31	1.00	1.00	1.00	.64	.75	.92	.017	.038	.056
D-M-L	.296	.342	.413	.80	1.04	1.18	.82	.94	1.00	.70	.80	.91	.034	.049	.073
G-G-L	.283	.358	.447	.86	1.06	1.31	1.00	1.00	1.00	.66	.77	.88	.016	.030	.043
CLA	.681	.720	.761	1.97	2.15	2.38	.00	.00	.02	.13	.24	.33	.121	.151	.250
BE13 1%, Need=67, Bias=1→1.5, 1.5, CV=(.25,.1)															
NEED	.356	.420	.510	1.17	1.28	1.37	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.400	.437	.510	1.31	1.33	1.37	.88	.93	1.00	.94	.98	1.00	.000	.004	.007
D-M	.361	.425	.510	1.18	1.29	1.38	.95	1.00	1.00	.98	1.00	1.00	.000	.000	.010
GUP	.380	.446	.511	1.22	1.32	1.45	.97	1.00	1.00	.88	.99	1.00	.000	.005	.020
G-G	.393	.452	.531	1.24	1.34	1.56	1.00	1.00	1.00	.79	.99	1.00	.000	.009	.033
D-M-L	.367	.436	.513	1.20	1.31	1.41	.82	1.00	1.00	.94	.99	1.00	.000	.006	.023
G-G-L	.378	.446	.521	1.21	1.32	1.53	1.00	1.00	1.00	.81	1.00	1.00	.000	.000	.023
CLA	.684	.734	.783	1.97	2.20	2.43	.00	.00	.02	.19	.35	.51	.118	.170	.268
BE14 2.5%, Need=67→201															
NEED	.761	.765	.769	1.02	1.08	1.16	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.787	.790	.792	1.06	1.11	1.20	1.00	1.00	1.00	.97	.98	.98	.000	.000	.000
D-M	.798	.838	.905	1.08	1.19	1.34	.90	1.00	1.00	.70	.90	.97	.001	.006	.040
GUP	.819	.852	.902	1.12	1.20	1.32	.95	1.00	1.00	.73	.88	.94	.004	.011	.031
G-G	.824	.860	.897	1.13	1.21	1.32	1.00	1.00	1.00	.75	.86	.94	.008	.018	.028
D-M-L	.798	.839	.908	1.08	1.19	1.35	.80	.96	1.00	.66	.89	.97	.001	.007	.037
G-G-L	.870	.891	.908	1.19	1.25	1.35	1.00	1.00	1.00	.73	.79	.85	.010	.016	.023
CLA	.979	.987	.993	1.32	1.39	1.50	.00	.00	.00	.02	.04	.08	.244	.376	.551
BE16 1%, Need=67→201, Bias=0.67→1, 1															
NEED	.215	.298	.368	.48	.61	.71	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.568	.607	.627	1.19	1.24	1.26	.96	.97	.99	.66	.68	.71	.000	.000	.000
D-M	.389	.538	.622	.79	1.11	1.31	.89	.98	1.00	.63	.76	.96	.003	.024	.051
GUP	.433	.526	.609	.85	1.08	1.30	.95	1.00	1.00	.64	.76	.92	.008	.026	.038
G-G	.437	.521	.601	.90	1.06	1.26	1.00	1.00	1.00	.67	.79	.90	.016	.026	.048
D-M-L	.389	.552	.635	.79	1.12	1.35	.79	.92	1.00	.60	.73	.96	.003	.026	.056
G-G-L	.500	.556	.613	1.00	1.13	1.25	1.00	1.00	1.00	.68	.75	.83	.014	.021	.041
CLA	.878	.899	.912	1.71	1.83	1.97	.00	.00	.00	.02	.05	.09	.214	.343	.548

SLA	D1: Final 1+Depln			D10: 1+ Rel. Incr			N9: Need Satfn (20)			N9 Need Satfn (100)			N12: Mn Down Step		
	5%	Med	96%	5%	Med	96%	5%	Med	96%	5%	Med	96%	5%	Med	96%
BE16-SE 1%, Need=67→201, Bias=0.67→1, 1															
NEED	.180	.311	.415	.37	.62	.78	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.529	.614	.680	1.11	1.24	1.37	.80	.94	1.00	.61	.68	.73	.025	.085	.154
D-M	.377	.543	.645	.78	1.07	1.32	.88	.98	1.00	.63	.76	.95	.002	.024	.049
GUP	.412	.534	.642	.85	1.06	1.30	.95	1.00	1.00	.64	.77	.92	.007	.024	.038
G-G	.434	.534	.638	.86	1.05	1.28	1.00	1.00	1.00	.66	.78	.90	.013	.027	.048
D-M-L	.391	.558	.662	.78	1.10	1.36	.78	.92	1.00	.60	.74	.95	.002	.025	.054
G-G-L	.479	.564	.640	.97	1.14	1.27	1.00	1.00	1.00	.67	.75	.82	.011	.021	.040
CLA	.842	.900	.961	1.65	1.80	2.02	.00	.00	.00	.02	.05	.09	.220	.349	.503
BE20 4%, MSYL=80%, Need=67→201															
NEED	.957	.958	.958	.98	.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.957	.958	.958	.98	.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.967	.982	.988	.99	1.01	1.03	.91	1.00	1.00	.66	.85	.97	.001	.021	.047
GUP	.972	.982	.988	1.00	1.01	1.03	.96	1.00	1.00	.69	.82	.93	.006	.020	.037
G-G	.976	.983	.989	1.00	1.01	1.03	1.00	1.00	1.00	.71	.81	.90	.011	.022	.037
D-M-L	.967	.984	.988	.99	1.01	1.03	.83	1.00	1.00	.62	.82	.97	.001	.024	.053
G-G-L	.982	.986	.988	1.00	1.01	1.03	1.00	1.00	1.00	.71	.75	.82	.012	.020	.027
CLA	.998	.999	1.000	1.02	1.03	1.05	.00	.00	.00	.00	.02	.05	.385	.623	.993
BE21 U[1-4%]%, MSYL=U[.4-.8], Need=67→134															
NEED	.639	.934	.969	1.02	1.20	1.55	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.672	.934	.969	1.02	1.23	1.55	1.00	1.00	1.00	.95	1.00	1.00	.000	.000	.000
D-M	.720	.938	.974	1.02	1.23	1.55	.96	1.00	1.00	.85	1.00	1.00	.000	.000	.024
GUP	.720	.938	.978	1.03	1.23	1.55	.99	1.00	1.00	.86	.99	1.00	.000	.002	.019
G-G	.722	.939	.980	1.03	1.23	1.56	1.00	1.00	1.00	.87	.99	1.00	.000	.005	.022
D-M-L	.726	.938	.975	1.02	1.23	1.55	.86	.99	1.00	.82	.99	1.00	.000	.002	.029
G-G-L	.730	.947	.982	1.03	1.25	1.58	1.00	1.00	1.00	.85	.94	1.00	.000	.008	.017
CLA	.961	.993	.999	1.05	1.34	1.88	.00	.00	.00	.01	.07	.14	.227	.372	.830
BE22 2.5%, Need=67→134, DD Time Lag=20															
NEED	.836	.893	.942	1.32	1.40	1.47	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.836	.893	.942	1.32	1.40	1.47	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.842	.894	.942	1.32	1.40	1.48	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
GUP	.842	.893	.942	1.32	1.40	1.47	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
G-G	.836	.894	.942	1.32	1.40	1.47	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M-L	.842	.894	.942	1.32	1.40	1.48	.94	1.00	1.00	.99	1.00	1.00	.000	.000	.002
G-G-L	.836	.894	.942	1.32	1.40	1.47	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
CLA	.851	.912	1.061	1.29	1.44	1.65	.00	.00	.00	.16	.21	.26	.128	.164	.202
BE22-SE 2.5%, Need=67→134, DD Time Lag=20															
NEED	.804	.884	.998	1.19	1.37	1.55	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.804	.884	.998	1.19	1.37	1.55	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M	.805	.884	.999	1.19	1.37	1.56	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.002
GUP	.804	.884	.998	1.19	1.37	1.55	1.00	1.00	1.00	.99	1.00	1.00	.000	.000	.002
G-G	.804	.884	.998	1.19	1.37	1.55	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
D-M-L	.805	.884	.999	1.19	1.37	1.56	.93	1.00	1.00	.98	1.00	1.00	.000	.000	.003
G-G-L	.804	.887	.998	1.19	1.38	1.55	1.00	1.00	1.00	.99	1.00	1.00	.000	.000	.007
CLA	.839	.932	1.083	1.27	1.43	1.68	.00	.00	.00	.15	.21	.29	.124	.161	.220
BE23 2.5%, Need=67→201, Strategic Surveys															
NEED	.761	.765	.769	1.02	1.08	1.16	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.787	.790	.792	1.06	1.11	1.20	1.00	1.00	1.00	.97	.98	.98	.000	.000	.000
D-M	.780	.833	.899	1.07	1.17	1.33	.92	.98	1.00	.71	.91	.98	.001	.009	.027
GUP	.809	.842	.891	1.09	1.19	1.31	.96	1.00	1.00	.75	.90	.95	.003	.009	.024
G-G	.802	.853	.888	1.11	1.20	1.31	1.00	1.00	1.00	.80	.88	.97	.007	.016	.028
D-M-L	.781	.842	.901	1.09	1.19	1.35	.82	.98	1.00	.66	.89	.98	.001	.008	.030
G-G-L	.874	.890	.904	1.19	1.25	1.36	1.00	1.00	1.00	.74	.80	.85	.011	.018	.026
CLA	.981	.989	.995	1.32	1.39	1.51	.00	.00	.00	.01	.04	.07	.310	.427	.709
BE24 Inertia Model, Need=67→134															
NEED	.411	1.249	1.371	.98	2.60	2.96	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.528	1.295	1.405	1.28	2.70	3.07	.94	1.00	1.00	.65	.68	.88	.000	.015	.029
D-M	.549	1.256	1.382	1.34	2.62	2.98	.95	1.00	1.00	.81	.97	1.00	.000	.005	.014
GUP	.524	1.252	1.376	1.29	2.61	2.97	.99	1.00	1.00	.82	.99	1.00	.000	.002	.013
G-G	.501	1.249	1.371	1.24	2.60	2.96	1.00	1.00	1.00	.84	1.00	1.00	.000	.000	.021
D-M-L	.575	1.256	1.382	1.41	2.63	2.98	.86	.97	1.00	.79	.97	1.00	.000	.006	.017
G-G-L	.518	1.249	1.371	1.27	2.60	2.96	1.00	1.00	1.00	.84	1.00	1.00	.000	.000	.013
CLA	1.154	1.302	1.390	2.48	2.76	3.18	.00	.00	.00	.06	.18	.24	.136	.177	.360
BE01X 2.5%, Need=67→134, Population=2000 in year 1															
NEED	.041	.203	.307	.06	.28	.42	1.00	1.00	1.00	1.00	1.00	1.00	.000	.000	.000
H	.468	.509	.550	.65	.72	.77	.75	.75	.75	.94	.95	.95	.037	.037	.040
D-M	.793	.830	.866	1.10	1.18	1.27	.87	.92	.98	.49	.57	.62	.032	.045	.064
GUP	.824	.866	.897	1.13	1.22	1.31	.94	.96	1.00	.43	.49	.55	.054	.074	.090
G-G	.812	.853	.887	1.12	1.20	1.29	1.00	1.00	1.00	.43	.49	.54	.083	.096	.110
D-M-L	.825	.856	.882	1.14	1.21	1.30	.78	.85	.92	.46	.53	.58	.036	.048	.066
G-G-L	.777	.825	.862	1.08	1.16	1.25	1.00	1.00	1.00	.48	.53	.59	.065	.084	.101
CLA	.987	.991	.992	1.32	1.39	1.51	.00	.00	.00	.00	.00	.01	.832	1.000	1.000

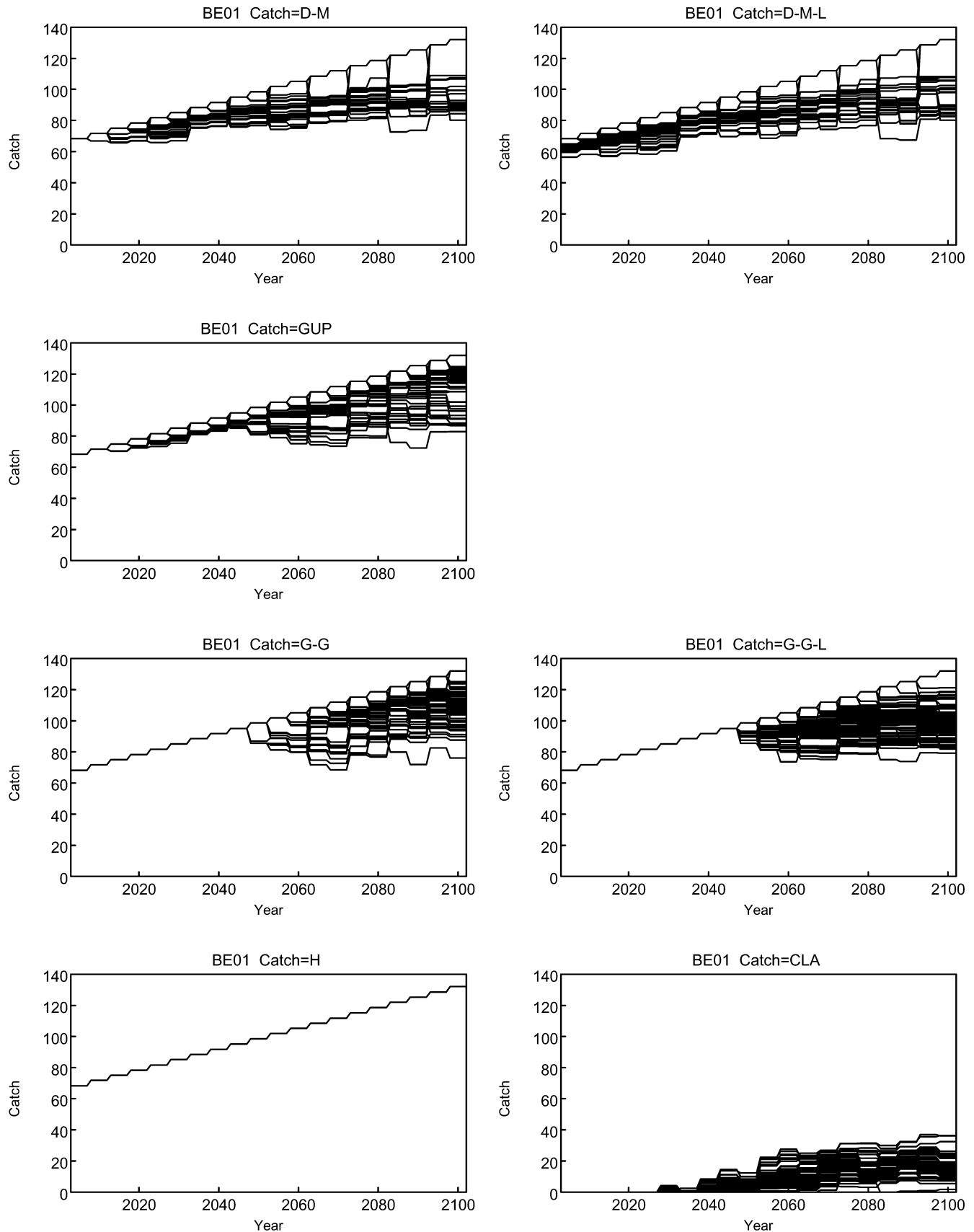
cont.

SLA	D1: Final 1+Depln			D10: 1+ Rel. Incr			N9: Need Satfn (20)			N9 Need Satfn (100)			N12: Mn Down Step		
	5%	Med	96%	5%	Med	96%	5%	Med	96%	5%	Med	96%	5%	Med	96%
BE16X 1%, Need=67->201, Bias=0.67-1, 1, Population=2000 in year 1															
NEED	.000	.000	.000	.00	.00	.00	1.00	1.00	1.00	.31	.31	.31	.167	.170	.172
H	.155	.160	.166	.30	.33	.36	.32	.33	.33	.23	.24	.24	.113	.116	.117
D-M	.000	.000	.044	.00	.00	.09	.84	.88	.93	.29	.31	.32	.104	.119	.127
GUP	.000	.000	.000	.00	.00	.00	.92	.94	.96	.31	.31	.32	.135	.138	.143
G-G	.000	.000	.000	.00	.00	.00	1.00	1.00	1.00	.31	.31	.31	.167	.170	.172
D-M-L	.000	.045	.103	.00	.09	.21	.74	.82	.88	.26	.29	.32	.106	.117	.127
G-G-L	.000	.000	.000	.00	.00	.00	1.00	1.00	1.00	.31	.31	.31	.158	.169	.172
CLA	.441	.454	.469	.85	.93	1.02	.00	.00	.00	.00	.00	.00	1.000	1.000	1.000
BE16Xa 1%, Need=67->201, Bias=0.67-1, 1, Population=2000 in year 1, 5yr surveys															
NEED	.000	.000	.000	.00	.00	.00	1.00	1.00	1.00	.31	.31	.31	.167	.170	.172
H	.155	.160	.166	.30	.33	.36	.32	.33	.33	.23	.24	.24	.113	.116	.117
D-M	.060	.119	.161	.12	.25	.32	.72	.79	.87	.22	.25	.29	.121	.132	.144
GUP	.000	.000	.000	.00	.00	.00	.89	.91	.94	.31	.31	.32	.122	.128	.135
G-G	.000	.000	.000	.00	.00	.00	1.00	1.00	1.00	.31	.31	.31	.156	.158	.170
D-M-L	.117	.164	.198	.23	.34	.42	.63	.70	.79	.20	.22	.25	.128	.139	.153
G-G-L	.000	.000	.000	.00	.00	.00	1.00	1.00	1.00	.31	.31	.31	.156	.158	.160
CLA	.441	.454	.469	.85	.93	1.02	.00	.00	.00	.00	.00	.00	1.000	1.000	1.000
BR11b-9 1%, Need=67-134, Bias=0.67-1, 1, M doubles															
NEED	.000	.000	.010	.00	.00	.02	1.00	1.00	1.00	.87	.93	1.00	.000	.066	.070
H	.166	.235	.330	.35	.48	.69	.83	.86	.90	.19	.22	.26	.155	.181	.203
D-M	.036	.079	.134	.07	.17	.27	.95	1.00	1.00	.65	.74	.84	.027	.042	.055
GUP	.039	.095	.147	.08	.20	.31	.98	1.00	1.00	.62	.72	.83	.035	.052	.073
G-G	.049	.102	.159	.10	.21	.33	1.00	1.00	1.00	.61	.71	.82	.042	.061	.082
D-M-L	.038	.092	.151	.08	.19	.31	.85	.96	1.00	.60	.69	.82	.035	.049	.060
G-G-L	.042	.090	.139	.08	.18	.28	1.00	1.00	1.00	.64	.74	.84	.031	.047	.079
CLA	.188	.258	.369	.39	.54	.78	.00	.00	.00	.00	.01	.06	.428	.754	1.000

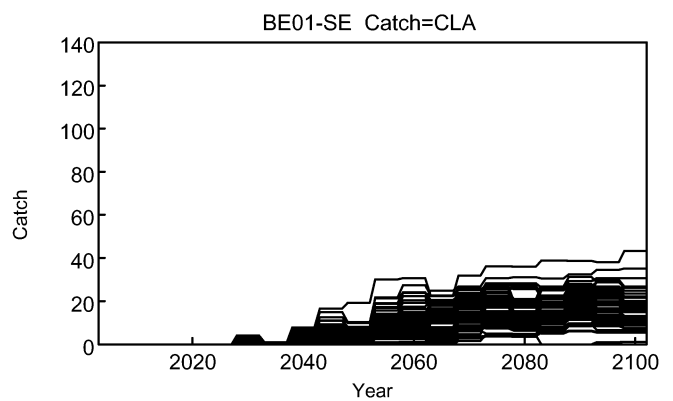
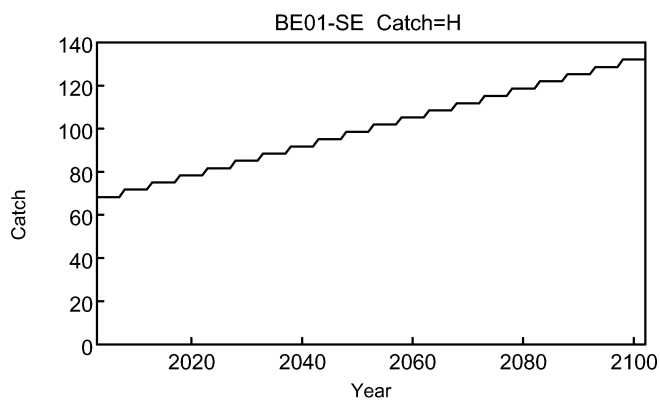
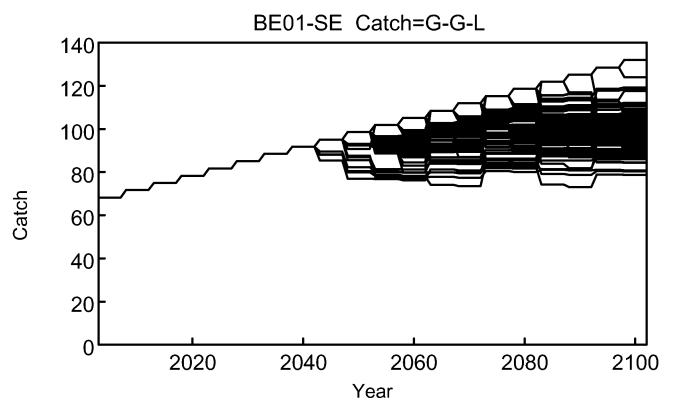
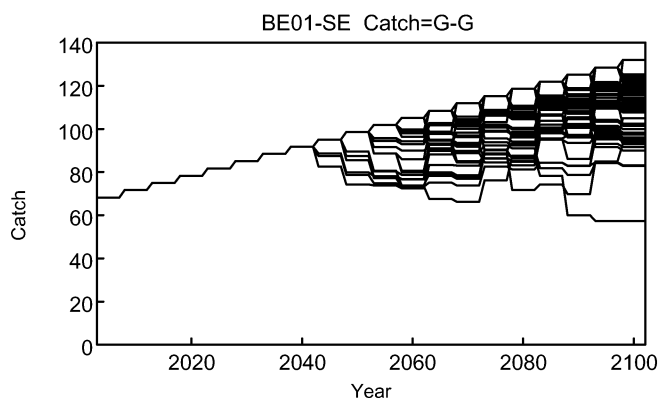
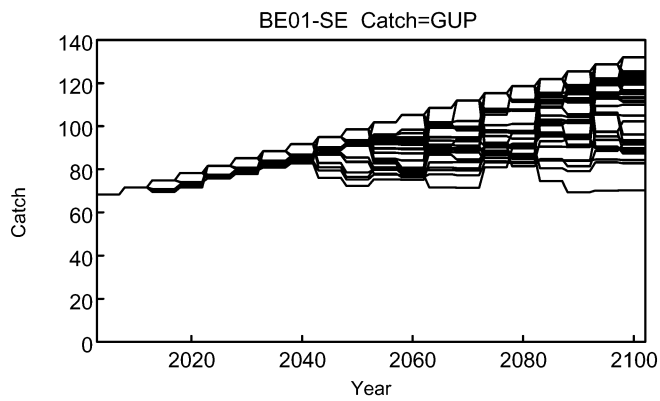
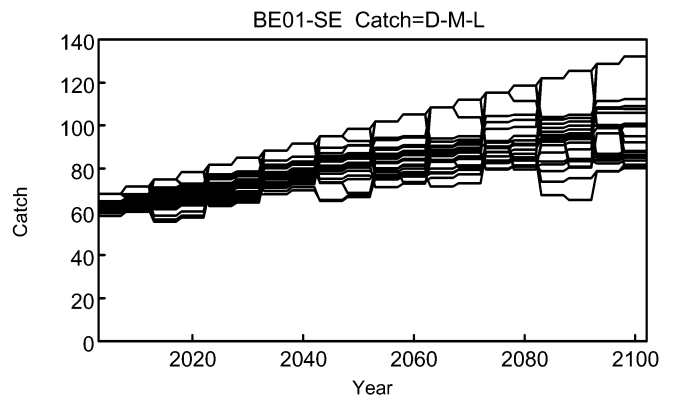
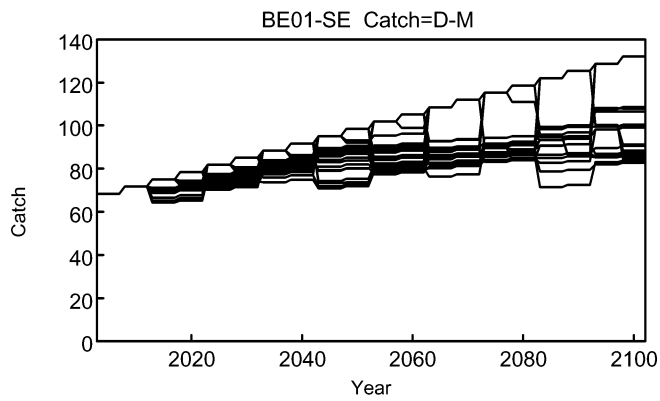
Appendix 5

THE 100 TIME-TRAJECTORIES OF STRIKE LIMIT FOR EACH CANDIDATE SLA FOR A SUBSET OF BE TRIALS

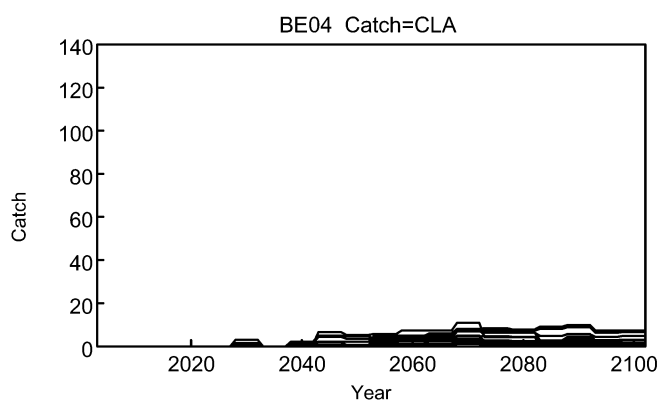
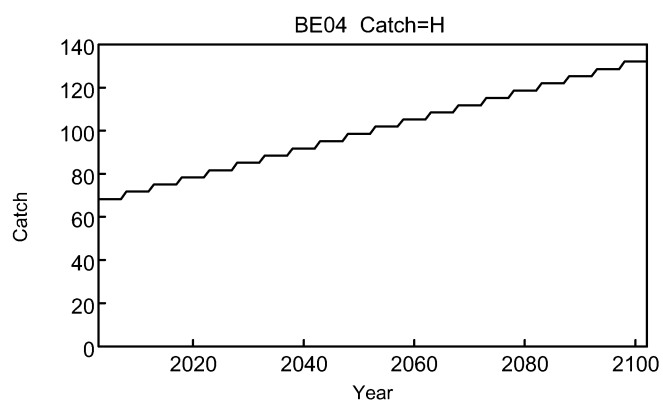
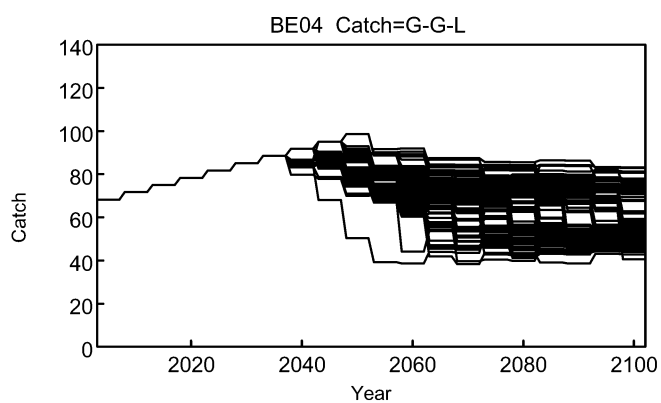
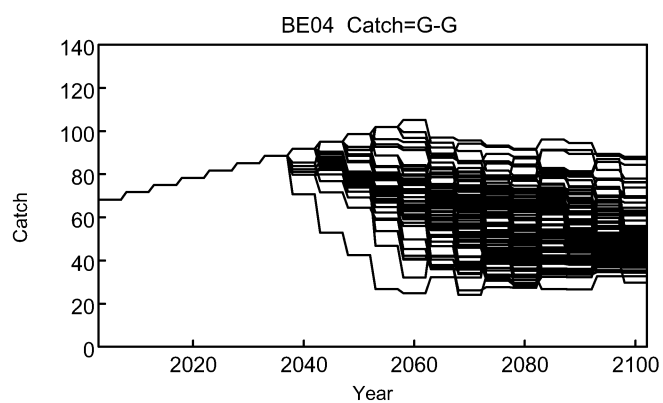
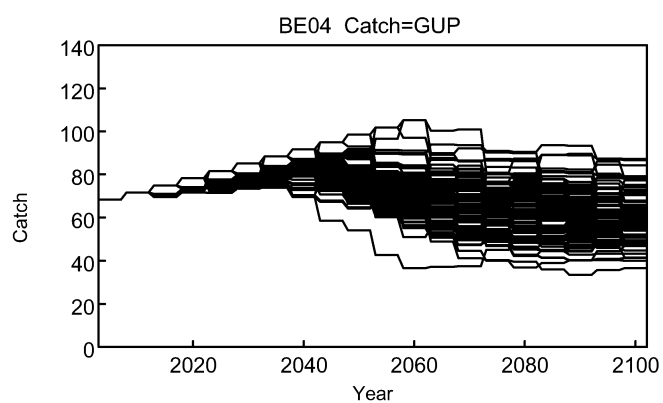
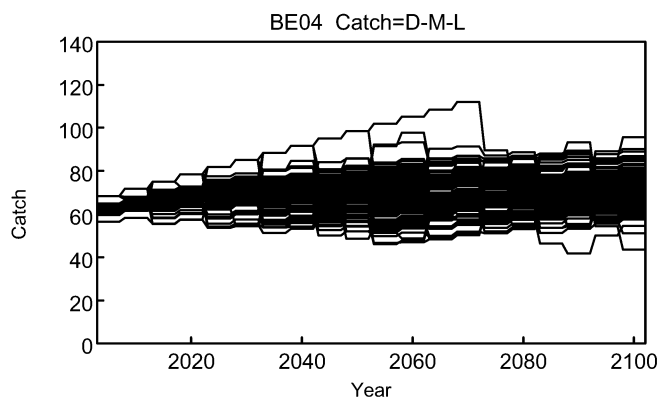
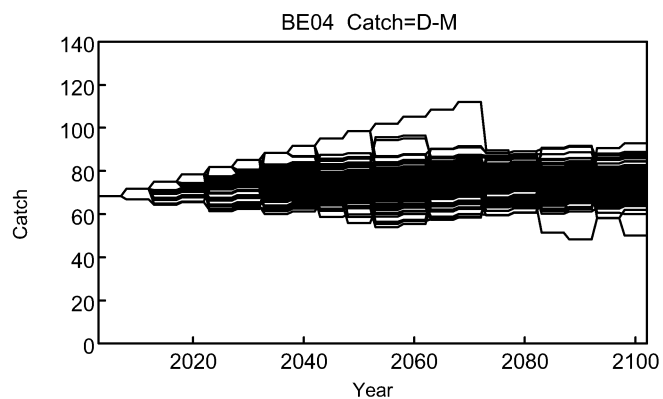
BE01 Base Case: 2.5%, Need=67->134



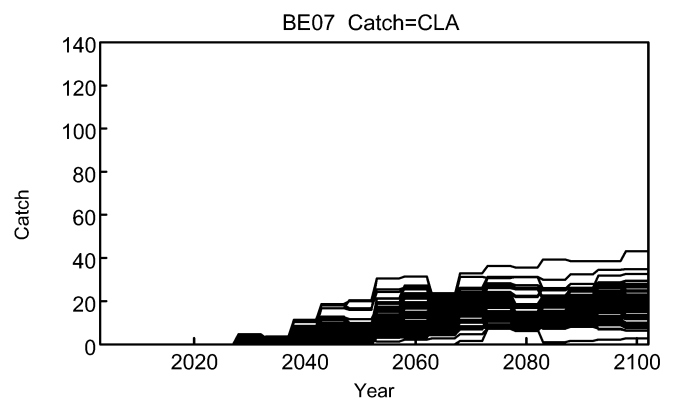
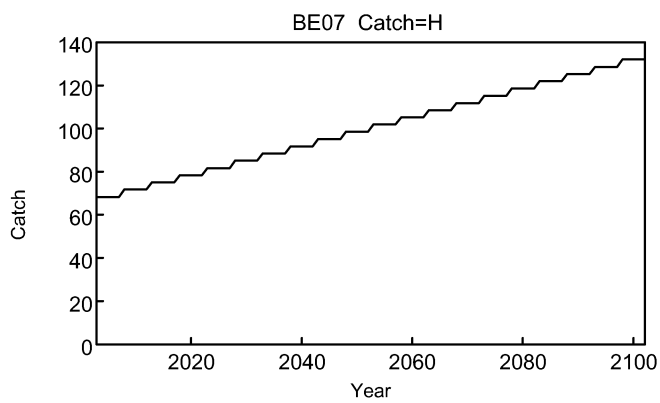
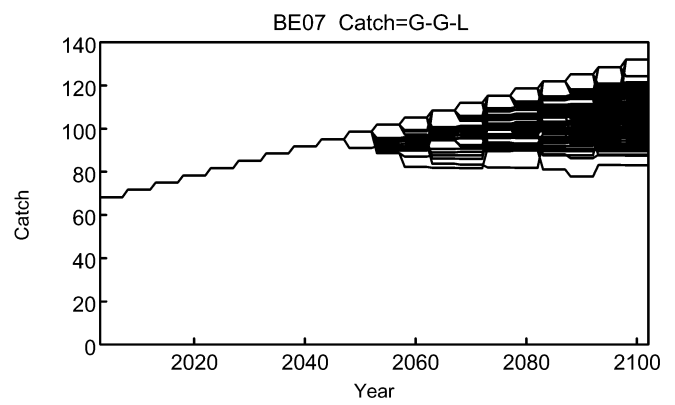
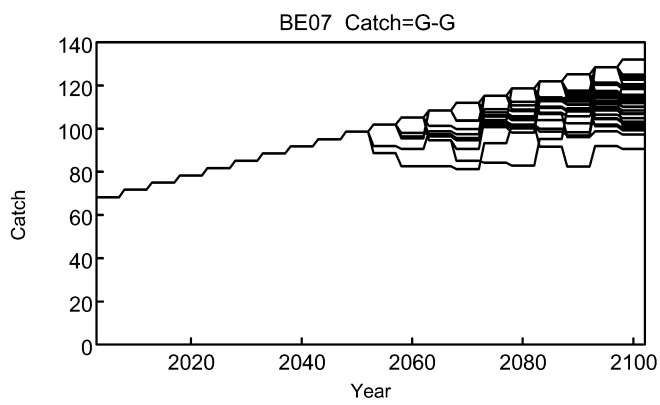
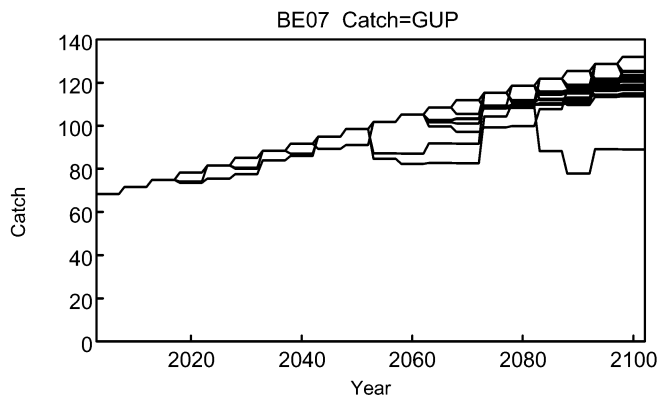
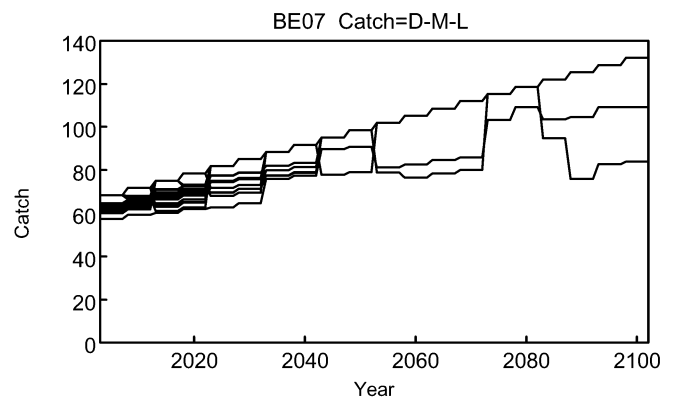
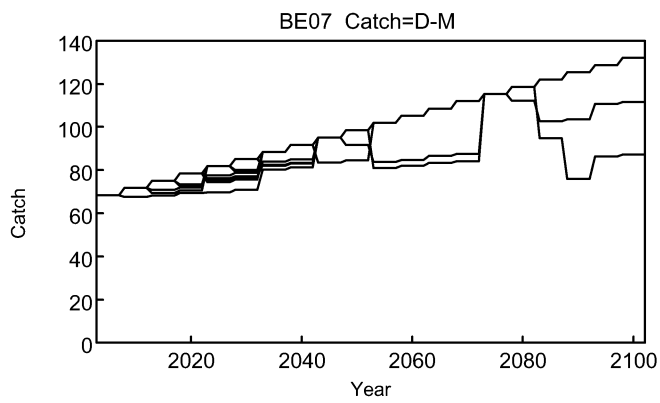
BE01se Base Case: 2.5%, Need=67->134



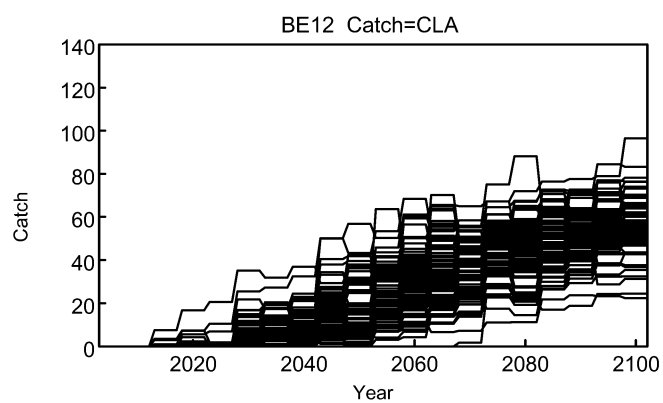
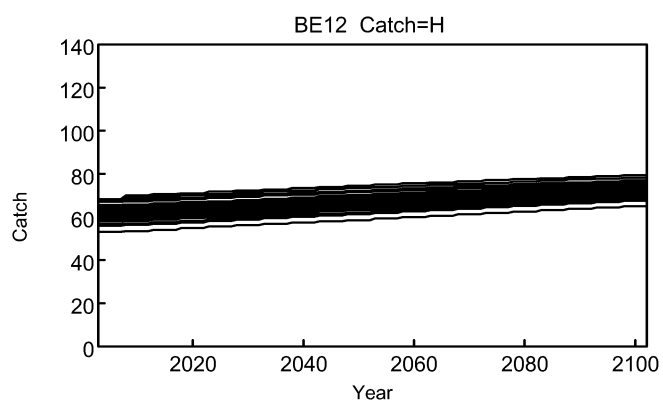
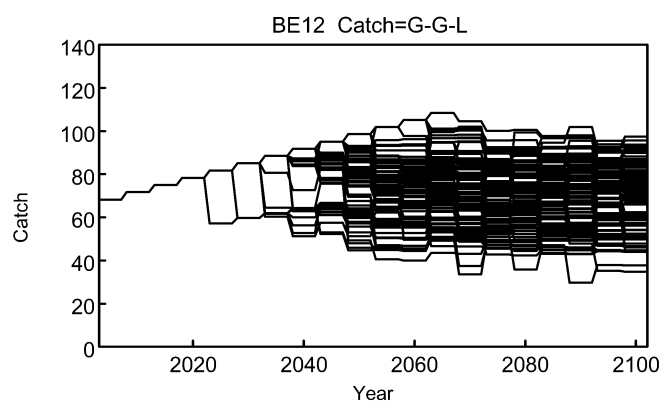
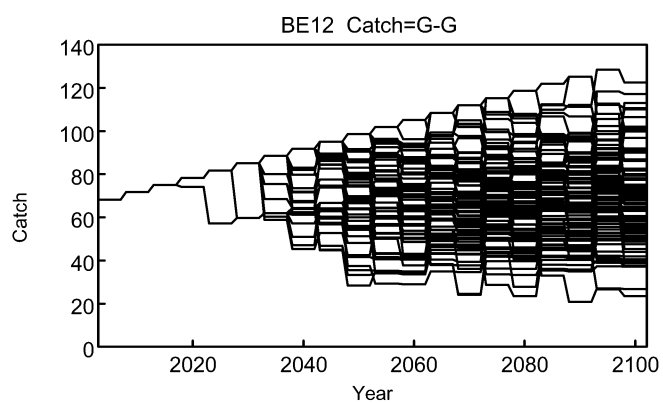
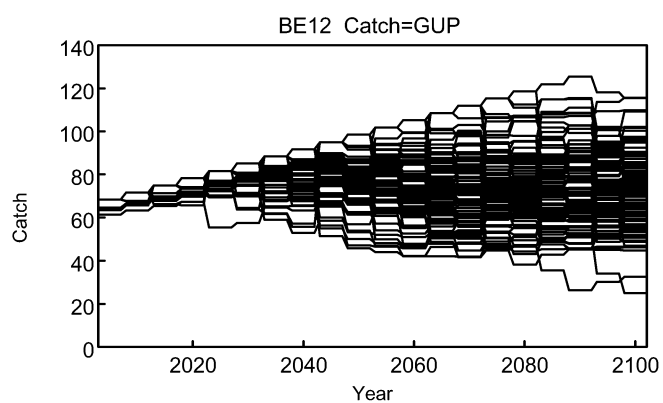
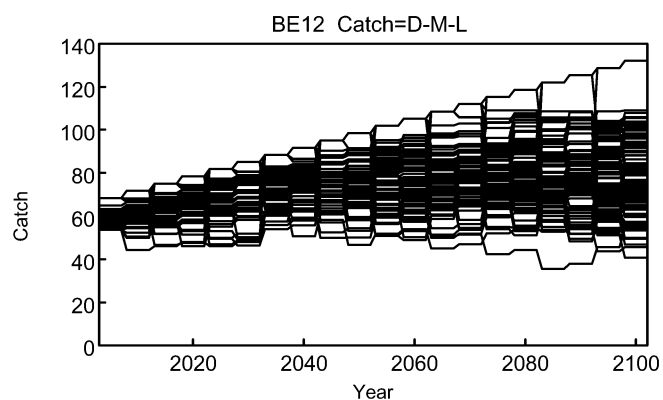
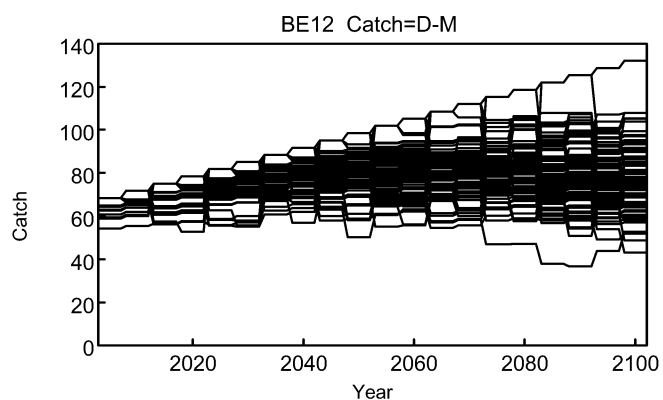
BE04 2.5%, Need=67->134, Bias=1,0.67



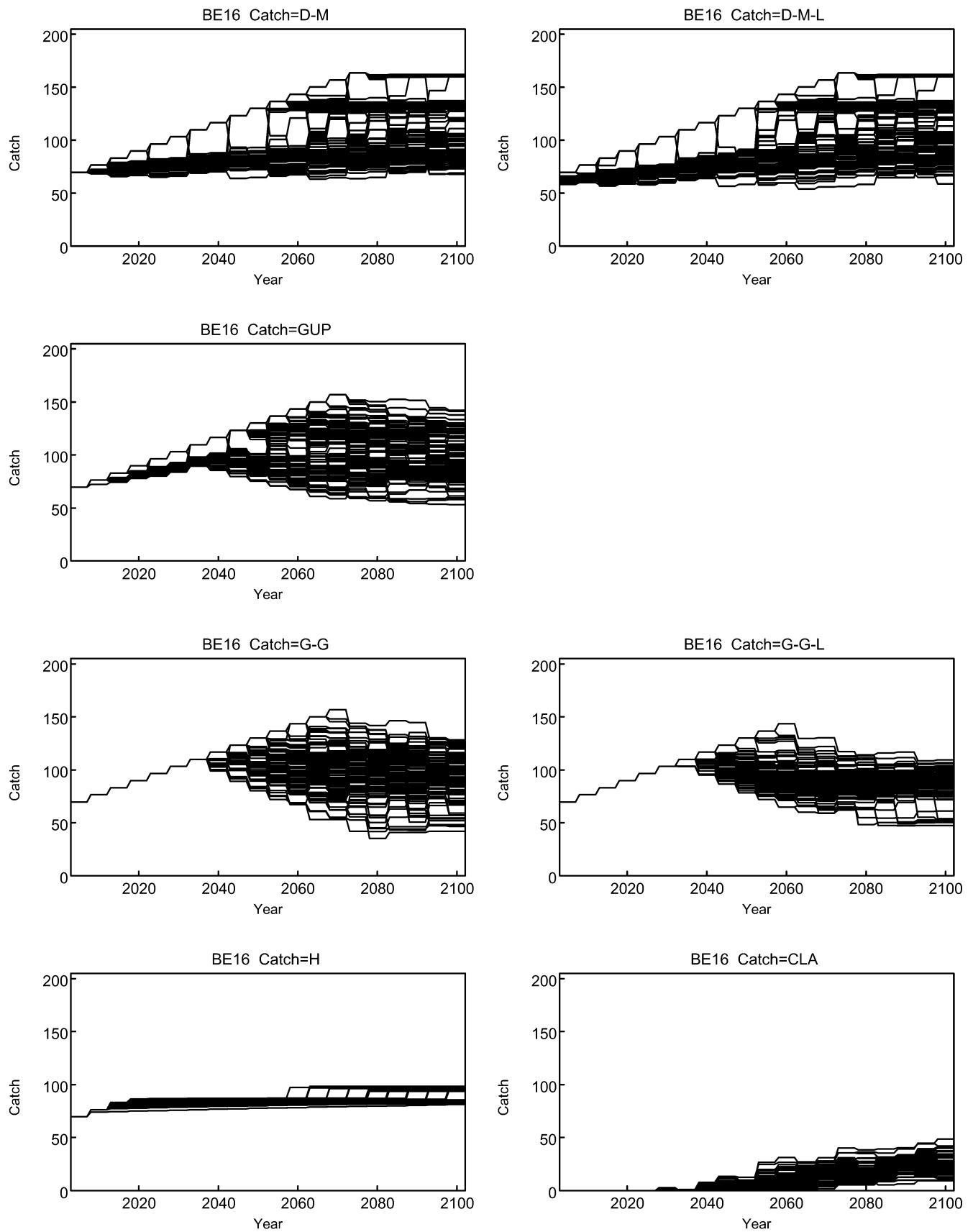
BE07 2.5%, MSYL=80%, Need=67->134



BE12 1%, Need=67->134, Bias=1->1.5,1.5, CV=(.25,.1)

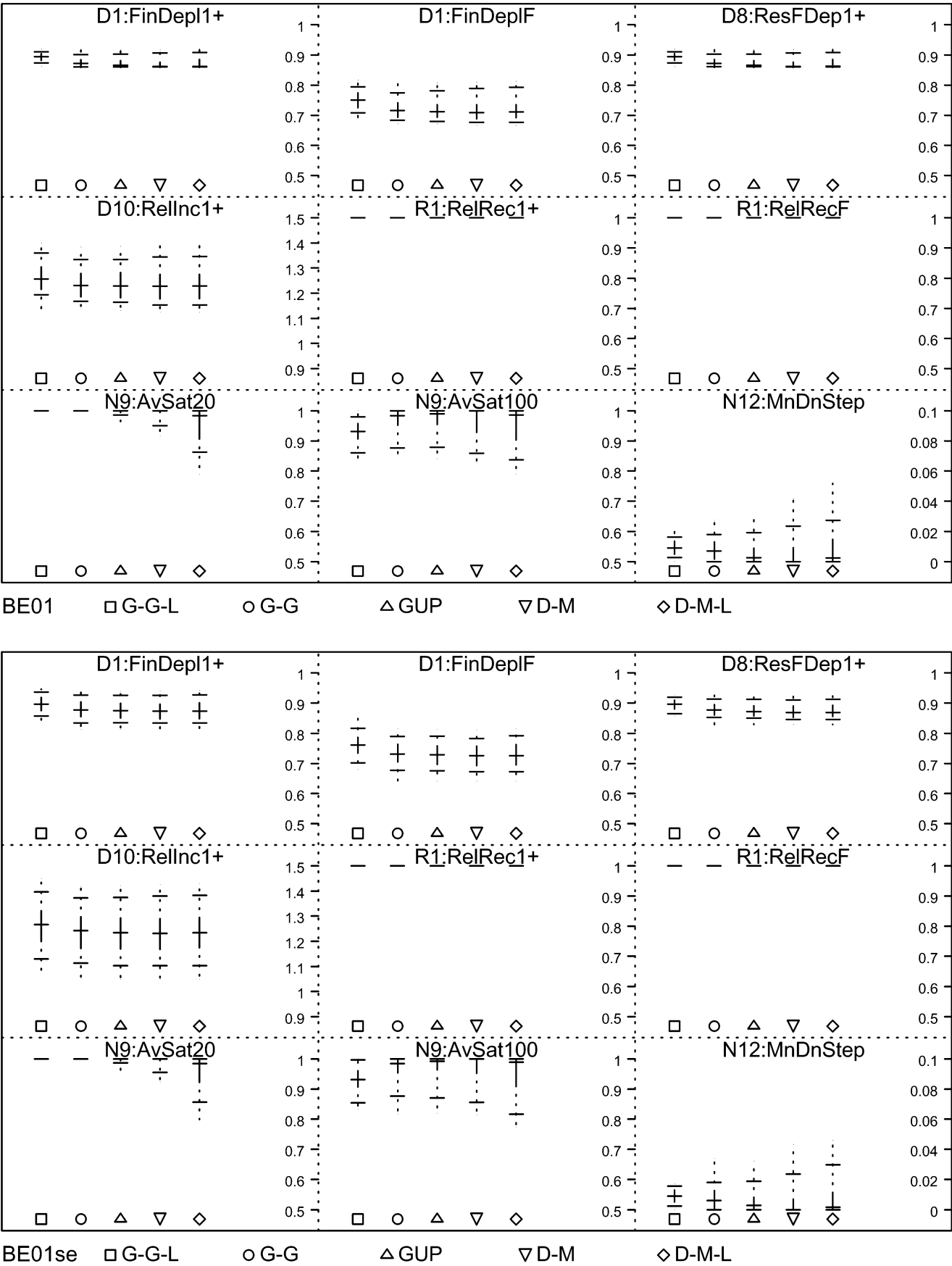


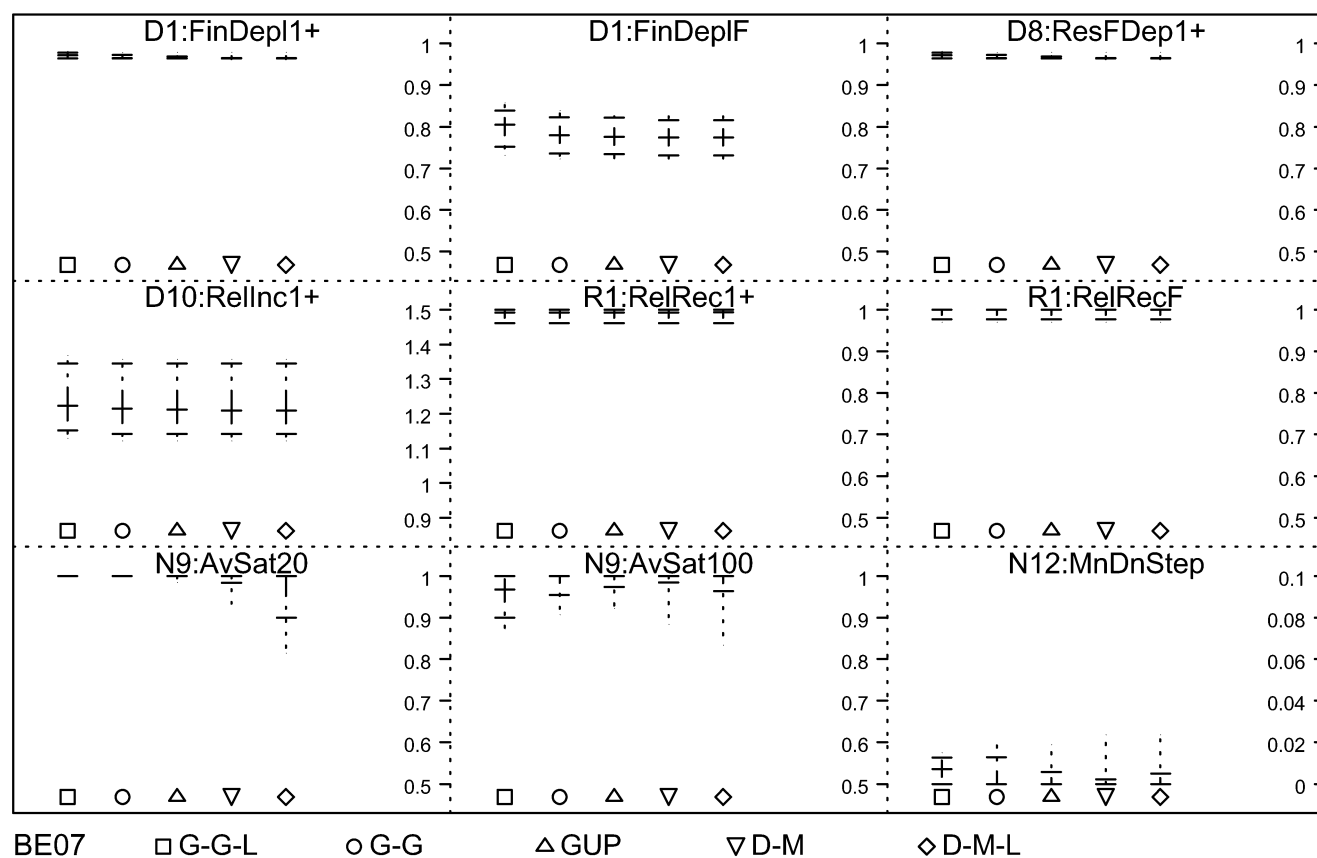
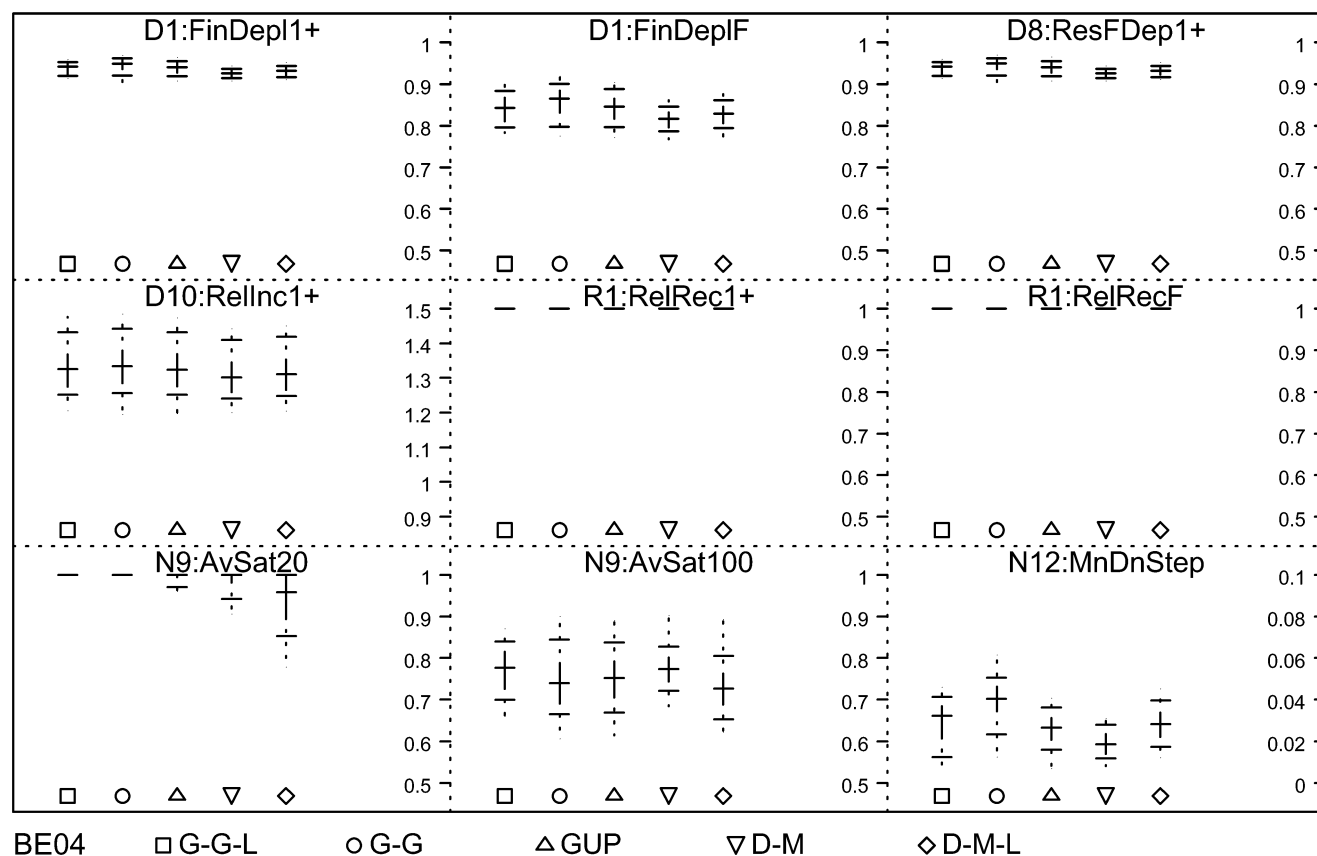
BE16 1%, Need=67->201, Bias=.67-1,1

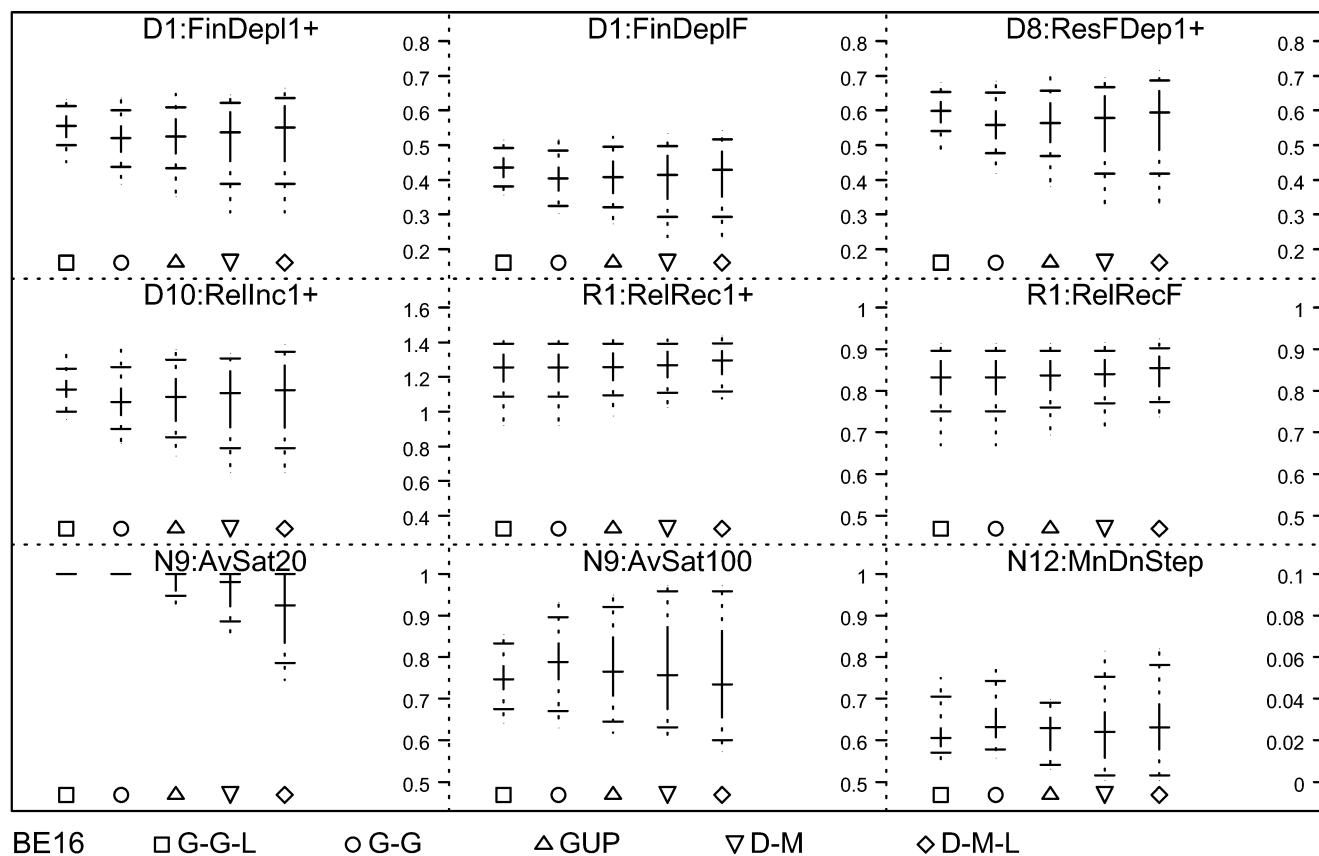
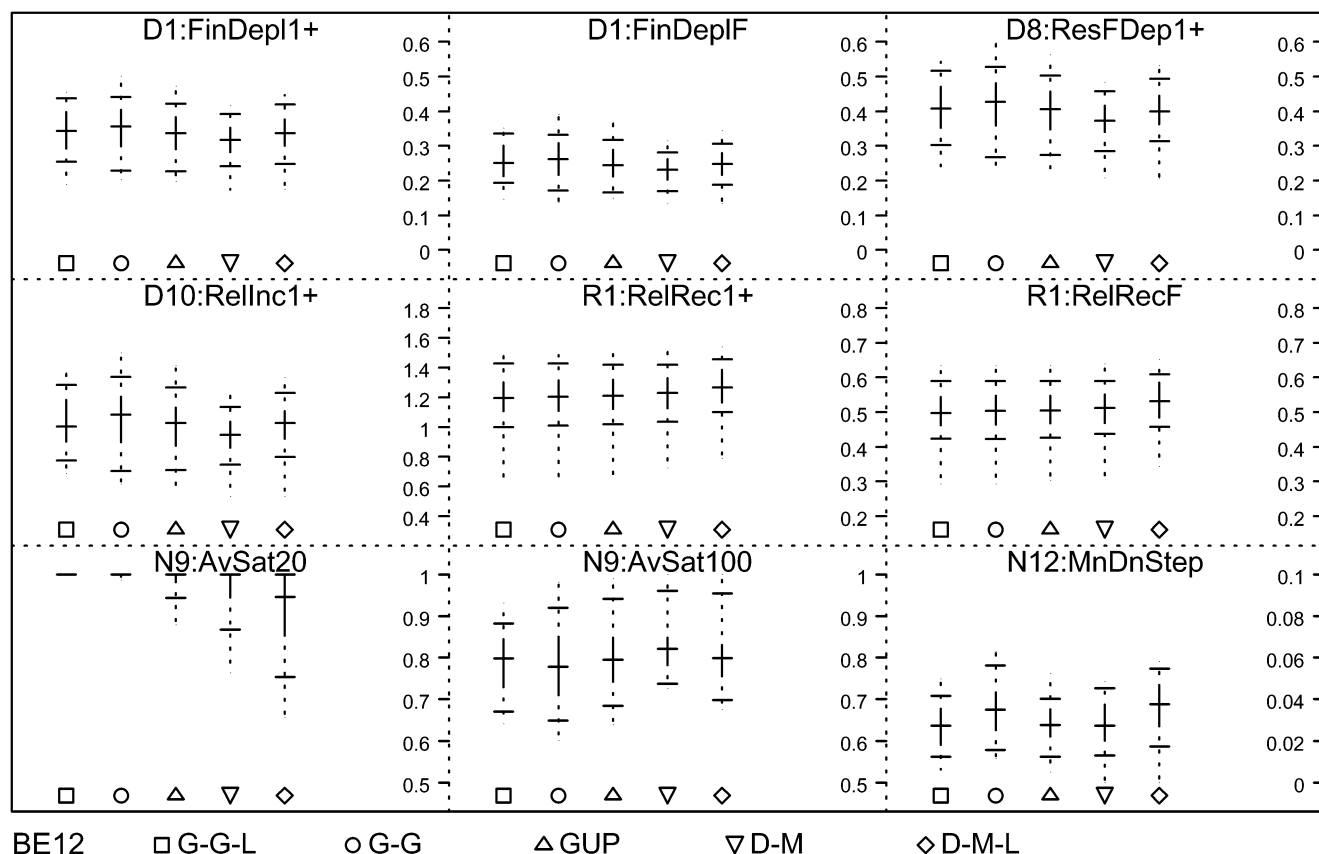


Appendix 6

THE BREIWK/ZEH PLOTS COMPARING THE MANDATORY STATISTICS FOR EACH CANDIDATE SLA FOR A SUBSET OF BE TRIALS

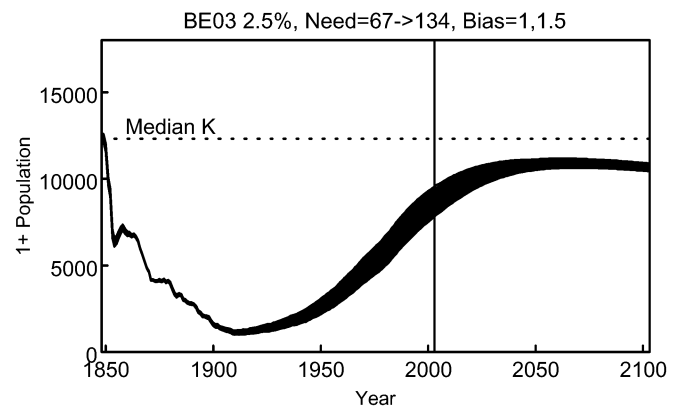
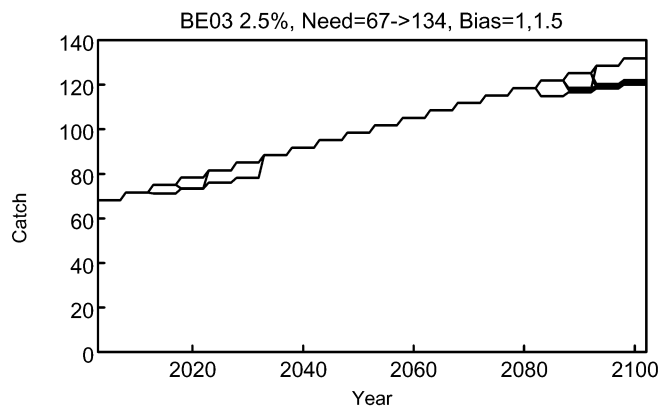
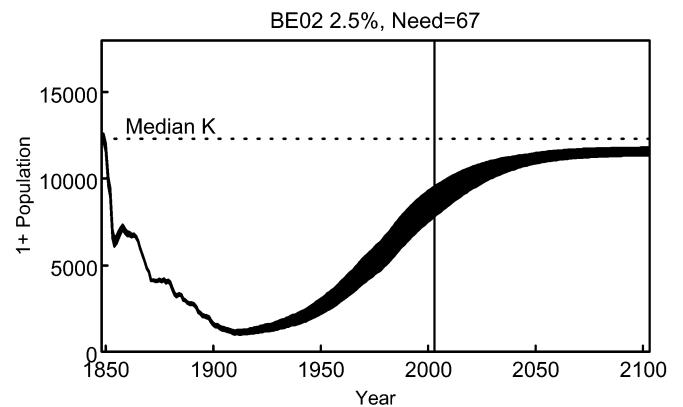
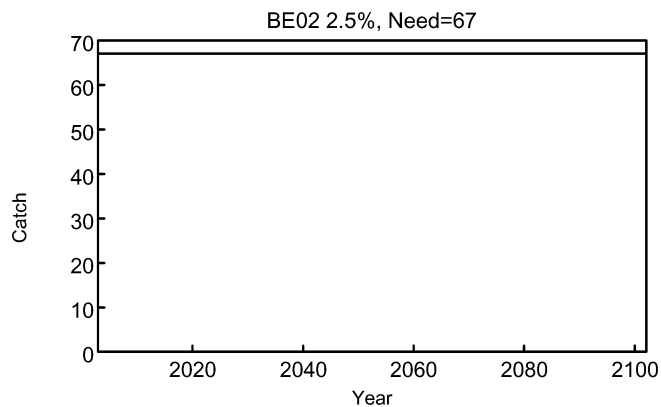
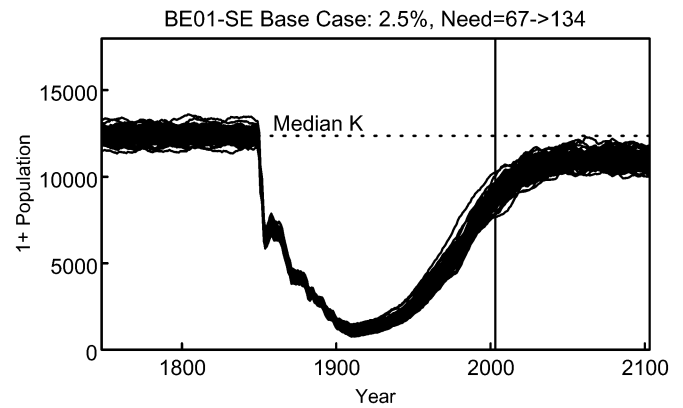
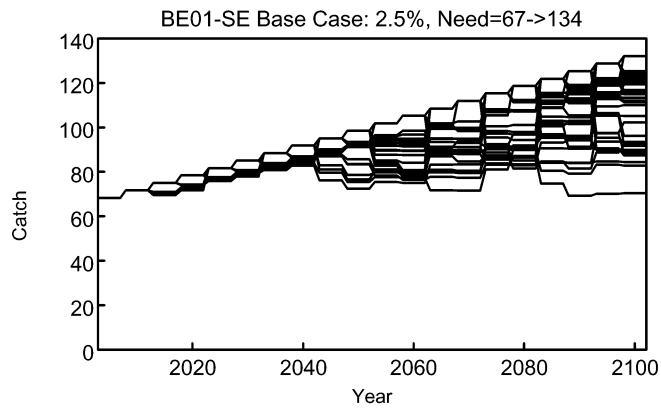
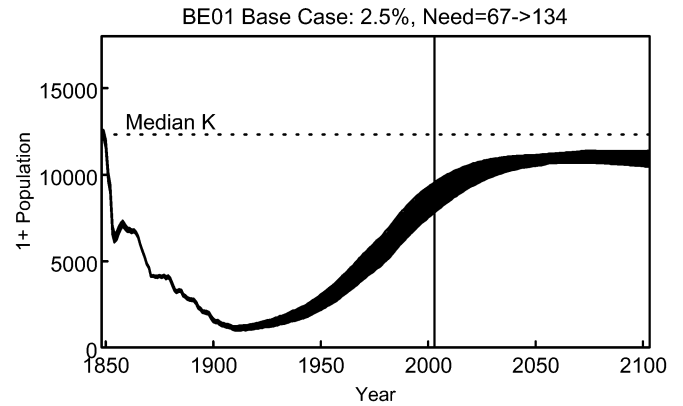
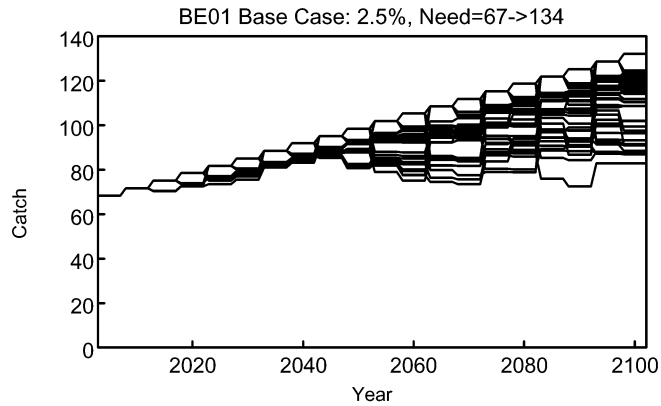


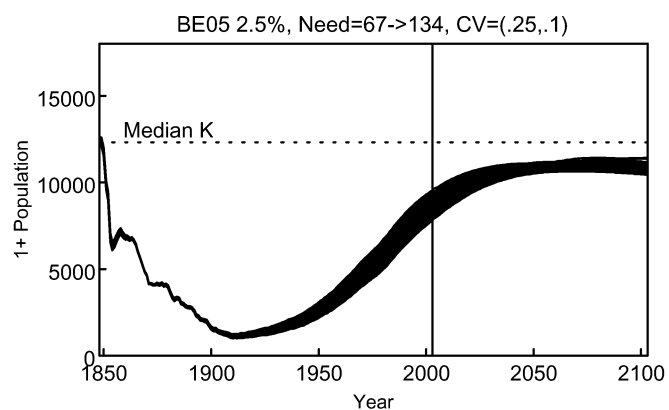
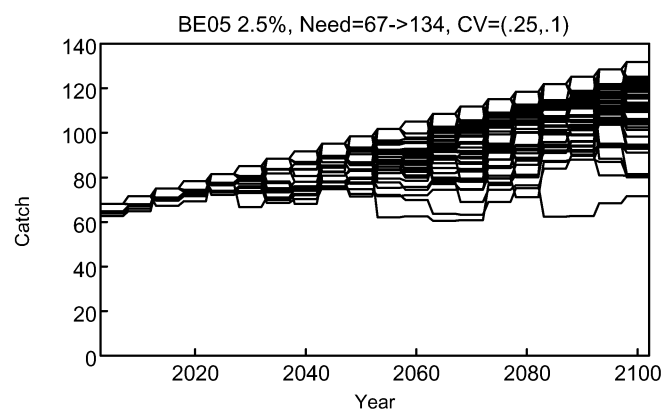
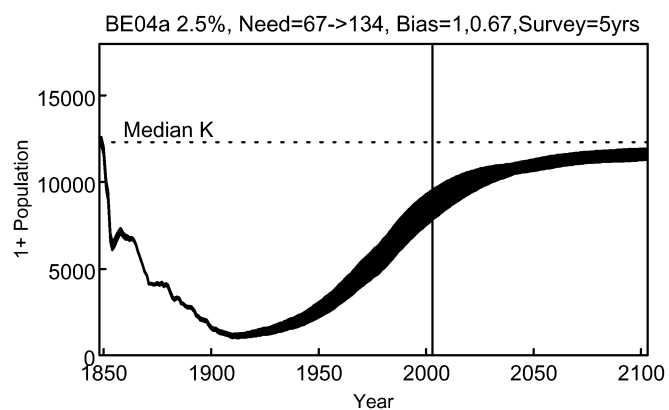
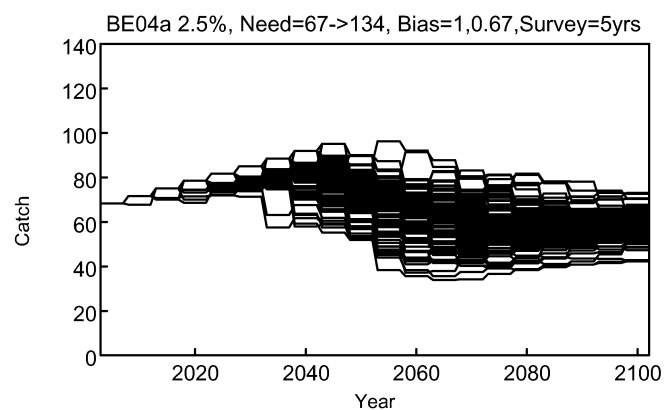
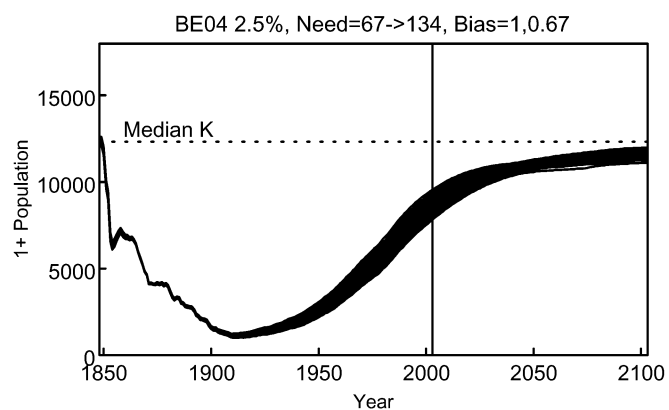
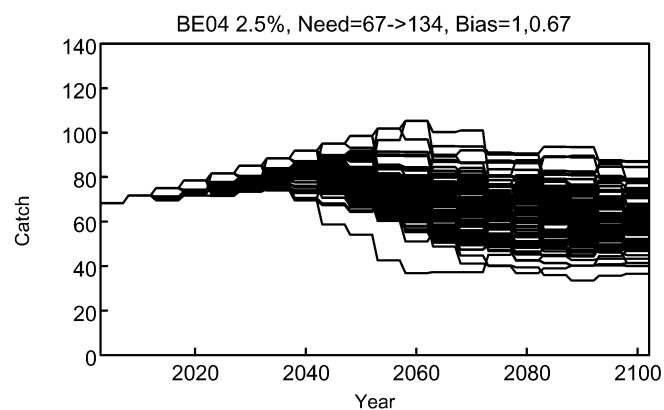
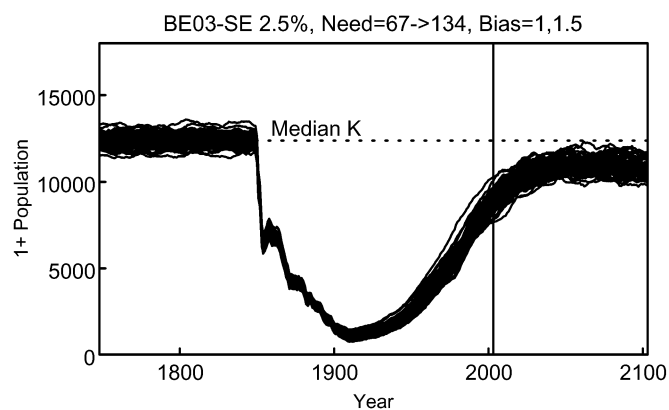
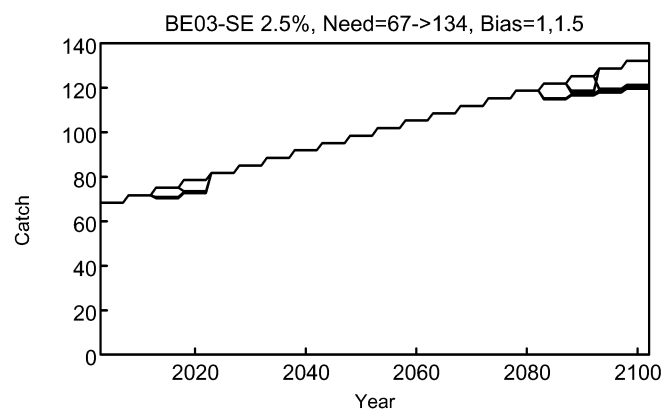


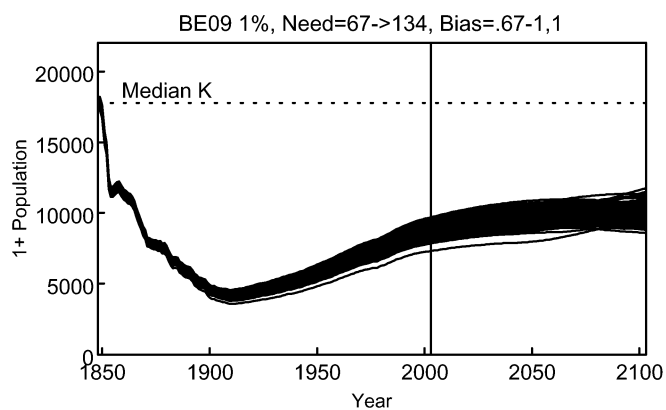
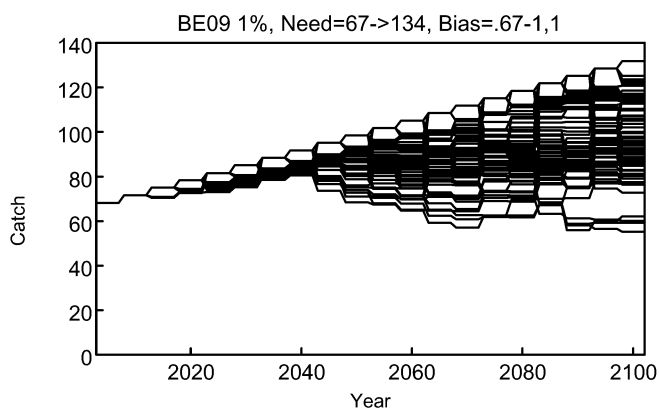
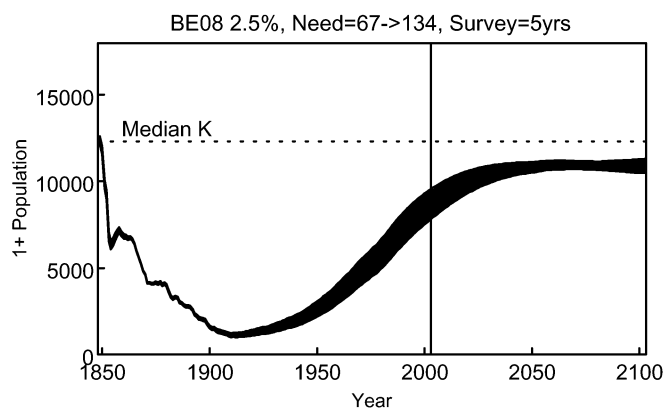
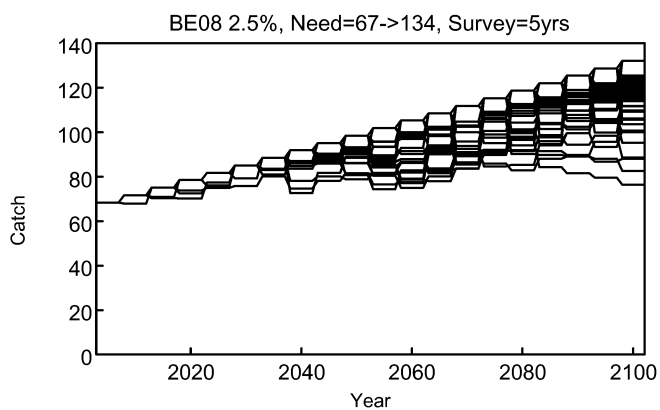
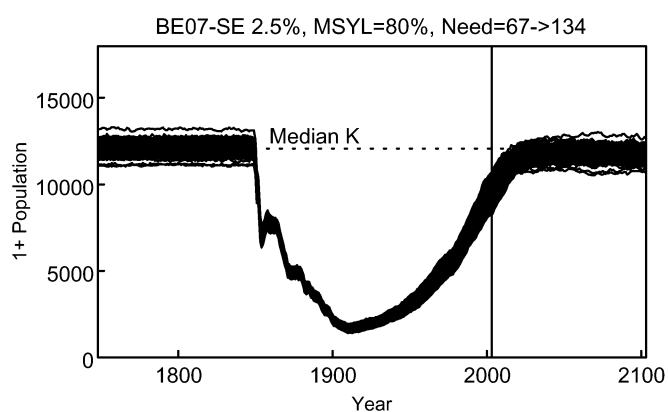
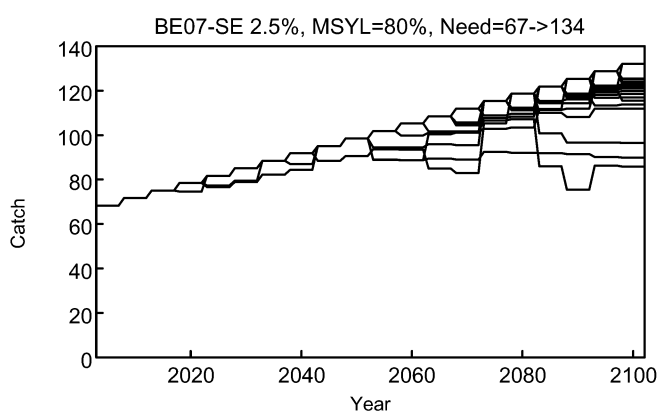
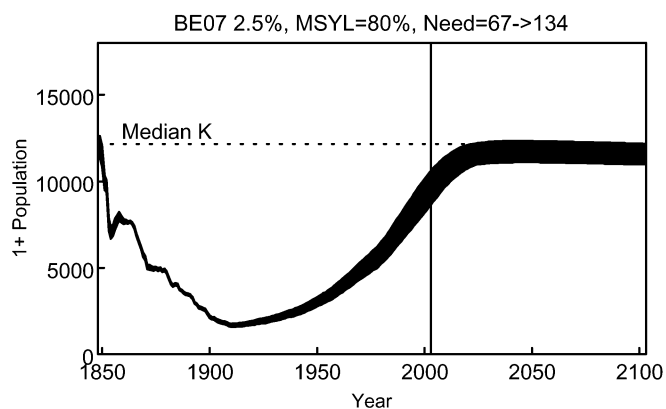
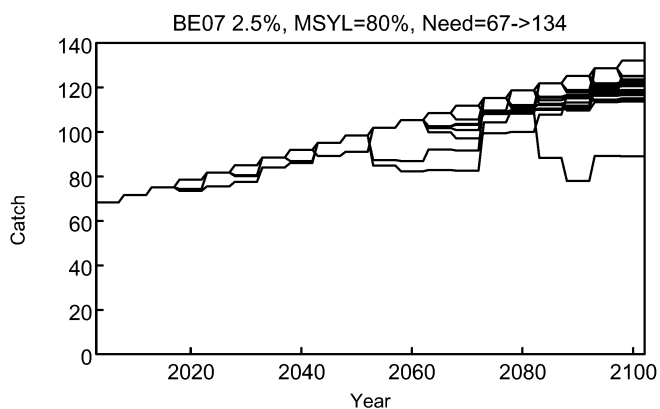


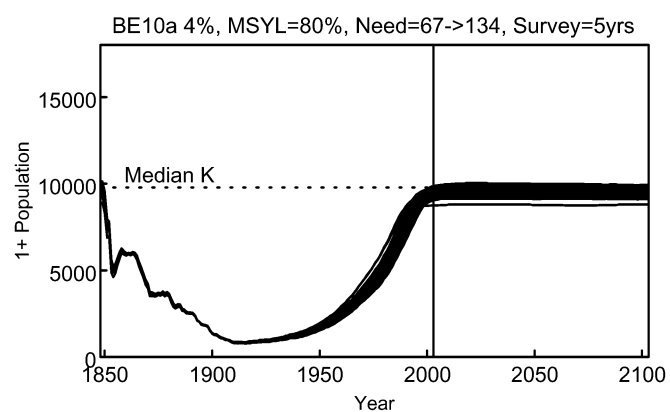
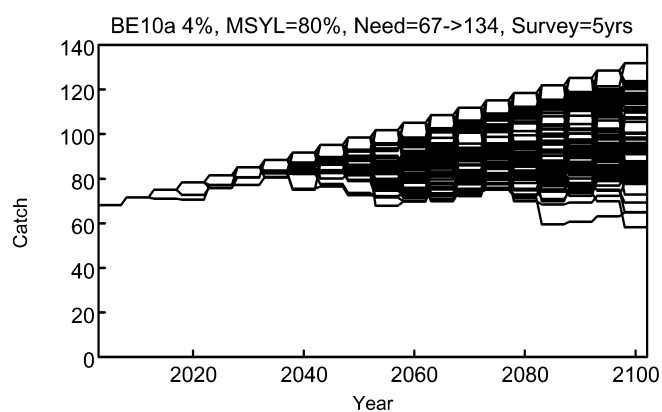
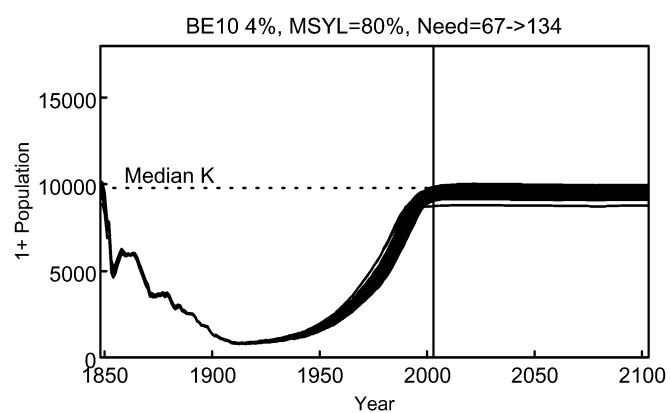
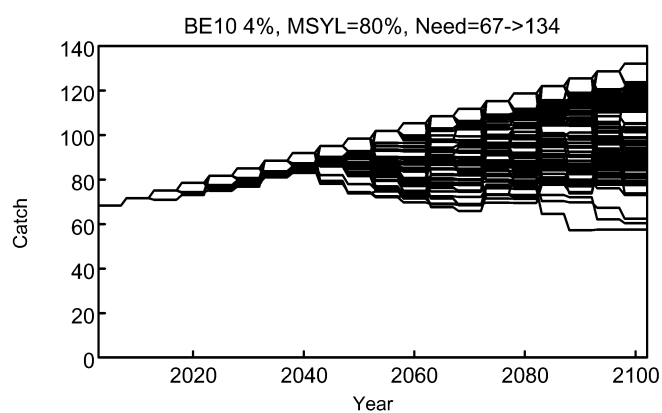
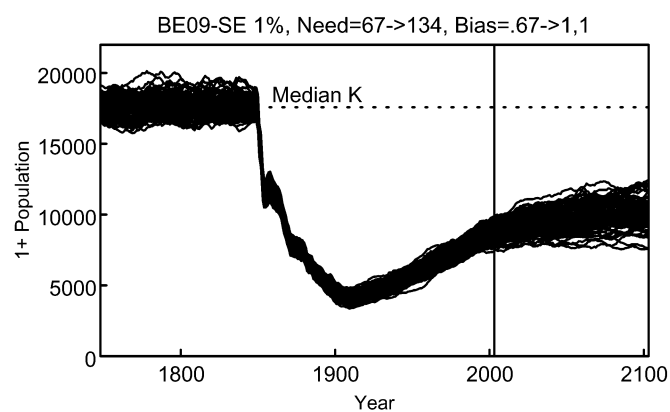
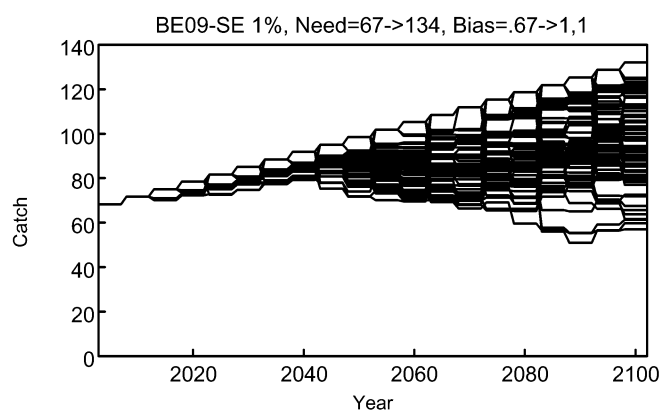
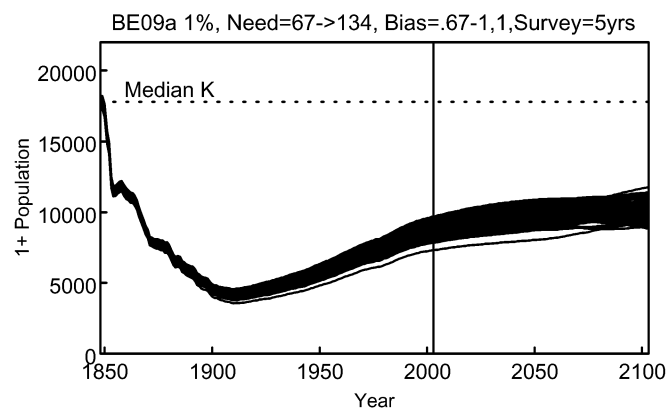
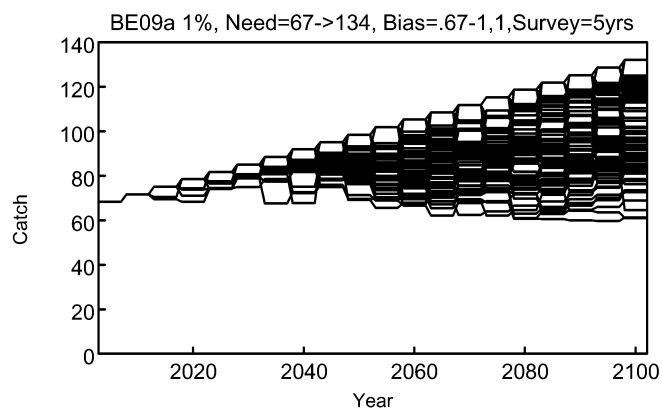
Appendix 7

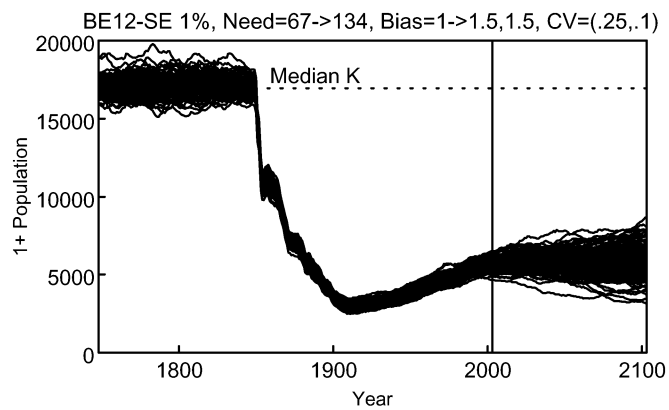
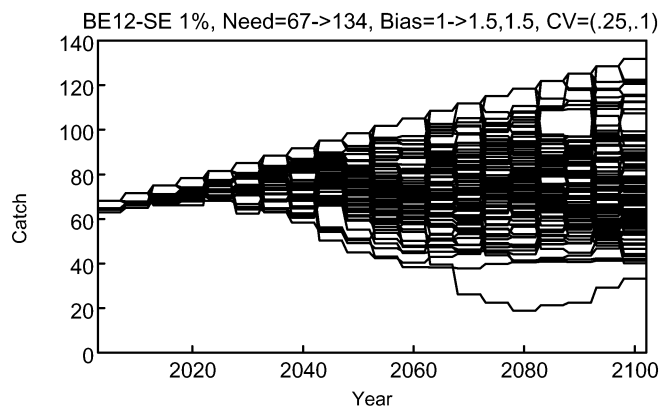
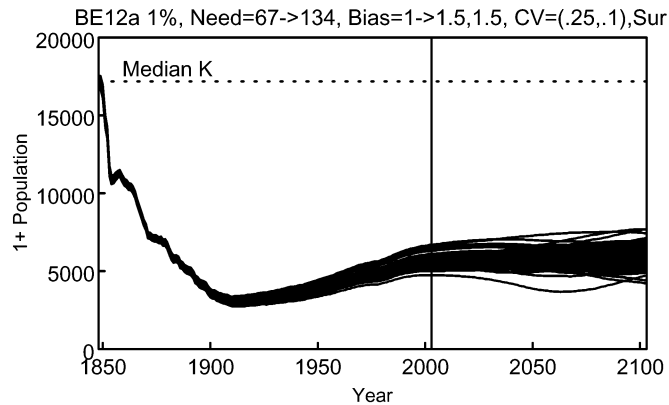
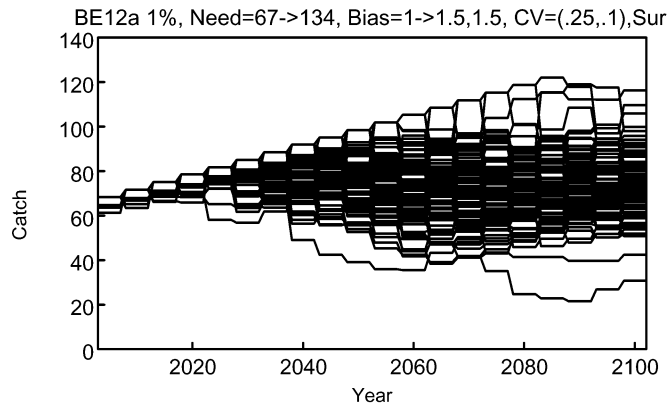
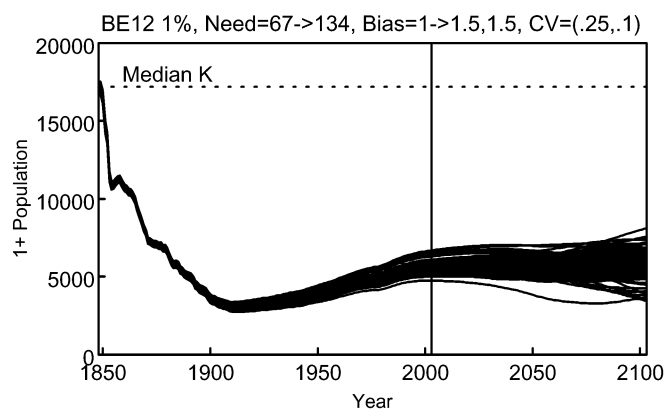
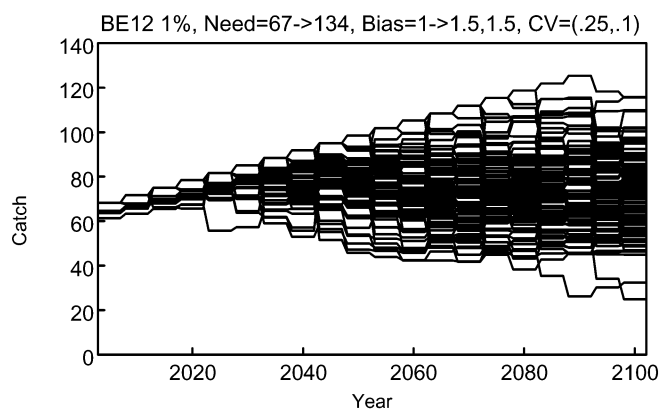
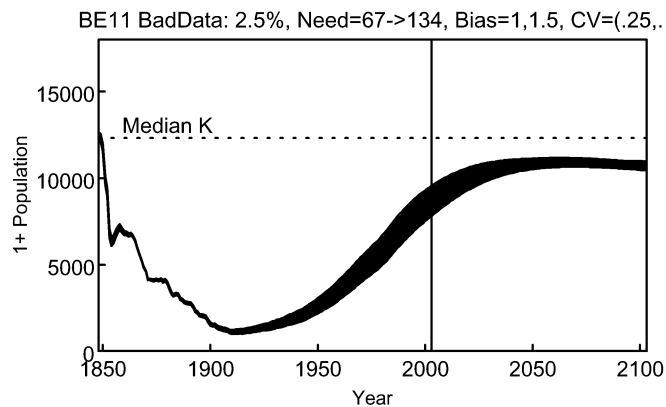
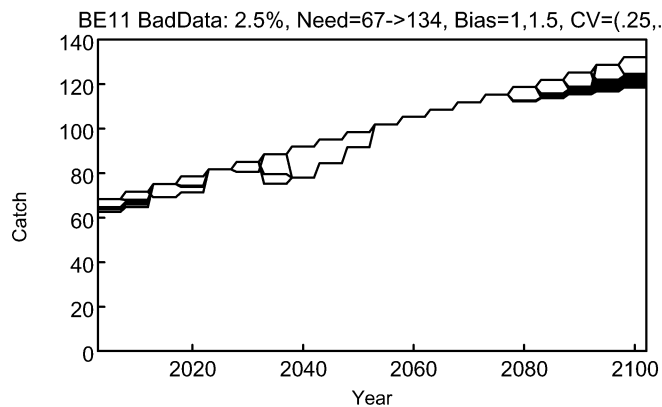
THE 100 TIME-TRAJECTORIES OF STRIKE LIMIT AND I+ POPULATION SIZE FOR THE BOWHEAD SLA FOR ALL TRIALS

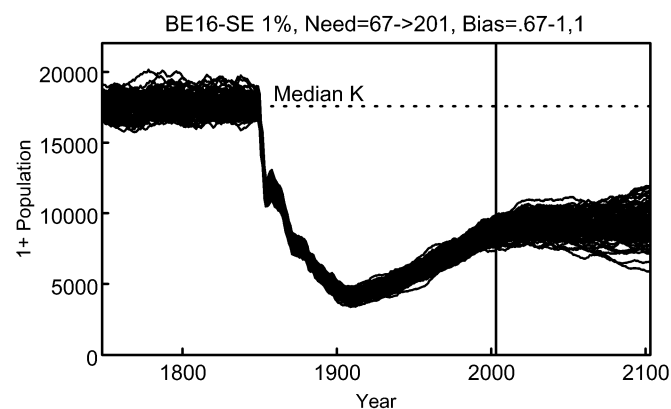
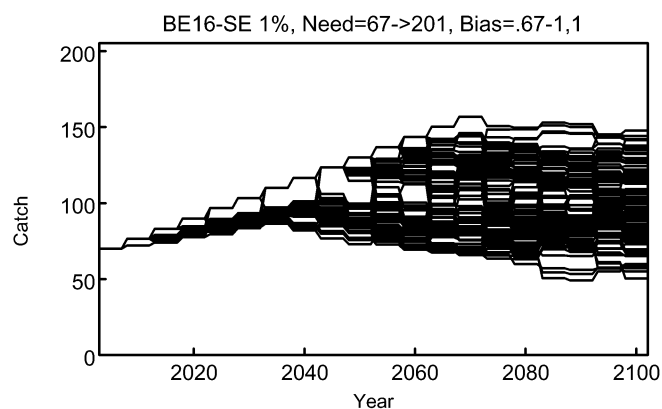
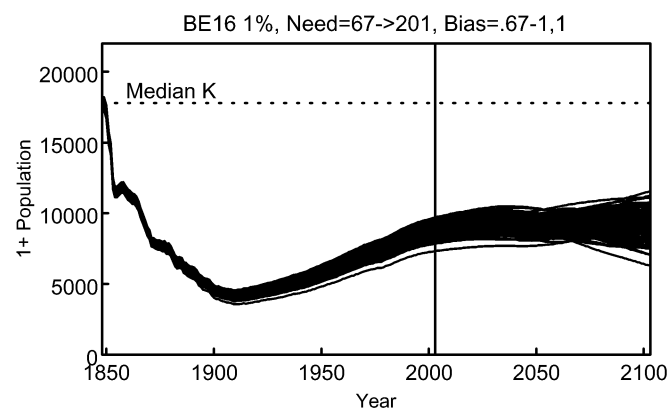
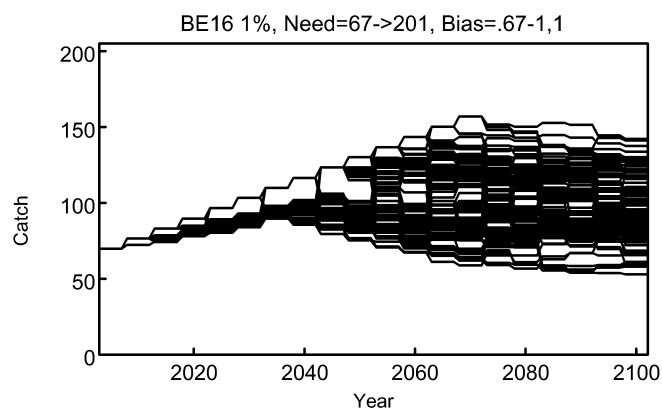
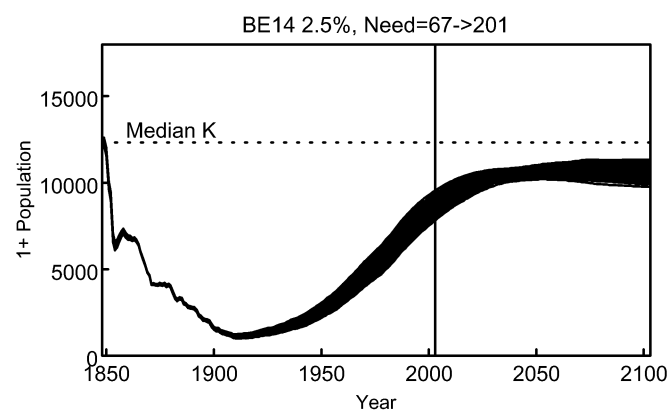
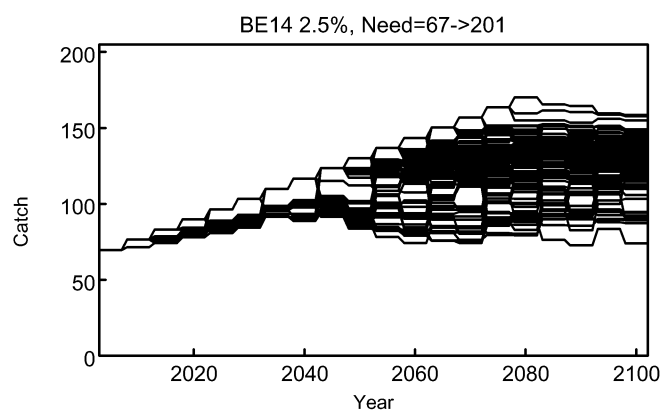
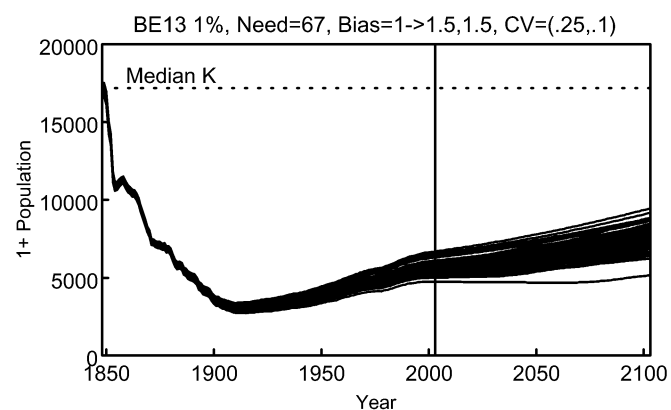
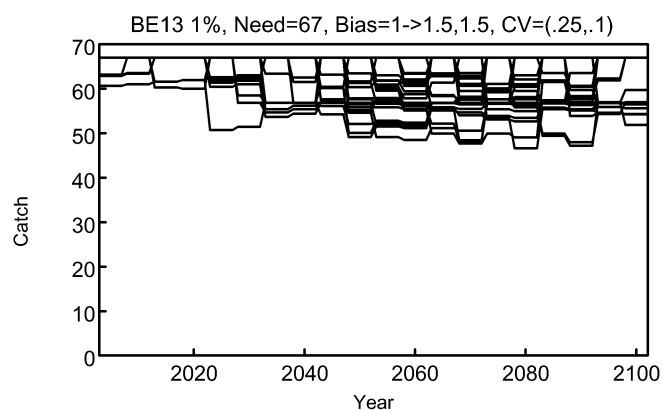


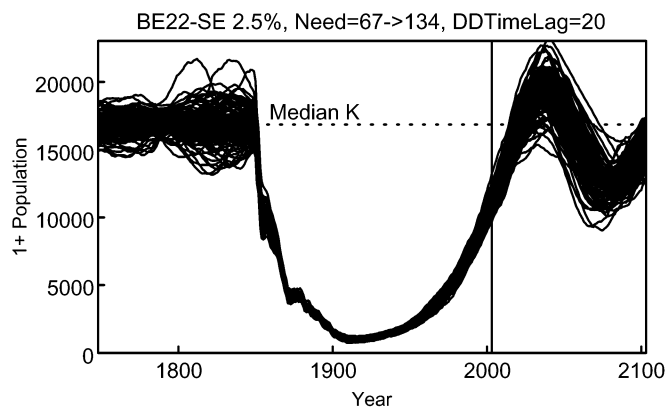
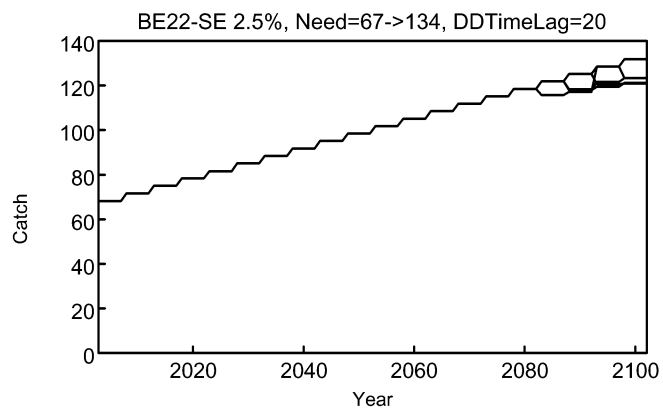
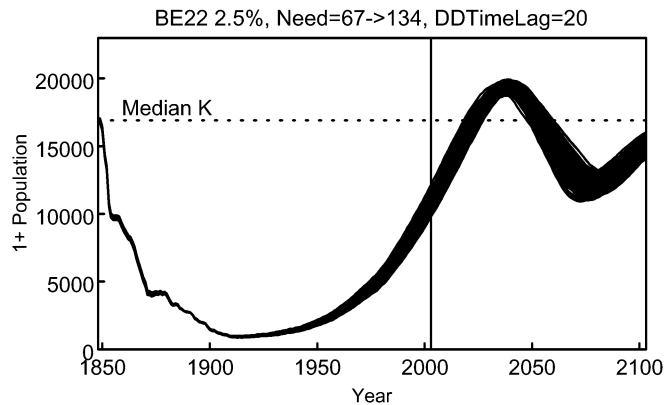
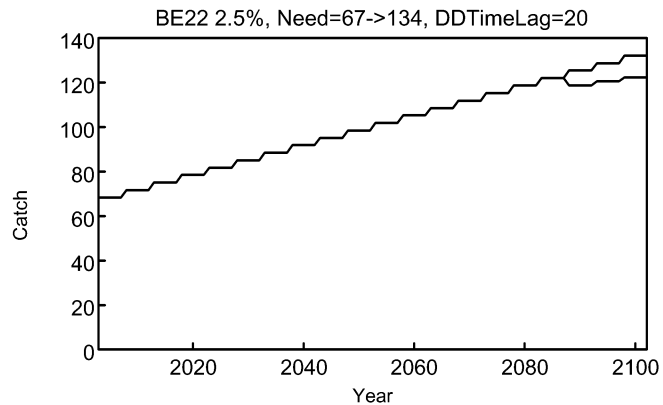
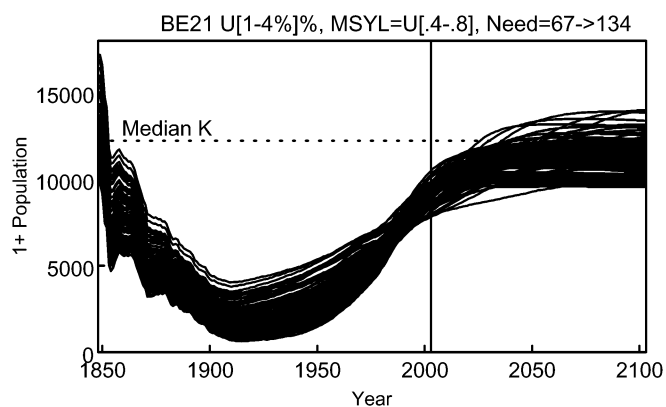
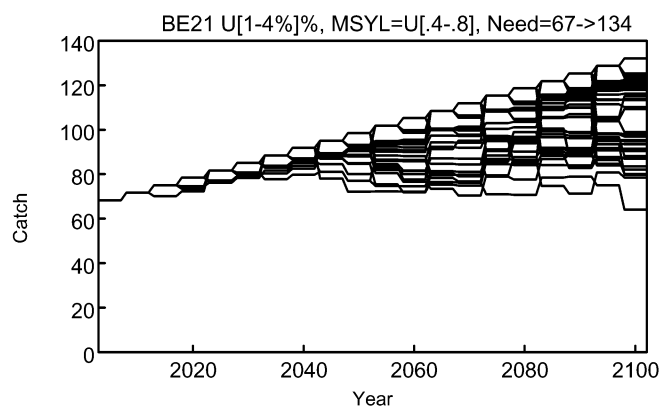
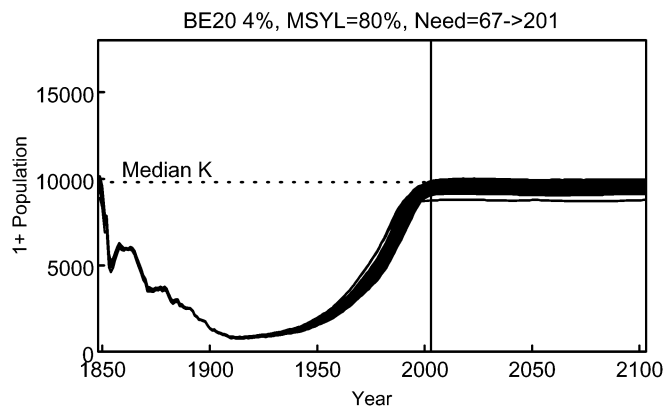
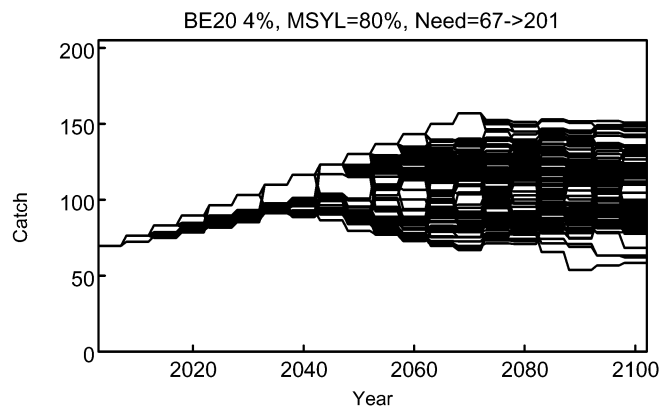


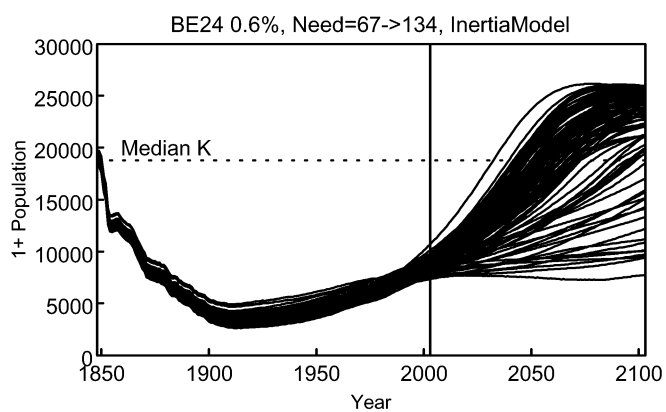
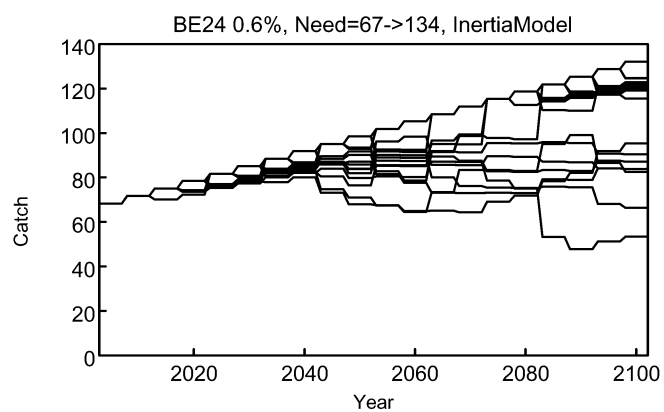
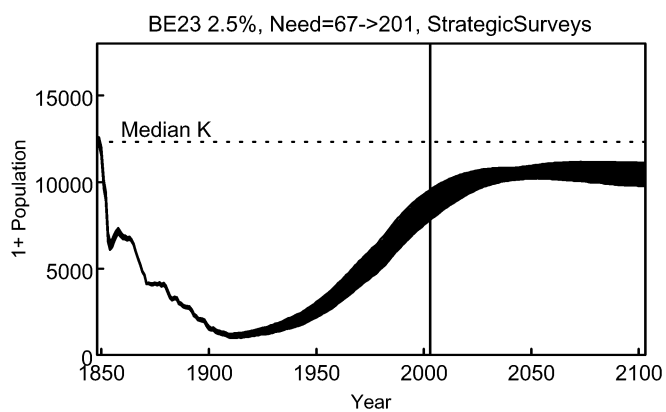
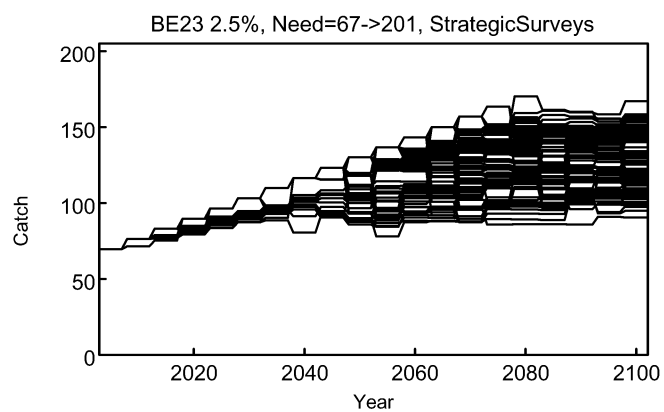


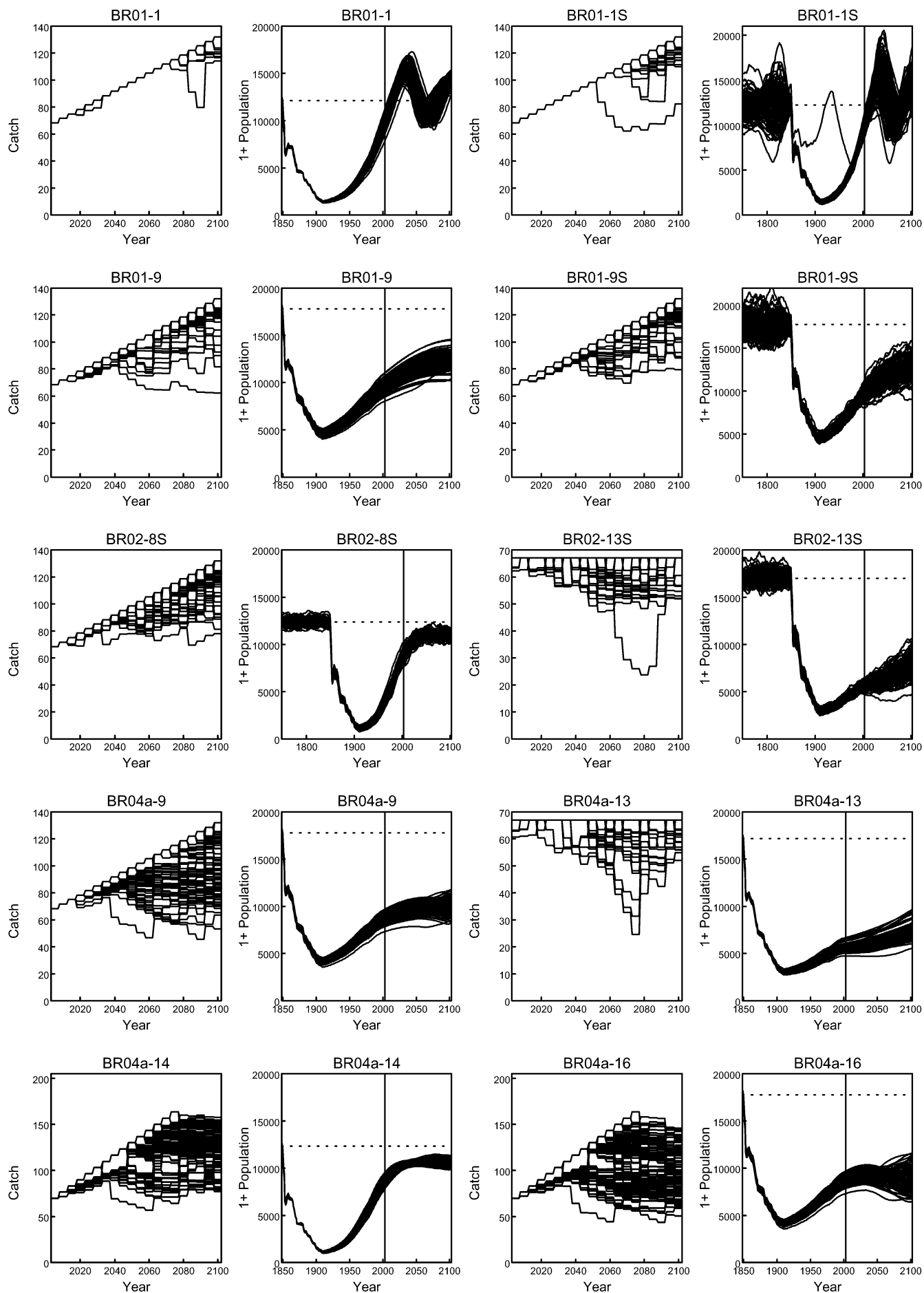


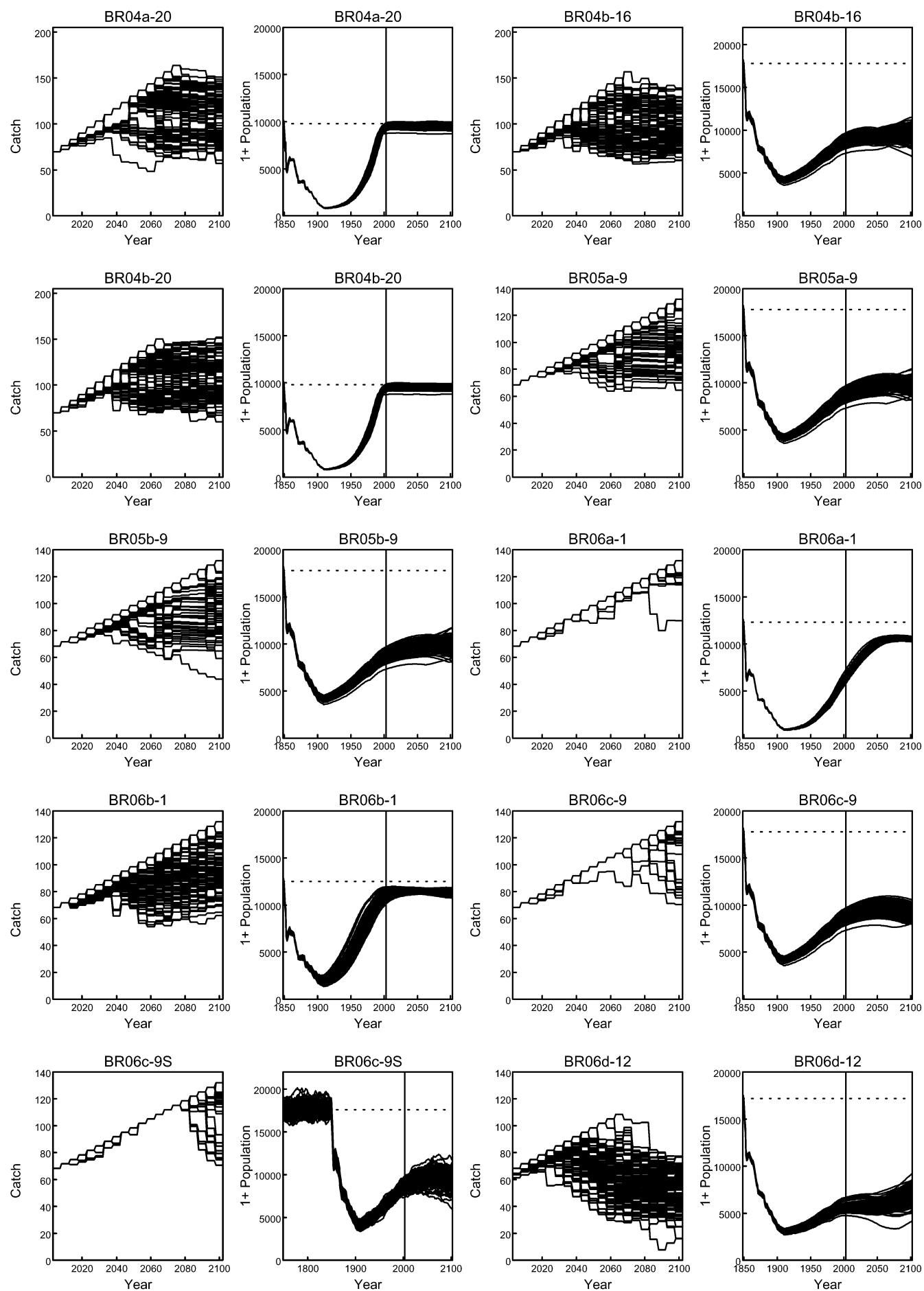


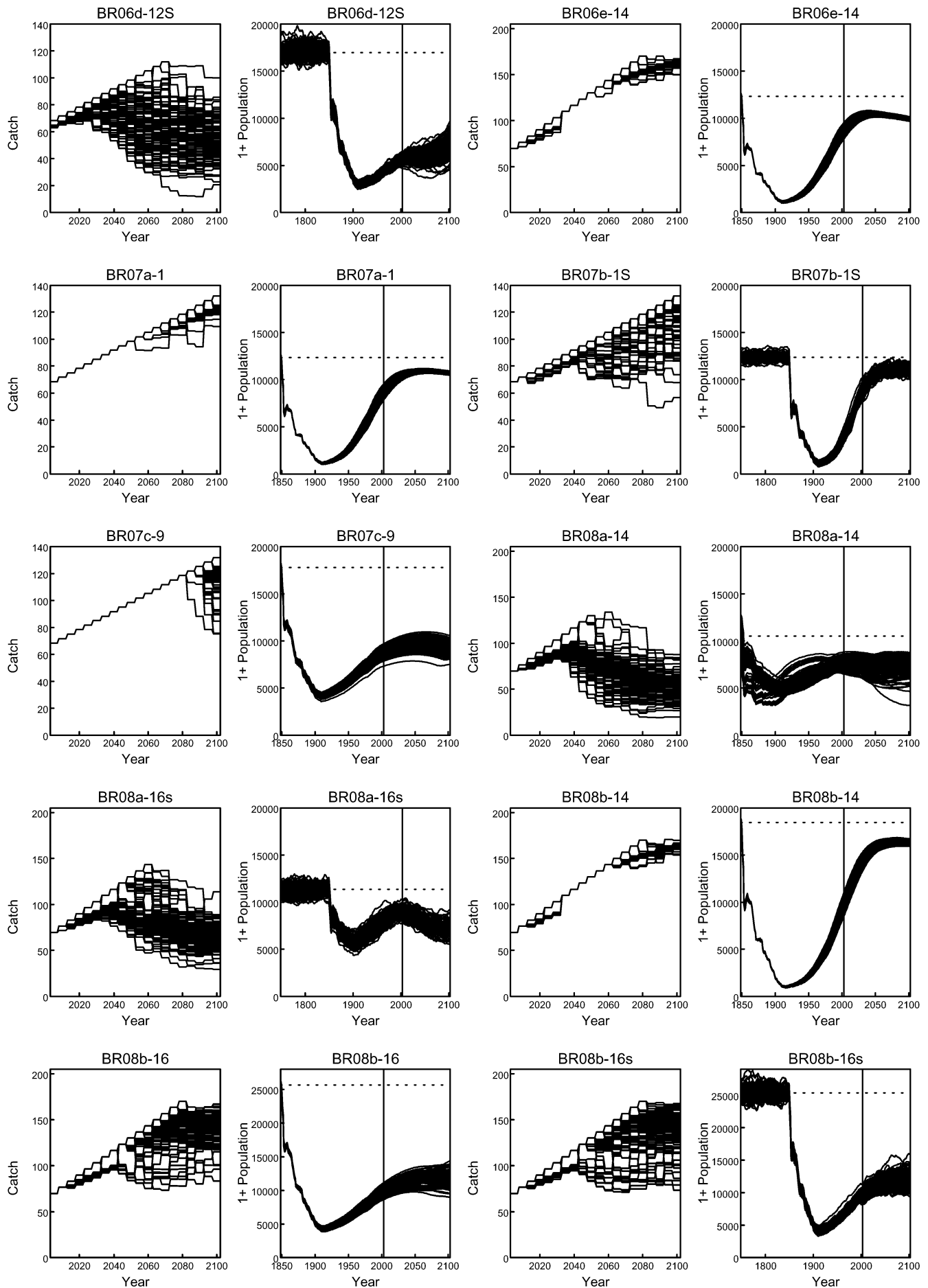


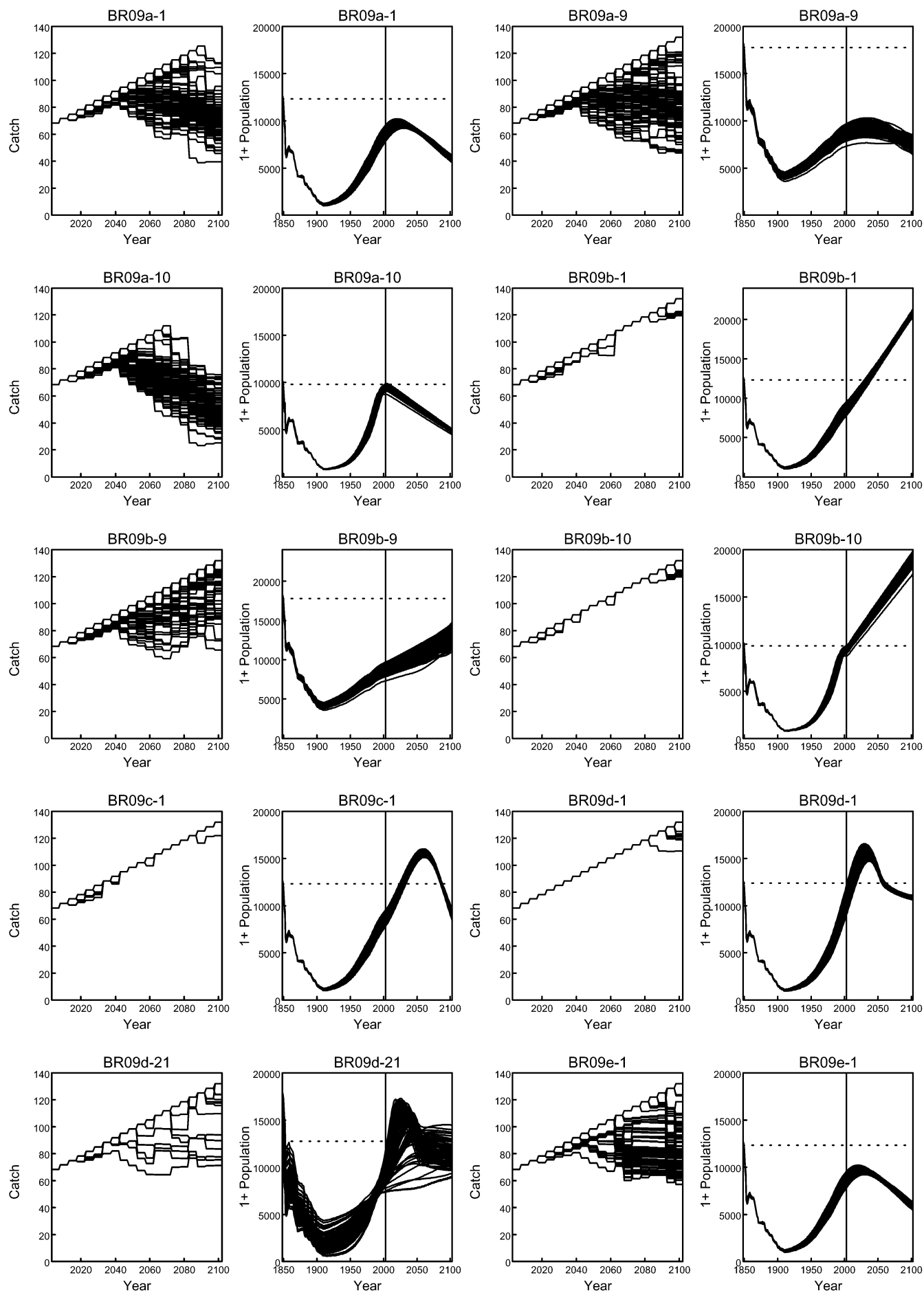


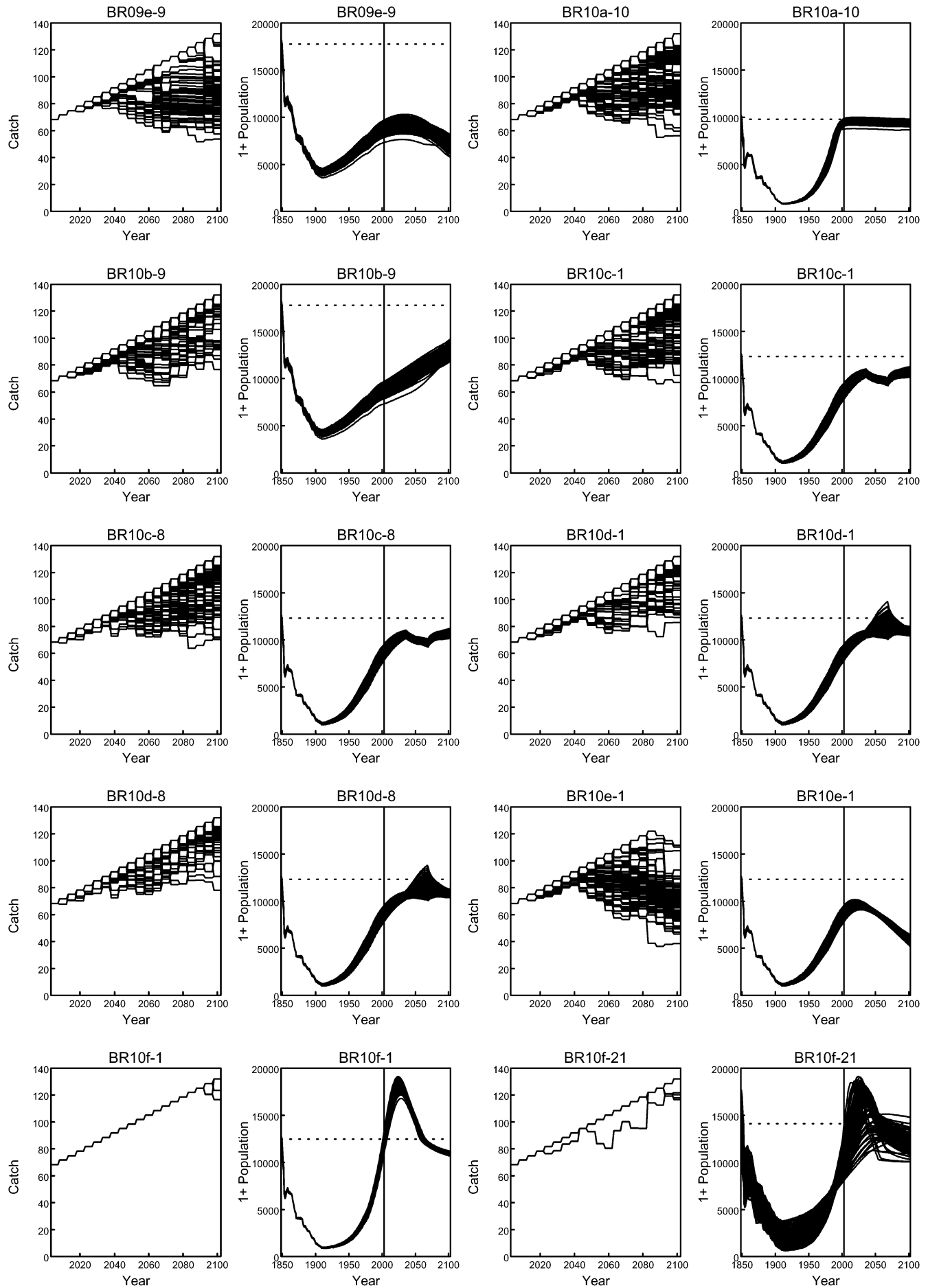


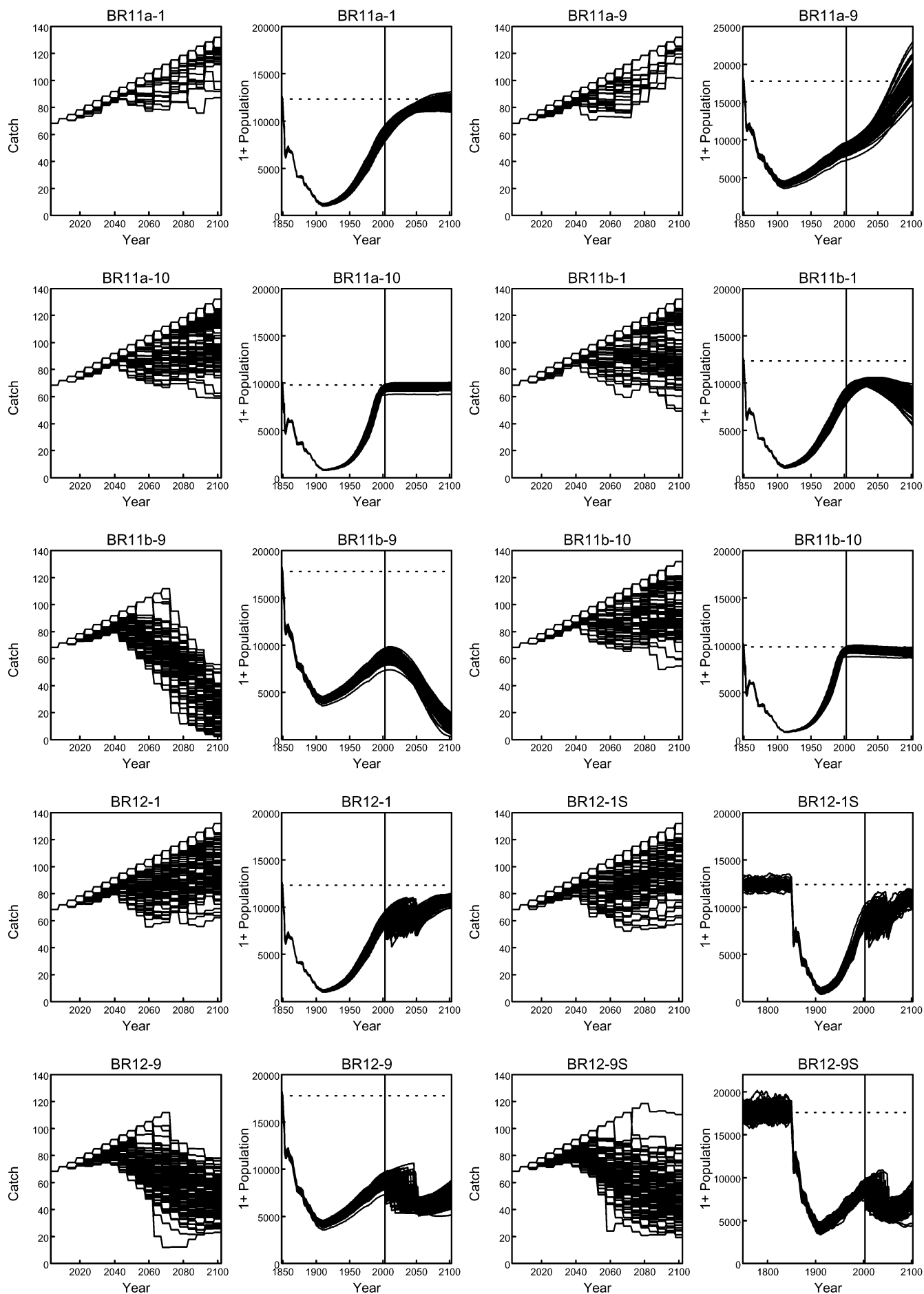


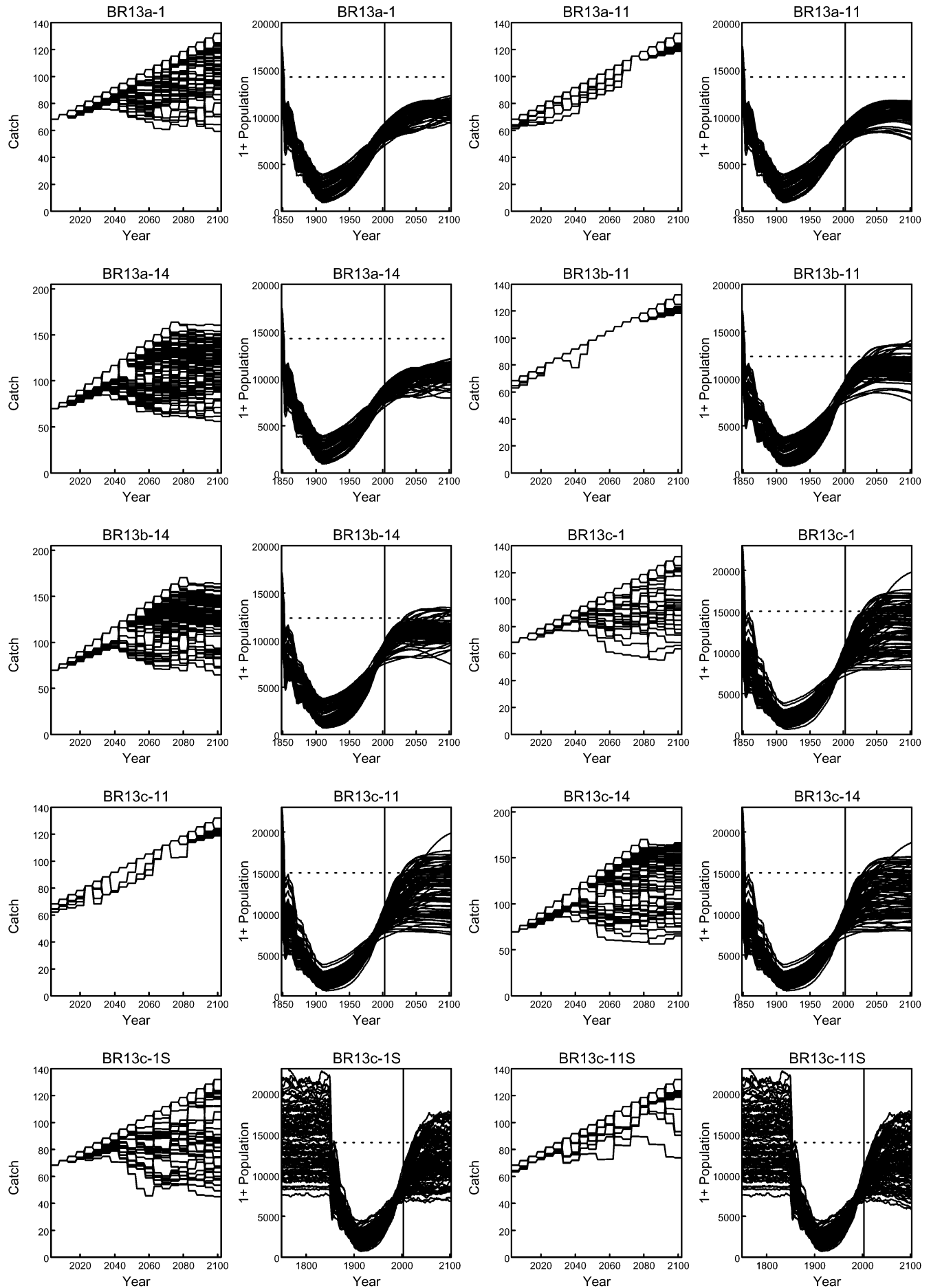


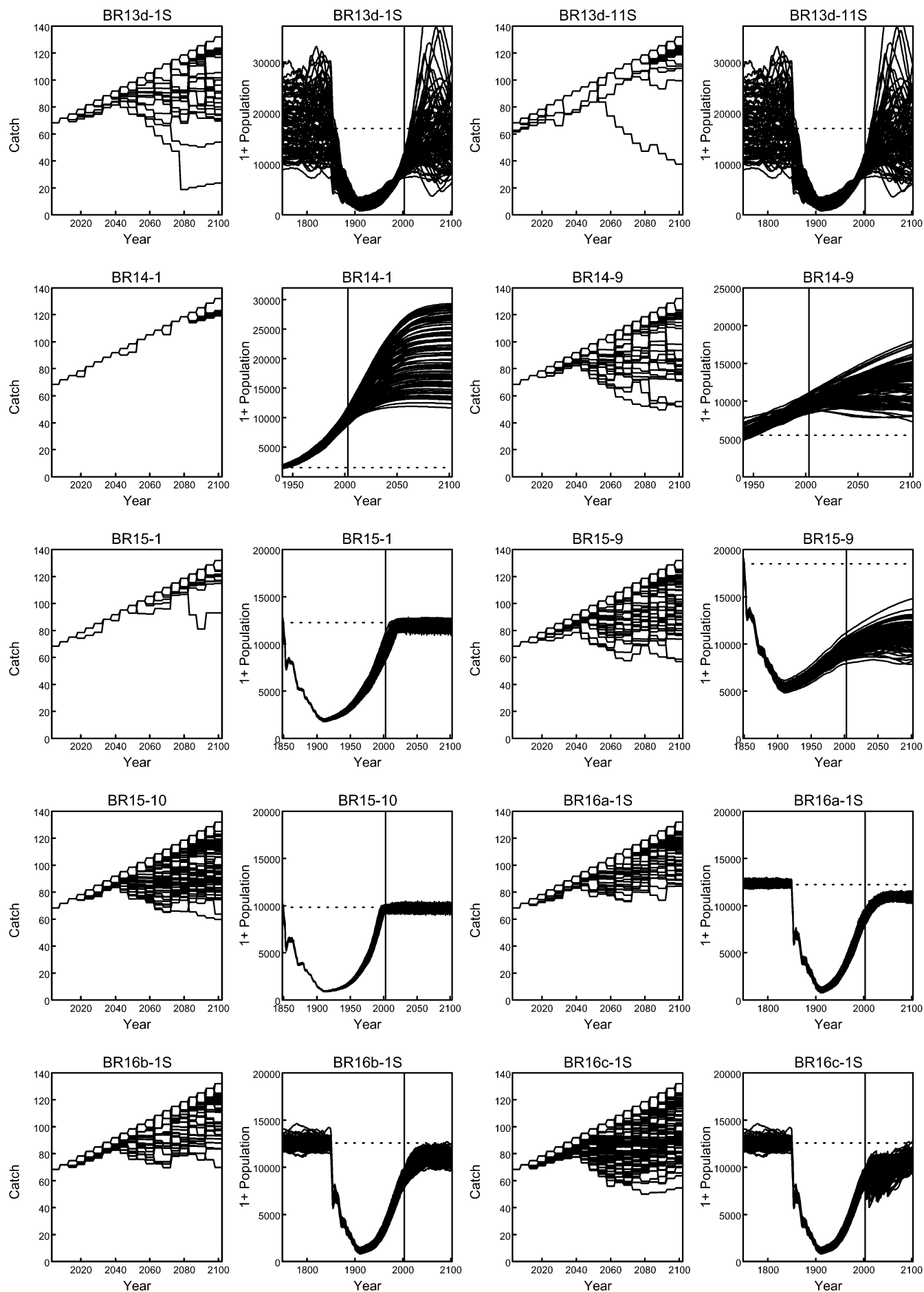


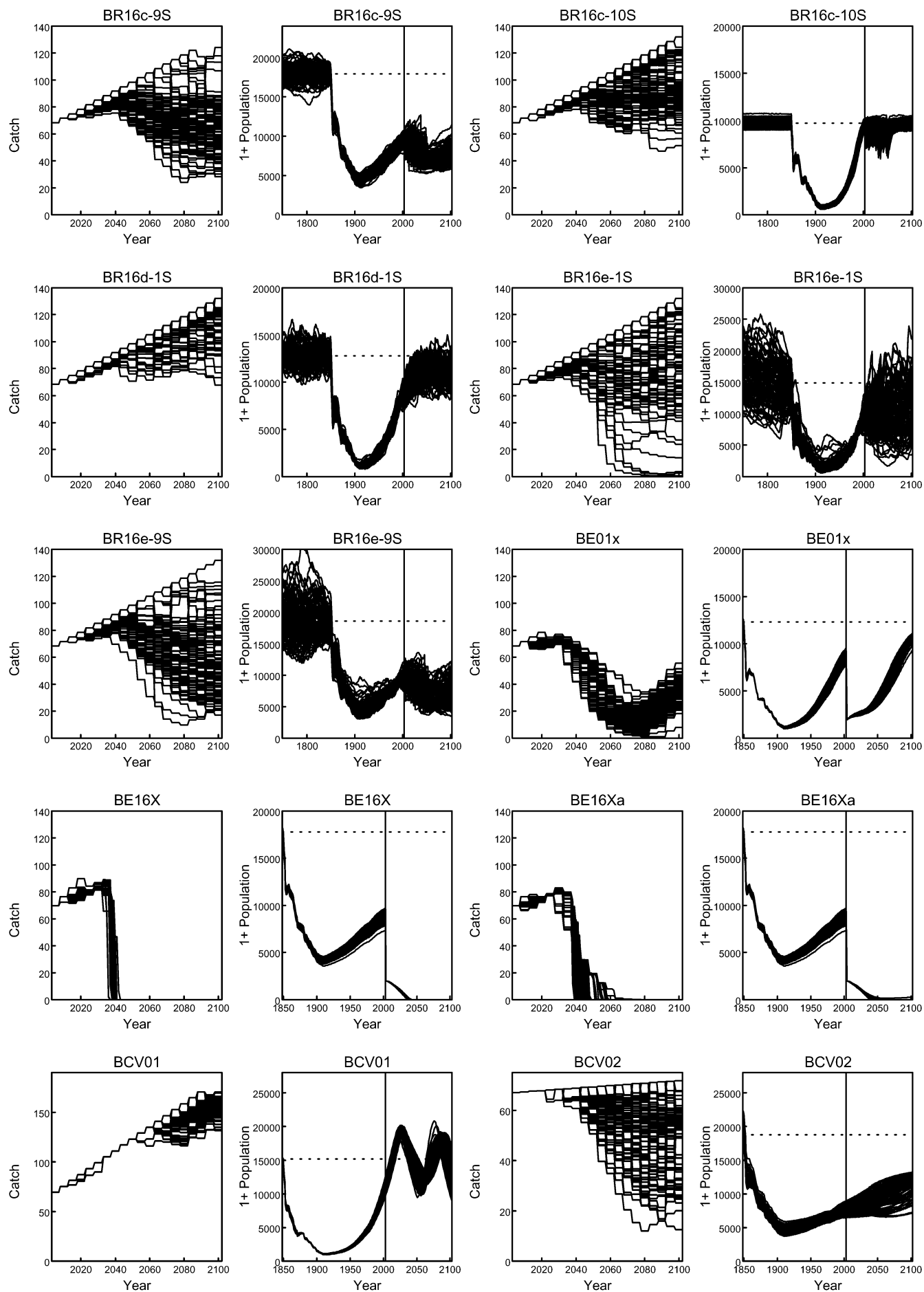


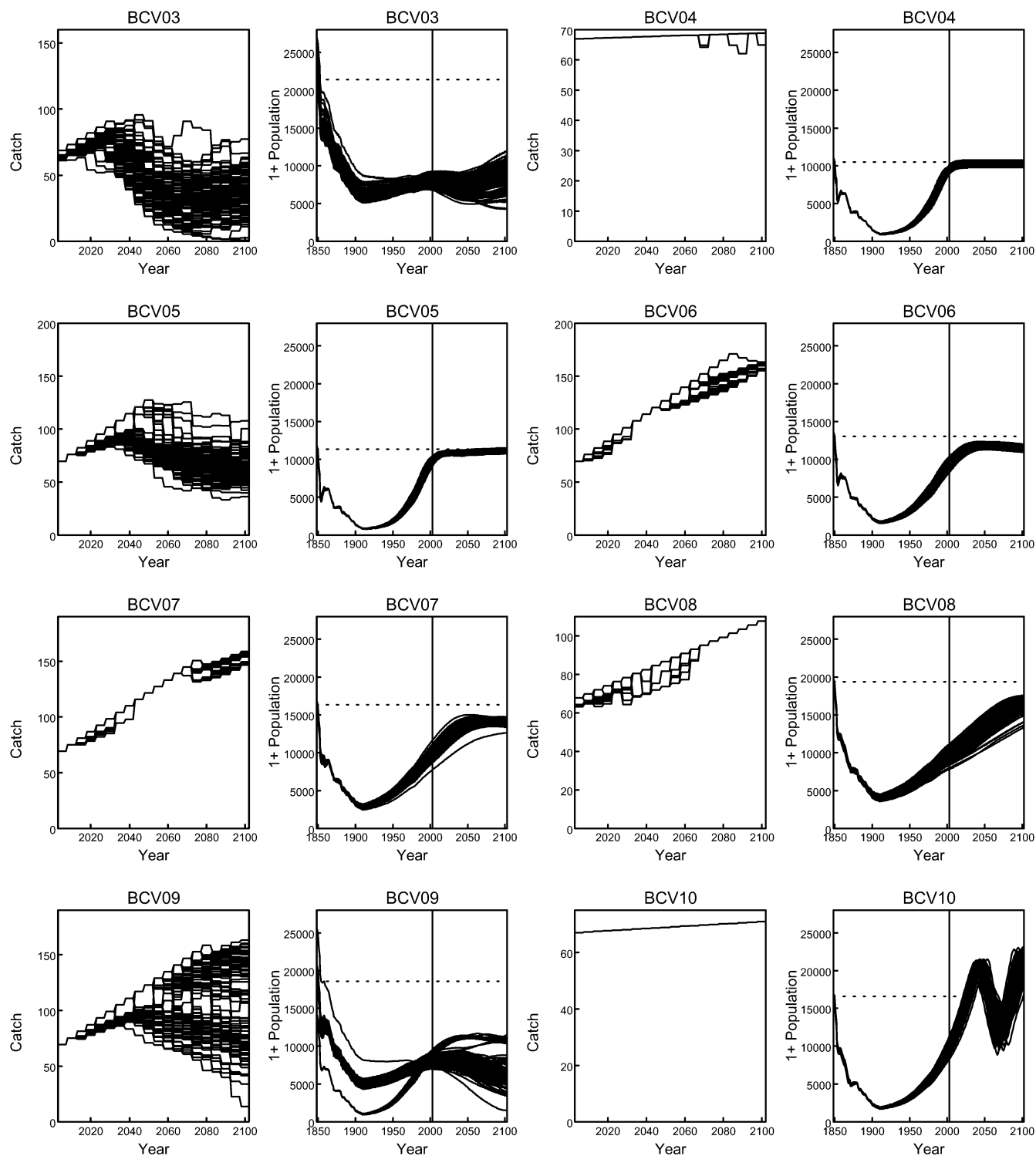






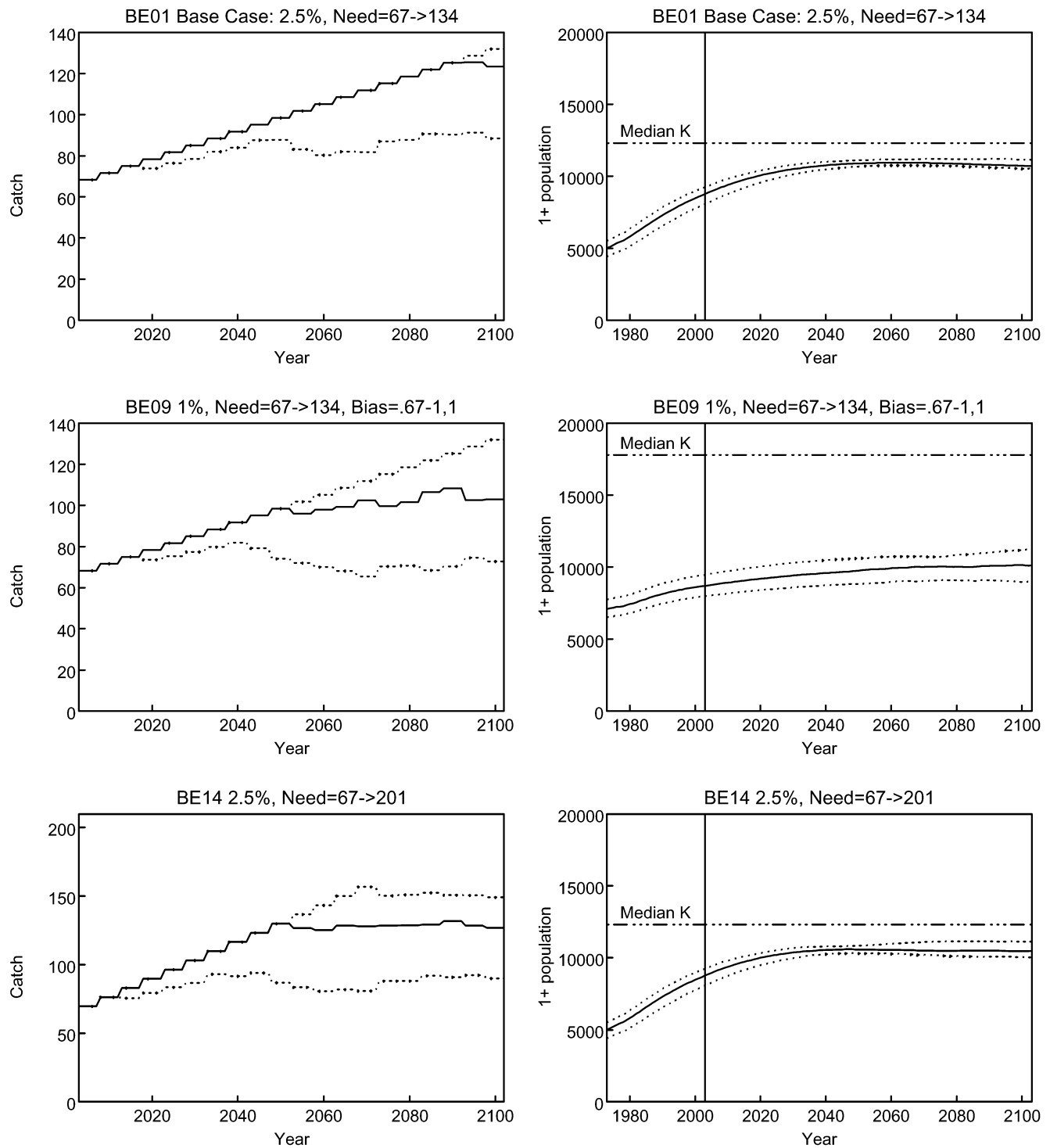






Appendix 8

THE MEDIAN (SOLID LINE), 5 AND 95%ILES (DOTTED LINES) OF THE TIME TRAJECTORIES OF STRIKE LIMIT AND POPULATION SIZE FOR THE BOWHEAD SLA FOR THE BE01, BE09 AND BE14 TRIALS



Annex F

Report of the Sub-Committee on Bowhead, Right and Gray Whales

Members: Walløe (Chair), Allison, Bando, Bannister, Berggren, Best, Borodin, Brandao, Breiwick, Brownell, Butterworth, Carlson, Childerhouse, Clapham, Clark, C., Clark, E., Cooke, Dalebout, Deimer, DeMaster, Diake, Donahue, Donovan, Etylina, Friday, Fujise, Funahashi, Garrigue, George, Givens, Goodman, Grønvik, Hakamada, Hatanaka, Haug, Hedley, Hester, Iniguez, Ishikawa, Kanda, Kasuya, Kato, Kawachi, Kawahara, Kell, Kim, Kock, Krahm, Lens, Manzanilla Naim, Matsuoka, Melnikov, Mikhalev, Miyashita, Morishita, Murase, Nagahata, Nagatomo, Nishiwaki, O'Hara, Ohsumi, Øien, Okamura, Palsbøll, Perrin, Pike, Punt, Rambally, Read, Reeves, Reijnders, Rennie, Robbins, Rogan, Rojas-Bracho, Rooney, Rose, Rosenbaum, Rowles, Sadler, Sakamoto, Santamaria, Schweder, Senn, Shimada, Simmonds, Skaug, Smith, Sohn, Suydam, Swartz, Tamura, Taylor, M., Thiele, Tichotsky, Tynan, Urban-Ramirez, Wade, Weinrich, Weller, Witting, Yamamura, Yasunaga, Yoshida, Zeh, Zelensky, Zenitani, Zerbini.

1. OPENING REMARKS, ELECTION OF CHAIR AND APPOINTMENT OF RAPPORTEURS

Walløe welcomed the participants and was elected Chair. Robbins acted as rapporteur, assisted by George, Manzanilla and Reeves.

2. ADOPTION OF AGENDA

The adopted agenda is given as Appendix 1.

3. REVIEW OF AVAILABLE DOCUMENTS

The documents available for discussion by the sub-committee included SC/54/BRG1, 3-27, E11, O16, O18 and SC/54/ProgRep Canada.

4. GRAY WHALES

4.1 In-depth assessment of eastern North Pacific gray whales

4.1.1 Catch and stranding information

SC/54/BRG21 provided details on the 2001 aboriginal catch of gray whales in the waters adjacent to Chukotka, Russia. The harvest was carried out in the Gulf of Anadyr, the Senyavin Straits and in the open waters of the Bering Sea. A total of 112 gray whales were harvested, including 62 males and 50 females. The length of these animals varied from 8-14.6m and the weight varied from 6-33.1 tons (averaging 11.2 tons). The largest whales were harvested in the Bering

Sea, including a 14.6m female (33.1 tons) and a 14.0m male (29.3 tons). Two whales were 'stinky' (smelled of medicine) during the 2001 season, and samples from those animals are currently being analysed by Russian and North American scientists. Information was also provided on the system of regulation and management of the subsistence hunt in this region.

Rowles commented that samples from the 'stinky' whales had been shipped to Fairbanks, Alaska and would be analysed for ketones and anthropogenic contaminants sometime after this meeting. In response to a query, Borodin noted that while the sexes of the 'stinky' whales are known, he did not have that information with him.

Borodin noted that the weight of harvested whales was estimated when weighed pieces of meat were distributed among the people of the village. There was also a special table used to estimate weight.

There was some discussion of strandings in the Chukotka region. Borodin noted that while it is difficult to accumulate stranding information over such a large coastline, he believed that most were entrapments in ice. Melnikov added that he has been collecting information over a 10-year period and believes that many gray whales are killed by killer whales. When asked whether these were mainly attacks on calves, Melnikov replied that 2-3 year olds were more frequent targets. It was also noted that the presence of killer whale scars is routinely documented when animals are harvested.

SC/54/BRG27 summarised basic biological data collected from harvested gray whales in Chukotka, Russia, primarily since 1980. Most of the discussion focused on two discrete periods: 1980-1992 and 1994-2000, the latter period marking a shift to a more traditional type of hunting in coastal areas. The data obtained from harvested animals included sex, size (length), age, physiological condition and a thickness of blubber indicator (blubber thickness in millimetres divided by whale length in centimetres). Following the change in the harvest method, there was a decrease in the number of whales taken, the ratio of females in the catch, and the length and corresponding age of harvested whales. A total of 542 whales were caught after 1994, compared to the 2,137 taken between 1980 and 1992. Body lengths of harvested whales were higher on average in the early period (female 11.95m, male 11.4m) than in the late period (female 8.95m, male 9.4m). Females dominated the catch in the earlier period, likely due to a preference for larger animals. However, the sex ratio of catches has not differed from parity since 1998 and the authors hypothesised that the composition of more recent catches reflects the actual sex ratio of the whales in that area. Between 1980 and

1992, the average age of harvested animals was 16.2 years for females and 14.1 years for males. In subsequent years, the whales harvested were predominately juveniles with an average age of less than two years. The percentage of pregnant whales among mature harvested females prior to 1992 was 13.4%; however it was noted that this should not be assumed to reflect the actual pregnancy rate of the population. Blubber thickness indicator values were also summarised by year, sex, reproductive status and age.

In response to a query, Borodin noted that the age data were considered to be rough estimates, especially for young animals.

Borodin confirmed that the percentage of pregnant animals harvested after 1992 was inadvertently omitted from table 2 of SC/54/BRG27, but was likely minimal because they were no longer harvesting many large animals. Caution was recommended regarding the use of such data as an indicator of the true pregnancy rate in this population. The sub-committee **recommended** that reproductive organs be collected and archived for detailed determination of pregnancy rates, as these are some of the few animals for which this will be possible. Borodin noted that Russia would welcome such a request.

Borodin presented a hypothesis that the change in the nature of the harvest in 1992 may have been a contributing factor for this population reaching carrying capacity. He estimated that the reduction in the number of gray whales harvested in recent years could have resulted in a 10-15% increase in whale biomass, with an increase in the proportion of large animals, in particular, because considerably less of this fraction of the population was harvested. An additional 25-30% increase might be expected due to population growth. He hypothesised that these rapid changes in the size and demographics of the population may have prevented it from properly adjusting to the available food base. As such, the management strategies that limited the harvest may have inadvertently been responsible for unnecessary mortality in this population.

SC/54/BRG23 summarised available information on the unusual mortality of eastern North Pacific gray whales in 1999 and 2000. The number of strandings documented along the west coast of North America increased to approximately eight times the annual mean calculated between 1995 and 1998. The unusually high number of strandings in 1999 ($n=283$) continued in 2000, with 368 animals recovered from Mexico to Alaska. Several factors may have contributed to the large number of strandings reported in those years including: starvation, natural and anthropogenic toxins, infectious diseases, ship strikes, detection effort and reporting, wind and current effects. There was also a change in the demographics of stranded animals during this period relative to 1995-1998, with an increase in the proportion of females and adult whales.

The proximate cause of death was determined in only three of 651 animals, and each presented potentially unique etiologies. Since most of the whales were not examined thoroughly, the actual cause of death of these animals is unknown. Of the many proposed factors for this mortality event, there was no evidence that fisheries interactions or wind/current effects played an important role. The emaciated condition of many stranded and living whales suggests that starvation may have been a predisposing cause. However this observation cannot be supported with sufficient quantitative data because: (1) the effects of decomposition on blubber quality; (2) variations in blubber thickness with age and sampling site; and (3) limitations in the number of animals that were examined thoroughly. International

cooperation should continue in order to better understand the basic biomedical parameters and the cause(s) of mortality in this species.

Clarification was requested on how carcasses were recovered and how much time might have passed from the time of death. Rowles noted that an animal will generally sink when it dies and can take 6-10 days to refloat before an examination is possible. Most carcasses stranded on land, although a few were found floating. There were also some live strandings, mostly of young animals.

While only a few deaths were positively attributed to ship strikes and entanglements, Rowles commented that the cause of death is difficult to detect unless an animal is thoroughly examined. As most of the 651 carcasses were not examined, the reported percentages do not necessarily reflect the rate at which the population is impacted by these activities.

Brownell asked about the availability of girth measurements, as those might yield insight into the nutritional health of stranded animals. Rowles replied that girth (or half-girth) measurements were only taken if the carcass was relatively fresh and accessible on the beach.

Urbán confirmed that no lipid analyses were performed for whales that stranded in Mexican waters. 'Skinny' whales were observed there in 1998 and 1999, but no measurements were made.

4.1.2 New scientific information

Urbán summarised SC/54/BRG24, a study of the distribution and abundance of gray whales in the Magdalena Bay complex at Baja California Sur, Mexico. This work compared cow-calf pairs to other whales in three well-defined zones: Santo Domingo Channel (north), Magdalena Bay (central) and Almejas Bay (south). Fifteen surveys were conducted over eight weeks, from 13 February through 3 April 1997. Santo Domingo Channel was the main calving zone within the lagoon complex, exhibiting the highest number of cow-calf pairs ($n=83$) and lowest total count of single whales ($n=17$). By contrast, cow-calf pairs in the central and southern areas totalled only 9 and 15, respectively, and single whales in these areas totalled 72 (central) and 94 (southern). The authors proposed that Magdalena and Almejas bays were mainly used for courtship and mating, or as congregation areas for young and immature whales that do not take part in active breeding. By contrast, Santo Domingo Channel was an important nursery ground. They concluded that it would be useful to continue these surveys, covering the entire season and employing similar effort across all of the areas of the complex.

SC/54/BRG26 described the movement patterns of mothers and single whales in Laguna San Ignacio based on satellite telemetry. Twelve gray whales (six mothers and six singles) were instrumented with Argos satellite-monitored radio tags in February 1996. Mothers stayed in the lagoon longer, made repeated excursions to and from the lagoon, and had a significantly higher percentage of locations inside the lagoon than single whales. However, the authors noted that this work took place at a time of year when the number of single whales usually declines, likely influencing their residency time in the lagoon. Extensive use of the entrance area and waters outside of the lagoon by single whales and the back and forth movements of mothers highlight the importance of surveying both inside and outside of the lagoon when estimating abundance.

The sub-committee welcomed this new information and noted that the results are consistent with previous work and contribute to the understanding of the wintering population. It was noted that the satellite tags, previously used on

humpback and right whales, achieved relatively short attachment times in the 1996 study. Urbán attributed this problem to the fact that gray whales in and near the lagoons have frequent physical contact with the bottom, one another and whalewatching boats, which may have affected the attachments. Clapham noted that similar problems had arisen during satellite tagging of North Atlantic right whales, where it was believed that the antennas and saltwater switches were damaged from physical contact between whales in surface active groups. He mentioned that some success had been achieved over the past year with a modified tag applied to southern right whales in South Africa. Urbán confirmed that no satellite tagging has taken place in Laguna San Ignacio since 1996.

SC/54/BRG11 examined trends in relative abundance of adults and calves in Laguna Ojo de Liebre and Laguna López Mateos (in the Magdalena Bay complex) based on a series of air and vessel surveys between 1980 and 1998. Temporal and seasonal patterns of abundance were estimated by fitting generalised linear models to weekly counts with a Poisson regression. For Ojo de Liebre, adult abundance peaked consistently on 6 February $\pm$ 4 days (95% CI), with a Gaussian window of lagoon use with scale parameter σ = 19.4 days (SE = 2 days). Calf abundance in that area peaked approximately one week later. The time series of peak relative abundance of adults and calves dipped significantly around 1990. The ratio of calves to adults was low from 1988-1991 (except in 1989). In López Mateos, the season of lagoon use was found to have varied over the years. The time series of peak relative abundance for adults showed a substantial drop in 1983, and then a period with variation around a constant level, but with a significant low (1998). The number of calves was also found to have been low in 1983, as well as in 1990 and 1998. The ratio of calves to adults declined substantially from 1981-1990. It has recovered since 1991, but not to its highest level in the early 1980s. The authors concluded that lagoon use and calf production were severely disrupted around 1990, at least in the two areas studied.

Clarification was requested on the placement of observers within the survey aircraft and the availability of perpendicular sighting distances. Schweder did not have first-hand knowledge of the field efforts, but believed that data on sighting distance were not available. He agreed that such data are valuable for calibrating strip width and survey efficiency. However, with the exception of the switch to a twin-engine plane in 1990, it was his understanding that the survey methods and procedures had remained relatively constant. Manzanilla-Naim and Rojas-Bracho cautioned on the existing sources of variability which might have not been taken into account in the analysis, and the inaccurate use of the concept of 'consistency' within the text of the paper. Schweder welcomed additional information on the data made available to him for this analysis. It was also his understanding that arrangements had been made for these data to be deposited with the IWC. He stressed the importance of having such data sufficiently well documented with respect to field methodology. However, he felt that the issues raised did not invalidate the broad conclusions of the paper.

Given the differential habitat use patterns described in SC/54/BRG24 and SC/42/BRG26, it was suggested that the authors might also consider treating mothers separately from other adults in future analyses.

SC/54/BRG16 reviewed existing information on gray whales on their wintering grounds in Mexican waters. This review included the history of exploitation in Baja

California, the formal protection of gray whales in Mexico, research in Mexican waters, abundance within the lagoons, distribution, calf production and mortality, duration of stay within the lagoons, birth rate, mortality, movements from telemetry studies, site fidelity from genetic studies, environmental and anthropogenic threats, and future research and monitoring needs. Among the biological aspects, it was mentioned that in relation to the distribution of mothers with calves, Laguna Ojo de Liebre is the most important area followed by Laguna San Ignacio and Santo Domingo Channel. These three areas included 91% of the mothers and calves counted in 1997. Laguna Ojo de Liebre also contains the greatest proportion of single whales during the winter, followed by Laguna San Ignacio, Bahía Almejas and Bahía Magdalena.

For the winter seasons 1997-2002 estimates of annual calf production suggest a decrease from the 1997 high (910 calves estimated) to a low in 1999 (286 calves), followed by a gradual increase to 670 calves during the period 2000-2002. Based on a comparison with the annual calf production estimated in Piedras Blancas, California, it was proposed that the areas outside the breeding lagoons constitute an important calving area that is utilised to a greater extent as the population has continued to increase. Estimates of the percent of mothers with calves utilising areas outside the lagoons ranged from lows of 33% to 36% (1997 and 1999 seasons) to a high of 53% in 1998.

Photographic identification of 975 single whales and 519 mothers with calf obtained during the winter seasons of 1996-2000 in Laguna San Ignacio revealed that the cow-calf pairs remain within the area approximately three times longer than single whales. The average time between first and last sightings ranged from 25.5 (95% CI = 20.1-30.9) days in 1999 to 19.1 (95% CI = 14.3-23.9) days in 1996. In contrast the average time between first and last sightings for single whales ranged from 6.8 (95% CI = 3.6-10.0) days in 2000, to 2.6 (95% CI = 1.7-3.5) days in 1996. Similar results were found in Laguna Ojo de Liebre during the 2001 winter season.

Based on the photo-identification of 34 females seen in more than one year, and 18 with calves in different winter seasons, calving intervals were estimated to range from 2-4 years. The mean length of the calving interval was estimated as 2.50 ± 0.29 years (95% CI = 2.21-2.8). This interval is significantly higher than the 2.11 (SD = 0.403) years estimated for the period 1977-1982.

Genetic data are being used to investigate the role of female-directed philopatry in winter habitat-use patterns. Within Laguna San Ignacio, significant genetic differentiation was present between mothers (adult females with calves; n = 42) and females (cows without calves), and between Laguna San Ignacio females and a random sample of females collected from outside of the winter range. This suggests that female fidelity to Laguna San Ignacio is restricted to the years that they produce a calf and that it is influenced by female-directed philopatry. No genetic differentiation was evident between Laguna Ojo de Liebre females.

Discussion of this paper focussed largely on the comparability of lagoon surveys and resulting trends in abundance and distribution. In Laguna San Ignacio, abundance estimates came from two time series: 1978-1982 and 1996-2000. In the early series, there seemed to be an increasing trend in abundance over the years and a late season influx of mother calf pairs from other areas. In the later series, counts were approximately 30% lower and the

late season influx of mothers was no longer detected. There also appeared to be an increase in the number of mothers seen outside of the lagoons. While the reasons for these changes were not known, Urbán commented that the only obvious change in the environment of Laguna San Ignacio since the early 1980s was whalewatching in areas preferred by mother calf pairs. The sub-committee also discussed discrepancies between calf counts in the lagoons and those made off central California during the northbound migration, but concluded that this issue might be better examined once all of the new data had been presented.

In discussion, it was noted that preliminary evidence for female-directed philopatry should be explored more fully, as regional impacts could have a larger effect on population recovery than previously expected. Rojas-Bracho confirmed that additional biopsy sampling efforts are planned. In response to a query, Urbán noted that photo-identification data that might help resolve the question of female site fidelity were limited in recent years to San Ignacio. There are plans to investigate the availability of photo-identification data from earlier years.

SC/54/BRG25 described the northern migration route and speed of one gray whale tracked with an Argos satellite-monitored radio tag. Between 8 and 23 February 1996, this individual travelled a distance of 1,794km from Laguna San Ignacio to a point north of San Francisco. The migration route was predominately near-shore and in waters < 100m deep, with 75% of the Argos-acquired locations averaging 7.3 ± 1.22 km from shore. Positions > 20km from shore and in water depths > 100m were received only when the whale crossed Vizcaino Bay or encountered the Channel Islands off California. During migration, the whale maintained an average speed of 134 km/d (5.6 km/h), suggesting a total coastal migration period of 49 days from Laguna San Ignacio to the Bering Sea. The sex of the tagged whale was not known.

Perryman *et al.* (2002) summarised results of seven shore-based sighting surveys for gray whale calves during their northbound migration. Calf estimates and a calf production index for the survey years (1994-2000) were given. In addition, the relationship between the duration of seasonal ice coverage over primary gray whale feeding grounds and the fluctuations in calf estimate was examined. Satellite data were used to measure sea ice coverage in the Chirikov Basin from weekly plots of ice-edge locations along a selected meridian. The meridian runs through the feeding grounds in the Chirikov Basin, Bering Strait and the Chukchi Sea. The authors then examined the correlation between the length of the feeding season (the period free of ice at a point along the selected meridian near the centre of the Chirikov Basin feeding grounds) and the calf estimates in the spring season immediately following the feeding season. The hypothesis was that impacts from shorter feeding seasons would act on existing pregnancies or neonate survival before the calves are counted during the sighting survey. Correlation tests were also conducted between the length of the feeding season and calf estimates for the spring season occurring one year later. This was done to determine whether shorter feeding seasons impact ovulation or conception, in which case an effect would not be observed in the spring season immediately following the feeding season. A significant positive correlation resulted between the duration of the feeding season and the calf estimates. No significant correlation was found between these factors with the one-year lag included. Results from this investigation formed the basis of further analysis presented in SC/54/BRG4.

SC/54/BRG3 gave the corresponding estimate for 2001 northbound calf production. A total of 87 calves were counted in 714 hours of watch, and the resulting estimate of 256 is the lowest estimate in the entire time series started in 1980. Photogrammetric data have also been collected on the width and length of whales for several years in the same area. The whales measured during the 2001 count appear to have been in better condition than in the two previous surveys. Brownell noted that an update on the 2002 calf abundance survey would be presented at this meeting.

Urbán noted that the same pattern was seen in the lagoons, where fewer skinny whales have been seen since 2001, and a higher calf production has been documented.

SC/54/BRG4 examined the relationship between sea ice and calf production in the eastern Pacific gray whale population. The authors identified a variety of regions throughout the Bering Sea thought to be important feeding areas for eastern Pacific gray whales, and then measured from satellite images the extent of sea ice covering these areas throughout the feeding season. The percentage of the identified feeding area that was ice-free was quantified, and then summed over the feeding season. A log-linear model was developed to examine the relationship between this ice-free index and calf production, as measured by the estimates of the number of calves passing central California during the northbound migration (Perryman *et al.*, 2002). The intent was to investigate whether relatively high sea ice cover (which implies reduced prey availability) would lead to lower calf production. A potential relationship was examined at three different lags, relating calf production to: (1) sea-ice cover in the feeding season prior to ovulation (a two-year lag to the calf estimate); (2) sea-ice cover during the 1st half of feeding season while pregnant (a one-year lag to the calf estimate); and (3) sea-ice cover during the 2nd half of feeding season while pregnant (a half-year lag to the calf estimate). A year effect was also examined to look for trends in calf production. The best fitting model (as selected by AICc) indicated that calf production was correlated with both sea-ice cover in the first half of the feeding season and with year. The sea-ice effect accounted for the most interannual variability in calf production, but there was also a slow decline in average calf production. The authors interpreted this as potentially representing a compensatory decline in fecundity as the population approaches carrying capacity. Sea-ice cover in 2001 was also measured, and the authors predicted calf production in the spring of 2002 would be from 349-703.

Tynan commented on long term, interannual and annual climatic trends and mechanisms that affect sea ice dynamics in the Arctic. There are two circulation modes of the Arctic Oscillation (AO): cyclonic (positive AO), and anti-cyclonic (negative AO). During a positive AO, strong westerlies transport ice off the Siberian shelves, decreasing sea ice concentration in the Siberian and Chukchi regions and increasing ice concentration in the Canadian Arctic and Beaufort Seas. Alternatively, during negative AO, ice tends to stay in the Arctic. Therefore, the AO can greatly affect sea ice distribution in the Chukchi Sea, which in turn could affect gray whale feeding opportunities. A longer-term trend of loss of sea ice in the Beaufort and Chukchi Seas of 11% is recorded. Climate modellers predict that long-term global warming will alter the pattern of cyclicity and behaviour of the AO, which could affect cetaceans. Tynan also noted that longer-term trends of decreased Arctic sea ice extent and increased temperatures 'sit on top of' the shorter-term oscillations in the Arctic. All of these mechanisms for sea ice variability could be contributing to variability in gray whale population dynamics.

Rowles noted that it is unlikely that gray whales spontaneously abort in the second and third trimesters in reaction to nutritional stress, as late term abortion in mammals poses a bio-medical risk. It seems unlikely that gray whales are using this strategy. Brownell noted that SC/54/BRG12 argued that when adult females are nutritionally stressed they may not ovulate. If it is true that ovulation does not occur when females are nutritionally or otherwise stressed, the correlation between access to food, termination of pregnancy and resulting calf production becomes unclear. Regarding the possibility of pregnancy termination, SC/54/BRG4 cites studies that demonstrate a link between adult female condition and the probability that existing pregnancies were carried to term in some pinnipeds. A key question is whether gray whales suppress ovulation, terminate pregnancy or loose calves following parturition. There are a number of reasons why emaciated whales might suppress ovulation. It is important to note that the shore-based calf counts are of the 'surviving' calves. As shown in SC/54/BRG16, estimates of calf production from the lagoons were lower than those from the northbound count in 1997-1999 and higher in 2000-2001. One explanation might be higher calf mortality in the latter two years.

Wade agreed that the correlation between the available feeding area while pregnant and calf estimates on the northbound migration could be due either to failure of the pregnancy or neonatal mortality prior to reaching central California.

Schweder noted that the authors assumed independence between annual calf counts. If the stock is close to carrying capacity, then correlation could occur between years because of density-dependent feedback. It is difficult to determine the significance and meaning of these correlations. Wade stated that even though estimates come from the same population, they can be considered independent samples.

Schweder further pointed out that a stock approaching carrying capacity would typically exhibit oscillations in the time series of calf counts. The series will therefore appear to show autocorrelation. The present oscillation in the trend invalidates the *p*-value when testing for correlations with another series such as the index of ice coverage of feeding grounds. Wade agreed that if a population were oscillating, this could lead to a possible problem in autocorrelation.

Urbán noted that in Laguna Ojo de Liebre, this model correlates well with the decrease in calf production in 1990 and the spectacular decrease in 1999-2001. The model prediction of calf production for 2002 is 349 to 703 and coincides with the visual count estimate of 670 for 2002.

Melnikov noted that the ice conditions in 1994 were similar to those in 1998 and that the geographical distribution of ice cover was an important factor to consider in the Chukchi Sea. When winds blow from the northeast there is a drift of ice to the west and southwest which closes up Long Strait and cuts off other feeding areas. Therefore, the ice conditions in the west and the east side of the Chukchi Sea are inversely related; when light ice conditions exist to the west, it is often heavier along the eastern shore.

SC/54/BRG6 documented the shore-based counts of southbound migrating Eastern North Pacific gray whales carried out by the National Marine Fisheries Service from 13 December 2000 to 5 March 2001, and from 12 December 2001 to 5 March 2002. Research protocol was essentially identical to that used in previous surveys and involved single observers independently searching for whales and recording data on effort and sighting time, location, count and direction-headed. In 2000/01, a total of 1,689 pods (2,754 whales) were counted during 592.6 hrs of standard watch

effort when visibility was recorded as fair to excellent. In 2001/02, there were 1,711 pods (2,800 whales) counted during 531.7 hrs. The southbound migration in 2000/01 was more protracted than ever before, with many whales still travelling south three weeks later than typical. However, in 2001/02, the migratory timing was normal, with the southbound migration ending in mid-February. Data analysis procedures were essentially the same as those used in previous years, although some correction factors are assumed to have remained unchanged between years because analytical programs are currently being revised. Accordingly, results presented are considered preliminary and are subject to change. The provisional abundance estimate from the 2000/01 census was 18,761 whales (CI = 15,429-22,812), and the 2001/02 provisional estimate was 17,414 whales (CI = 14,322-21,174). Both of these estimates are well below the previous (1997/98) estimate of 26,635 whales (CI = 21,878-32,427). These low estimates might have been caused by an unusual number of whales that did not migrate as far south as Granite Canyon in these seasons, or the abundance may have declined following the high mortality rates observed in 1999 and 2000. The high stranding rates in 1999 and 2000 appear to reflect an acute mortality event, not a chronic one.

Butterworth was concerned that the use of the Hermite polynomial fits ended up producing a dip in the tails and not a smooth curve as expected. He questioned if this polynomial was the best approach given the constraints that were needed to make the model 'fit' the data. If the curve were smoothed out it would increase the abundance estimate. He questioned to what extent these bumps are an artifact of the analysis method. He suggested that other methods be examined to model the sightings data.

Breiwick responded that there were often many effort periods in a single day that could not be shown clearly in a figure and that the model was fit to these data and not the daily sighting rates shown in the figure. He mentioned that the tails of the curve had to be fixed or the model would not converge. He noted that the tails typically account for about 3-4% of the abundance estimate.

Butterworth recommended that non-parametric models be considered even though he was not sure the results would change substantially. He also questioned if fewer sources of variability were accounted for in earlier estimates, such that the variance of estimates for all years was not comparable.

Breiwick noted that there were additional sources of variation in the 1995/96 and subsequent estimates; however, he had fit an unweighted, rather than a weighted, exponential curve to the abundance series. He also presented logistic equation fits to the series that corresponded better to the data.

Butterworth noted that a relative weighting method should be considered, given the influence of the last two abundance estimates. He also commented on the logistic regressions and asked if stranding data could be taken into account in a more complex model, given the increase in strandings during 1999 and 2000. He recommended that these data should be considered in conditioning the trials in the AWMP.

Zeh noted that these estimates are preliminary, that variance estimates will be revised, and that both the differences in the variance estimates and additional data (such as strandings) are best accounted for in the assessment model. Punt noted that the variances were dealt with correctly in the assessments.

Wade has considered introducing stranding data as a covariate of survival in a model. This would be a stochastic model with environmental variance in survival (what

modellers call process error). This cannot be extended too far back in time, but a simple model can be tested over a short term. He noted that there have been changes in abundance estimates as great as 21% in past years, so the present drop could be due in part to sampling error.

Givens noted that if some whales did not migrate as far south as the counting site, then a low population estimate with a small CV could result.

Brownell cautioned not to use carrying capacity as the 'scapegoat' for a possible decline, but to consider other explanations until the population dynamics are more fully understood. It is important to look at the character of the migration, such as southbound animals that do not migrate past the counting station (as alluded to in SC/54/BRG6). There are now more data on summer residents, but the time when these animals take up residency is not known. It would be useful to do a survey at the end of the southbound migration in these resident areas. Mortality during 1999 and 2000 likely had some impact on the estimates, but the low calf production could have a larger effect.

Ohsumi pointed out that as a population reaches carrying capacity, it will oscillate, and this corresponds to the observed pattern. He believed that the lower count was not a factor of missing the southbound whales. However, Borodin suggested that the differences in the estimates indicated changes in the size of the population that were too large to be biologically plausible.

Tynan observed that, from the point of view of a biological oceanographer, a strong environmental event such as the major El Niño of 1997/1998 could contribute to a change in population size. There is evidence of El Niños affecting latitudinal shifts and migratory pathways of many marine species. Ice dynamics (e.g. ice extent and coverage) on polar feeding grounds have been linked to El Niño-Southern Oscillation.

Aguilar noted that when there is an increase in sea temperature, the effect of pathogens can be magnified and this may explain some of the die-offs and strandings.

Borodin noted that there are other factors, in addition to carrying capacity limitations. Whales are not insects, and populations do not drop in such a short period of time, even when ENSO events and strandings are considered. He considered the 26,000 whale estimate to be an overestimate, and that populations will attain a natural equilibrium with the environment.

4.1.3 Assessment model results

A revised assessment of the eastern Pacific gray whale population was presented in SC/54/BRG7. Previous gray whale assessments were presented to the sub-committee in 1997, as papers SC/49/AS3 and SC/49/AS24 (based on methods subsequently published as Punt and Butterworth (2002) and Wade (2002), respectively). Those assessments were based on fitting population models to the time series of total population estimates from the survey on the southbound migration. Since those assessments were completed, new abundance estimates are available for three years (1997/98, 2000/01 and 2001/02). Additionally, there is now an eight-year time series of annual estimates of the number of calves passing central California (Piedras Blancas) during the northbound migration, data which had been used in only a preliminary way in Wade (1997). SC/54/BRG7 presented four analyses, one using only the population estimates, and three variants using both the population estimates and the calf production estimates: (1) using all the calf estimates; (2) using all the calf estimates less the estimates from 1980 and 1981 (in order to test sensitivity to use of the estimates from

Poole, 1984); (3) using all of the calf estimates as well as an assumed value of 1,100 for 2002 (in order to test sensitivity to an expected higher calf estimate in this year).

The model and statistical techniques were essentially the same as used in SC/49/AS24, including the use of an additional variance parameter, as recommended by model selection using the Bayes Factor (Wade, 2002). Over the four scenarios run, current carrying capacity (K) was estimated to be about 22,000, with 95% probability intervals between 19,000 and 35,000. The posterior distribution for K, the equilibrium population size (current carrying capacity) was more precise than in previous analyses (e.g. SC/49/AS24). The reason for the increased precision is the addition of three abundance surveys, four calf surveys, and the inclusion of the earlier calf estimates from Poole (1984).

The maximum population growth rate was estimated to be about 7-8%, with probability intervals from about 4-11%. The point estimates of current depletion level (N_{2002}/K) of the gray whale population were around 100% of K, so the population was estimated to currently be at K, although lower bounds of the intervals were as low as 71%. There was essentially zero probability that the population was currently below MSYL. It was noted that the use of the calf estimates did not substantially change the results, but made them more precise, particularly the estimates of K.

The quantities Q_0 and Q_1 have previously been recognised as the most appropriate quantities to use for management advice (IWC, 1998, p.94). Both Q_0 and Q_1 are zero if the stock size is estimated to be $< 0.1K$ and $0.9 MSY$ if the stock is estimated to be above MSYL. For stocks between $0.1K$ and MSYL, $Q_0 = \min(RY-1, 0.9 MSY)$ and $Q_1 = \min(MSYR \cdot P, 0.9 MSY)$, where RY is the estimated Replacement Yield, MSYR is the Maximum Sustainable Yield Rate and P is the estimated abundance (Wade and Givens, 1997).

The point estimates for Q_1 ranged from 605-669, with the lower 5th percentile of the posterior distributions ranging from 455-490. The point estimates for Q_0 were quite similar, which is not unexpected because Q_0 and Q_1 are identical for populations estimated to be above MSYL, which is the case here.

The model estimates that a density-dependent decline in fecundity occurred throughout the 1980s and 1990s, that the population had nearly levelled off by around 1990, and that average calf production should have levelled off by 2000. It was noted that the abundance estimates have been roughly stable since 1984. In the single analysis in which the model was not fit to the calf production data, the model still estimates a compensatory decline in fecundity occurred throughout the 1990s. This is consistent with the independent results of an analysis of the calf estimates themselves, which indicated a slow decline (SC/54/BRG4).

Higher mortality of gray whales in 1999 and 2000 (suggested by higher stranding rates) along with lower calf production from 1999 to 2001 could have led to a decline of gray whales in those years. Population estimates in 2000/01 and 2001/02 that were lower than estimates in most recent years are consistent with this idea. However, negative residuals in abundance estimates of this magnitude have been seen in earlier years in the gray whale time-series. It is impossible to determine how much of the drop in the estimates is due to a real decline in the population or is due to sampling error in the estimates.

Wade noted that calf production was low in the eastern Pacific gray whale population in 1999, 2000, and 2001, and it appears to be correlated with environmental conditions in

the Bering Sea (Perryman *et al.*, 2002). While this could be due solely to a dramatic environmental change, it could also be due in part to the population being close to carrying capacity. The higher number of gray whale strandings in 1999 and 2000, relative to previous and subsequent years, also contained a greater proportion of sub-adult and adult gray whales than usually seen. This suggests that survival rates of all age classes were likely lower in these years, along with the reduction in calf production. Taken together, these events could be indicative of a population near carrying capacity that experiences substantial nutritional stress during poor environmental conditions, which is translated into lower reproduction and higher mortality. Alternatively, the effects on the population could be solely due to environmental change. However, although these effects have been seen only in recent years, the conclusion in SC/54/BRG7 that the population is close to K is not due just to data collected since 1999, but is mainly due to the lack of increase in abundance estimates seen since 1984. In other words, this did not result just because of environmental conditions seen during 1999-2001.

In discussion, Punt questioned how it had been possible to prevent the population from substantially exceeding carrying capacity. Wade responded that his approach used a generalised-logistic function of fecundity similar to Breiwick *et al.* (1984). This allowed the fecundity to be turned off fast enough to prevent the population from overshooting.

Brownell commented that calf production in this model is actually the number of calves surviving for at least three months and wondered what the result would be of taking actual calf production into account. Wade responded that when the model was fit to the calf data, the fecundity term in the model accounted for the early calf survival as well. He also clarified that it was not just the past three years of calf production that appeared to be low, but rather a decreasing trend in the long term.

In SC/54/BRG10, assessments of this stock were performed using the standard BALEEN II model (Punt, 1999) and the inertia model developed by Witting (2000; 2001). The inertia model is a density-regulated model that uses between-generation changes in the heritable component of fecundity to induce additional density-dependence that is delayed one generation. The advantage of this model is that it reconciles abundance estimates with historical catches, which traditional assessment models cannot do without assumptions like an increase in carrying capacity. The results of the analyses based on the BALEEN II model are qualitatively and quantitatively very similar to those of SC/54/BRG7 although the results are not identical owing to slight differences in the model formulation, the choice of the model parameters, and the data included in the likelihood function. The analyses based on the inertia model do not lead to predictions of substantial future declines in abundance at levels of catch similar to current harvests, unlike the previous application of this model to the data for the gray whales (Witting, 2001). This is attributable to several factors, including: inclusion of the pre-1930 historical aboriginal catches; use of a sex-structured population dynamics model; use of a Bayesian approach to update the prior distributions for the biological parameters of the model; and allowance for additional variance in the likelihood function. Analyses based on the standard BALEEN II model fit the calf count data better than the inertia model and indicate a population at its (current) equilibrium level and that the current catches are sustainable.

There was considerable discussion on the degree to which each of the models fit available data on calf production. Wade noted that the BALEEN II model achieved a better fit because the term CV_{add} on the calf production had a prior distribution with a fixed upper bound that was too low. Punt agreed the upper bound in his analysis was close to the centre of the distribution in Wade's analysis. Givens cautioned against specific interpretation of the fits to calf data, mentioning that it could also be argued that the smooth fit of the inertia model fit the calf data better than the 'bumpy' fit of the BALEEN II model. Punt agreed, noting that a key issue will be whether there is observation error or process error in the abundance estimates and that will determine how the data are weighted.

Schweder noted that both models take a Bayesian approach with the same priors and wondered if either had done sensitivity analyses on the use of other priors. Punt responded that he had chosen the same priors as in the 1997 assessment in order to maintain consistency and to span the likely range indicated by the data.

Punt commented that the replacement yield is different in the two models because his model allowed the population to go over carrying capacity more frequently. Schweder wondered how there could be substantial replacement yield when the population was thought to be at carrying capacity. Punt noted the age structure of the population has not necessarily stabilised at carrying capacity. One can have positive or negative replacement yields both under and over the carrying capacity until the stabilisation occurs.

The inertia model was also used to explore the sensitivity of time-trajectories of total (1+) population size to future catches at, below and above existing limits (Appendix 2). Based on this work, the population was predicted to decline from a maximum in 2010, even in the absence of future catches. The extent of decline increased with increasing catches and, for a constant catch of 475, there was a greater than 5% chance of resource extirpation by 2080. Nevertheless, a constant catch of 475 animals will maintain the population above the equilibrium level with high probability until about 2030. For catches at twice the current catch level, there was apparently zero chance of resource extirpation by 2100.

Although the mechanisms of selection and inheritance in the inertia model are just as plausible as those of direct density regulation, it was noted in last year's sub-committee report that some members doubted the biological reality of the model as applied to large whales. Given the lack of evidence presented for or against the biological mechanisms assumed in the inertia model, it was unclear how to weigh the inertia model results. The sub-committee **agreed** to seek management advice in quantities such as Q_0 and Q_1 , and to check that advice for model uncertainty against the inertia model that uses exponential functions and a catch history starting in 1600. Without commenting further on the plausibility of the inertia model governing gray whale population dynamics, the sub-committee noted that the model results (Appendix 2) did not give cause to modify management advice from the BALEEN II or similar models.

The sub-committee **recommends** additional research to investigate the observed changes and differences in the counts of gray whales, particularly gray whale calves observed in the breeding lagoons and along their migration routes (Appendix 3, table 1), and to better understand the factors that are influencing the productivity of this population. Specific recommendations are listed in Appendix 3. It further **recommends** that an intersessional

Workshop be convened before the 55th meeting of the Scientific Committee to bring together the most recent and historical data with which to examine process error in gray whale abundance, including: mother/calf counts, pregnancy rates in catch data and seasonal distribution at the end of the southbound census. This Workshop should also review relative habitat information (e.g. prey base) for examination and analysis relevant to the dynamics of the population.

4.1.4 Management advice

The sub-committee noted that the assessments in SC/54/BRG7 and SC/54/BRG10 (using the BALEEN II model) used similar methods and yielded similar results, though they differed in some details, such as the behaviour of each model close to its unexploited equilibrium level. Table 1 shows estimates and probability intervals from each method for several biological and management-related quantities. Table 2 shows estimates from SC/54/BRG7 compared to estimates from the previous assessment in Wade (1997). The sub-committee **agreed** that management advice could be formulated on the basis of the results from the approaches in SC/54/BRG7 and SC/54/BRG10. Both assessments indicated the population was above MSYL, and may be close to or above its unexploited equilibrium level (K).

In the previous assessment, the Committee **agreed** that management quantities such as Q_0 and Q_1 were more appropriate for management advice than RY for populations thought to be above MSYL. As the Committee previously noted, RY approaches zero for populations approaching K. However, Q_0 and Q_1 are identical for populations exceeding

MSYL, and the sub-committee **agreed** to use Q_1 to provide management advice for the eastern Pacific gray whale. The lower 5th percentiles for estimates of Q_1 in SC/54/BRG7 and SC/54/BRG10 were 482 and 475, respectively, using the methods of the last assessment. When the estimates of calf production were additionally used, the lower 5th percentiles for estimates of Q_1 were 466 and 463, respectively.

The last full assessment of this stock was in 1997 (IWC, 1998, pp.92-94), and substantial new information has become available since then. The estimates of Q_1 are very similar to the estimates from the previous assessment (Table 2, e.g. the lower 5th percentile from Wade (1997) was 472 compared to 482 from the new assessment). Based on data and analyses examined this year, the sub-committee **agreed** that a take of up to 463 whales per year (the lower of the 5th percentiles of Q_1) is sustainable for at least the medium term (~30 years), and is likely to allow the population to remain above MSYL.

4.2 Western North Pacific stock of gray whales

Subjected to intensive commercial whaling in the 19th and 20th centuries, the Western North Pacific gray whale population currently exists in small numbers and is considered to be one of the world's most endangered populations of large whales (Weller *et al.*, 2002). Since 1995, joint USA-Russia ongoing studies of western gray whales off northeastern Sakhalin Island, Russia (the 'Piltun Feeding Ground') have resulted in a photographic dataset that can be used for mark-recapture survival estimation. In SC/54/BRG9, Pollock's robust design model with Huggins' closed capture estimator was used with 19 monthly capture

Table 1
Comparison of results (medians and 90% probability intervals) based on priors and methods used in SC/54/BRG7 and SC/54/BRG10.

Quantity	SC/54/BRG10 No calf data	SC/54/BRG7 No calf data	SC/54/BRG10 Calf data used as absolute	SC/54/BRG7 Calf data used as absolute
MSYR	4.4 (3.0, 5.5)	5.1 (3.0, 6.7)	4.2 (3.5, 5.1)	4.7 (3.4, 6.1)
MSYL	0.85 (0.61, 1.09)	0.66 (0.53, 0.78)	0.80 (0.61, 0.92)	0.62 (0.52, 0.78)
K	19,058 (15,920, 29,794)	21,740 (19,480, 35,430)	19,292 (17,471, 22,653)	22,610 (19,830, 28,470)
N_{2002}/K	104 (80, 120)	100 (71, 102)	108 (98, 117)	99 (84, 101)
$N_{2002}/MSYL$	122 (95, 158)	148 (124, 174)	138 (116, 165)	158 (128, 175)
Q_1	626 (475, 824)	669 (482, 883)	568 (466, 669)	608 (463, 794)

Table 2
Comparison of results of the new assessment in SC/54/BRG7 with results from a previous assessment, SC/49/AS24.

Quantity	SC/49/AS24 No calf estimates	SC/54/BRG7 No calf estimates
MSYR	3.4 (2.3, 5.9)	5.1 (3.0, 6.7)
MSYL	0.62 (0.51, 0.78)	0.65 (0.53, 0.78)
K	34,090 (20,360, 74,250)	21,740 (19,480, 35,430)
$N_{current}/K$	72 (34, 101)	100 (71, 102)
$N_{current}/MSYL$	121 (53, 160)	148 (124, 174)
Q_1	642 (472, 898)	669 (482, 883)

occasions from 1997-2001. This model has the desirable property that it separates the estimation of capture probability (using re-sights within a year) from the estimation of survival (using re-sights between years). Constant non-calf and calf survival and a constant or time-varying random emigration model were assumed. The effects of various combinations of time, survey effort, and an individual residency covariate were examined in models of capture probability. The *residency* covariate was designed to reduce heterogeneity in capture probability caused by potential differences in whale behaviour, such as if some whales use the study area for most of the feeding season while other whales use the study area temporarily before moving on to other locations. Using AICc model selection, models incorporating individual heterogeneity in residency patterns provided better fits to the data. Non-calf and calf survival were estimated as 0.941 (SE = 0.0194, 95% CI = 0.890-0.970) and 0.389 (SE = 0.1255, 95% CI = 0.185-0.642), respectively, averaging across the best models ($n = 4$) in order to account for model uncertainty. The non-calf survival point estimate is lower than an indirect estimate from the eastern population, but the level of uncertainty in that estimate makes direct inter-population comparisons premature at this time. The calf survival estimate is much lower than a 'reasonable' calf survival estimate suggested for Gulf of Maine humpback whales. However, few large whale calf survival estimates exist for comparison. Estimation of survival is critical for assessing the status of western gray whales, which is necessary for the increased protection, conservation and management planning of this critically endangered population.

The sub-committee was particularly interested in the use of an individual residency covariate in this analysis and suggested that others might also consider this approach. Ohsumi asked whether a population could be maintained with such low survival rates. Wade responded that he hadn't explored that issue thoroughly yet and that he would not want to make a strong statement either way. He agreed that it was worth pursuing further. It was noted that the survival rate in the paper was from approximately six months to 1.5 years.

Swartz commented on evidence in eastern North Pacific gray whales that juvenile immature whales may not undertake a full migration until they become sexually mature. In the eastern North Pacific, strandings of juvenile whales predominate along the migration route during all months of the year, and there is evidence that some summer 'residents' that do not migrate to the summer feeding grounds are often smaller presumably immature animals. If juveniles in the western population do not make full migrations until they are older, they may not be re-sighted on the summer feeding grounds where they were photographed as calves. They may also be exposed to environmental threats elsewhere within the range of the species (i.e. entanglement in commercial fishing gear, ship strikes, harassment disturbance, accidental harvest, etc.). In this regard, Swartz noted the importance for all range states to make an effort to report sightings of western gray whales throughout their presumed range, and to make special efforts to provide them with protection to ensure their successful recruitment into this very small and endangered population.

The sub-committee noted that a skeleton of a young gray whale was discovered on the eastern coast of Kyushu (Miyazaki Prefecture) in March 2002. This whale could be one of the 'missing' yearling gray whales reported in SC/54/BRG9. Therefore, the sub-committee **strongly**

recommends that efforts be made to extract DNA from the Miyazaki specimen and that microsatellites of that animal be compared to all 'missing' yearlings from the Piltun feeding ground. The sub-committee also **recommends** that details on the stranding of the Miyazaki specimen be presented to the Committee next year.

Recent photo-identification data collected on the Piltun Feeding Ground indicate that most reproductive females follow a three-year inter-birth interval (SC/54/BRG12). This pattern deviates from the commonly observed two-year interval in other whale species, including eastern gray whales. The three-year calving interval observed in western gray whales is hypothesised to be due to nutritional stress, and compounded by ongoing anthropogenic disturbance while on the feeding ground. If western gray whales have increased their calving interval from two years, as typically reported for eastern gray whales, to three years, the change will decrease overall calf production by at least 20%. This change, if persistent, will have a major impact on the potential of the population to recover from its depleted state. The annual return of reproductive females while pregnant, resting and lactating indicates that this feeding ground is of significant importance to the continued survival of this population. Therefore, it is critical that these whales feed in this area without anthropogenic disturbances.

SC/54/BRG14 presented evidence of behavioural disturbance from seismic surveys on the Piltun Feeding Ground. During summer 2001, high-intensity seismic surveys were conducted in this area during a six-week period. To test the hypothesis that the distribution of gray whales on the feeding ground would shift away from nearby seismic surveying occurring to the north, the number of whales and number of pods (dependent variables) sighted during systematic scans in relation to three independent variables (i.e. pre-seismic, seismic, post-seismic) were examined. Results indicate that significantly more whales and more pods were in the scan area during the seismic condition than during the pre- and post-seismic periods. These findings suggest that whales shifted their distribution into the scan area (i.e. from north to south) and away from the region where seismic surveys were conducted between 1 August and 8 September. Once the seismic surveys had ceased on 9 September, overall whale and pod numbers in the scan area returned to pre-seismic levels, suggesting that whales had reoccupied the region from which they had been displaced. The western gray whale population is critically endangered and depends on the Piltun Feeding Ground for the majority of its annual food intake. Disruption of feeding due to anthropogenic disturbance, as detailed here, is a biologically significant event that could have major negative effects on individual whales and the population as a whole, especially those observed to be 'skinny'. Half of the adult females with calves have been recorded as 'skinny' over the past three years.

Members of the sub-committee commended the authors on their efforts, and particularly on the design of the project. Based on the evidence presented, it appeared that a causal link could be established between seismic activity and short-term shifts in animal distribution. Best questioned whether the results might reflect a seasonal change in the distribution patterns of these animals. While no specific analyses had been done, both Weller and Brownell considered this to be unlikely in light of their data from the previous four years.

The sub-committee discussed the magnitude of the displacement and its potential relationship to the poor nutritional health of this population. Limited behavioural

observations suggested that the animals continued to feed during displacement. However, the concern was that feeding was limited to sub-optimal habitats during seismic activities. While there is not a great deal of information on the availability of prey, past Russian surveys suggest that the benthic biomass in the general seismic survey area is higher than elsewhere on the Sakhalin Shelf (Koblikov, 1986). The shift observed (20-25km) is comparable to what has been observed for bowhead whales exposed to seismic and other industrial noise in the Beaufort Sea; however, the disturbance is of greater potential concern in this case because it takes place across such a large portion of the feeding season. Brownell noted that seismic disturbance was unlikely to be the primary cause of poor health in this population, given that a similar situation is also occurring in the eastern North Pacific population. However, if displacement results in reduced foraging opportunities, then seismic activities have the potential to aggravate the existing 'skinny' whale situation and to further negatively impact a population that is already under stress.

Borodin referred the sub-committee to the results of a Russian sightings survey in the Sea of Okhotsk that corresponded with the post-seismic period of the SC/54/BRG14 study (Appendix 4). Forty-one gray whales were observed off the northeast coast of Sakhalin Island and Borodin noted that none appeared to be 'skinny'. Brownell responded that 'skinny' animals would have been difficult to discern from a large survey vessel. Details of these sightings (number of pods, locations, etc.) were not provided and the sub-committee urged that a more detailed report on this survey be presented to the Committee next year.

Zeh recalled the recommendation of the Committee last year that no seismic work be conducted while whales are present on their feeding ground. Brownell noted that as a result of the IWC Resolution 2001-3 (IWC, 2002a, p.55), the Russian government was able to get the seismic work stopped last summer. C. Clark commented that this paper provides empirical evidence in strong support of the sub-committee's initial concerns (IWC, 2002b, p.182) that seismic activities can have a major impact on gray whales. He also noted that last year the sub-committee recommended acoustic monitoring and behavioural observations be conducted to examine noise-related disturbance of these whales and emphasised that this recommendation should be implemented.

In SC/54/BRG13, photographs of gray whales from several geographic locations in the Okhotsk Sea and western North Pacific were compared to a catalogue of 106 western gray whales identified between 1994 and 2001 on the Piltun Feeding Ground. Photographic recaptures of whales from areas within the Okhotsk Sea were made to the catalogue of known individuals from the Piltun Feeding Ground, but no such recaptures were found for comparisons with the western North Pacific. Recaptures of whales photographed in other regions emphasise: (1) the small size of the population; and (2) the value of coordinated photographic matching of gray whale images, particularly those collected in areas within the known distribution of western gray whales, as a means of providing information to better understand the range and movements of this critically endangered population. Thus, range wide coordination in matching photographs, comparing sightings data and, when possible, tissue samples (for DNA matching) are vital to providing increased protection for the western gray whale population.

Two sightings surveys are scheduled within the range of the western gray whale during 2002. SC/54/RMP21 described plans for surveying along the eastern side of the

Korean Peninsula in May and SC/54/RMP9 along the eastern coast of Sakhalin Island in August-September 2002. As shown in SC/54/BRG13, valuable information on western gray whale movements can be obtained from any new photographs as most whales in the population have now been identified on the Piltun Feeding Ground. Therefore, the committee **strongly recommends** that every effort be made to photograph, following protocols outlined in SC/54/BRG13, any gray whales sighted during the aforementioned surveys in 2002. Swartz emphasised the importance photo-id research for learning more about the movements of these whales and monitoring their status.

As in previous years, the sub-committee **strongly recommended** that the ongoing (1995-2001) USA-Russia western gray whale research and monitoring programme, and national programmes, be continued and expanded into the future. It is a matter of **absolute urgency** that this research programme be continued, as it is currently the only means for assessing the status of this critically endangered population. The basic research methods being used to monitor the population (vessel-based photo-identification work, shore-based distribution and behavioural observations, and biopsy sampling) must be continued annually. The photo-id programme is an excellent way to monitor the status of this population. Genetic sampling needs to be continued in order to validate long-term individual identifications, determine sex and examine the relatedness of individuals. Additional actions are needed to ensure: (1) adequate and stable funding for the continuation of the current research and monitoring programme; (2) establishment of more effective range-wide monitoring and protection measures; (3) increased cooperation between science, industry and government.

Additional research **recommended** by the sub-committee includes: (1) benthic sampling and prey resource assessment (i.e. prey base evaluation) in known foraging locations and in areas outside of the feeding ground; (2) simultaneous theodolite-based behavioural observations and acoustic monitoring of industry-related noise to examine possible disturbance; (3) satellite and radio telemetry work to determine movements on the feeding ground, migration pathway(s) and location of the wintering grounds (tag design and attachment protocols, however, should first be assessed on eastern gray whales to evaluate safety and effectiveness); and (4) obtain DNA and photos to match to existing catalogues of such materials of any stranded or living animals.

The sub-committee noted that at previous meetings, the Committee had **recommended** that the Commission arrange to bring together scientists from countries with an interest in, or within the range of, this stock and consider measures required to maximise the chances of its recovery. The sub-committee wished to further support this recommendation and to encourage a meeting of scientists to discuss the current status of the western gray whale population, develop the foundation for range-wide research on the population, and update the 10-year research and monitoring plan presented to the Committee in 1999 (Appendix 5).

Research in Chinese coastal waters is of particular importance, as this region is suspected to be the wintering grounds (i.e. calving and breeding) for the western population and is therefore critical to its survival and recovery. The sub-committee **recommends** that ground searches in combination with local knowledge interviews be used to determine gray whale locations within the wintering grounds and that photo-identification and biopsy sampling

be implemented where possible. It is suggested that research protocols and methods follow those developed during the USA-Russia studies off Sakhalin Island. Comparisons of photographs and DNA collected from China and elsewhere to similar materials already catalogued from Sakhalin Island will provide important new information on the population. Ohsumi suggested the possibility of holding an international meeting to plan research on the wintering grounds.

The sub-committee also **recommended** continuation and further development of comparative studies between the western and eastern gray whale populations to better understand the health of individual whales in both populations.

Sufficient data exist to demonstrate that baleen whales, in particular bowhead and gray whales, are very sensitive to industrial noise, especially from seismic surveys (Malme *et al.*, 1988; Richardson, 1998). Therefore, it is important to reduce anthropogenic disturbance to the lowest possible level. The sub-committee took special note of the seismic surveys conducted on the gray whale feeding ground off Sakhalin Island during August-September 2001 and the shift in whale distribution related to this source of disturbance. Brownell noted that as a result of the IWC Resolution 2001-3 (IWC, 2002a, p.55) the Russian government was able to stop the seismic work last summer. The sub-committee commended this action. However, additional seismic work is planned for 2002, 2003 and the future. Therefore, the sub-committee again strongly **recommended** that no seismic work be conducted on or near the Piltun Feeding Ground while whales are present because: (1) gray whales in this area have shown strong avoidance responses to seismic survey activities and were displaced from important feeding habitat; (2) this region is the only known feeding ground for the population and is therefore critical to the continued survival of the population; (3) 'skinny' whales, including many reproductive females with calves, have been observed in the area between 1999 and 2001 and require maximum food intake during the summer feeding season; (4) the cumulative impacts of seismic operations on the health and survival of these whales, especially 'skinny' animals, are unknown and of concern.

During the summer of 2001, the oil and gas industry conducted a number of research activities related to these whales and the sub-committee strongly urges that these studies and associated findings be presented to the Scientific Committee for review at the earliest possible date. Furthermore, the sub-committee **recommends** that all future monitoring and mitigation plans for seismic surveys and other activities (e.g. planned construction of piers and pipelines bisecting the feeding ground and migratory corridor) related to Sakhalin oil and gas development be reviewed by an independent panel of outside experts that are not directly funded by the operators working in the area.

The sub-committee noted that it is a matter of **absolute urgency** that every effort be made to reduce anthropogenic mortality (including direct catches) and disturbance to zero.

5. RIGHT WHALES

5.1 North Atlantic right whales

Clapham reported on progress regarding recommendations from past IWC meetings and workshops concerning North Atlantic right whales (Appendix 6). A proposed workshop on right whale genetics has not been conducted, and for logistical and other reasons is unlikely to be convened in the near future. However, progress has been made on genetic

studies, notably in analysis of historical specimens. Analysis of mtDNA extracted from bone from the 16th century Basque fishery at Red Bay, Labrador has been undertaken by Brad White and colleagues at Trent University; this has shown that the majority of 'right whales' previously identified by bone (Cumbaa, 1986) were actually bowheads. The one right whale in the sample represented a haplotype that was not among the five known from the modern population, providing tentative support for the belief that the majority of genetic variation was lost during major periods of exploitation prior to the 20th century. However, this cannot be evaluated until the results are published and additional specimens from that period are analysed.

Rosenbaum described on-going work to compare historic specimens from the eastern North Atlantic (from the Bay of Biscay to Iceland) with genetic variation (historical and extant) in the western North Atlantic population. Some initial encouraging results were presented in Rosenbaum *et al.* (2000). It is hoped that this work can be expanded to include eastern North Atlantic right whale specimens that are currently housed at European institutions. The sub-committee strongly **recommends** that European institutions holding North Atlantic right whale specimens grant access to these samples for genetic analysis. The sub-committee looks forward to receiving results concerning genetic diversity and stock structure on right whales on both sides of the North Atlantic Ocean.

Biopsy sampling continues in the modern population, with some samples obtained from the calving grounds in the southeastern USA in 2002.

Two seasons of aerial photogrammetry work in the Bay of Fundy have been conducted by the US National Marine Fisheries Service, and have yielded a large sample of data on length of identified individual right whales; these data will be tied to information on sex, age and reproductive condition as obtained from sighting histories. An extensive study of the reproductive biology of this population has also been conducted in the last year at the New England Aquarium; this includes work on reproductive endocrinology (investigated successfully through faecal steroid hormone analysis), toxicology and scarification. A feasibility study on stress analysis (Southwest Fisheries Science Center, La Jolla) has proved useful in that animals of known health state (entangled, dead or apparently healthy) showed significantly different levels of stress in analysis of biopsy samples. Body condition studies using ultrasound have continued and a useful comparative study was conducted on southern right whales.

Studies of previously satellite-tagged right whales have shown no apparent impact of the tags on these animals; observations of these individuals will continue over the next few years. There are no plans for satellite tagging this year, although a test of a modified tag design has been conducted on southern right whales in 2001. Results from this work will be published in due course. In response to a query, Clapham noted that he was not aware of any progress on efforts to use harvested bowhead whale carcasses to assess injury from satellite tagging (recommended by the Committee in 2001).

Right whales continue to die or become seriously injured by entanglements in fishing gear or ship collisions, and this remains the highest priority in the US government's management of this species. Areas which are characterised by predictable concentrations of feeding right whales have been subject to seasonal area closures to fishing gear; other areas, in which right whales occur less predictably, are closed if sightings exceed a trigger density. A workshop to

discuss possible modifications to fishing gear that would reduce the risk of entanglement while allowing fishing to continue is being planned for the near future. Gear modification is widely seen as the ultimate solution to the entanglement problem; in the meantime, disentanglement programmes continue.

A document summarising management options to address the serious problem of ship strikes of right whales has been produced and is currently under detailed review by the US government. Options include speed reductions, shipping lane changes and a variety of technological measures (the efficacy of which remains untested). A proposal to move a shipping lane in the Bay of Fundy has been prepared by the Canadian government and has been submitted to the International Maritime Organisation (IMO). Aerial surveys continue to be flown regularly in major shipping areas to warn mariners of the presence of right whales.

Research to monitor vital rates in this population continues, and funding support for the North Atlantic Right Whale Catalogue and its associated database remains a priority for the US government.

5.2 North Pacific right whales

The sub-committee received two reports of North Pacific right whale sightings over the past year. Brownell reported sightings of five right whales during aerial surveys in the southeastern Bering Sea in 2001 (13-23 July). Surveys covered approximately 2,000 n.miles on effort, following methods described in LeDuc *et al.* (2001). In addition, three right whales, in two groups, were sighted in the western North Pacific during JARPN II surveys (SC/54/O16).

With regard to upcoming work, Brownell noted that vessel and aerial surveys for North Pacific right whales will be performed in the southeast Bering Sea between 7 July and 3 September 2002. It is anticipated that some additional survey effort will take place off of the Kodiak Archipelago. Satellite tagging may be attempted.

Tynan requested that the sub-committee recommend that nations support additional survey effort for North Pacific right whales.

5.3 Southern right whales

SC/54/BRG8 presented evidence of a summer right whale feeding ground on the west coast of South Africa. The current understanding of right whale seasonality on the South African coast is that it is normally distributed between April/June and December/January, with a peak in September/October, and very low numbers over the period January to April. Most of the data in support of this come from the south coast of South Africa, between Cape Town and Port Elizabeth. However when pelagic whalers from the USA and France first arrived on the South African coast in the late 18th century, they operated mainly between the months of late October/December and April/June, or completely outside the currently 'understood' season. These vessels operated on the west coast, however, north of Cape Town, where catches were substantial, on the order of 300-600 whales in a single season. These catches were centred round St Helena Bay, a major embayment on the west coast.

Recent incidental observations in the St Helena Bay region resulted in 26 sightings of 54 right whales between February and April, or in summer. Five episodes of feeding (or presumed feeding) behaviour were also witnessed, all of which seemed to be directed at copepods. Four cow-calf

pairs seen had been photo-identified about four months earlier on the south coast, and so had moved onto the west coast in summer. In a cooperative programme with Bruce Mate of Oregon State University, 21 right whales were satellite-tagged on the South African coast in September 2001. The results from this experiment will be reported fully next year, but only the results from three individuals were considered in the paper. These three whales all moved into St Helena Bay between late September and mid-October, one from the south coast and the other two from Saldanha Bay on the west coast. One animal's tag ceased transmitting after it had been in the bay for 36 days, but the other two tags continued transmitting until the whales left the bay after 48 and 100 days, giving a minimum average residence time of 61 days. During this period the whales did not utilise the whole bay but were highly concentrated in an ellipse about 15 n.miles by 10 n.miles, in a north-east bearing from Stompneuspunt. This ellipse corresponds almost exactly with an upwelling plume that extends northeastwards from Cape Columbine in summer. Such a summer feeding ground in coastal waters has not been recorded previously in the Southern Hemisphere, and provides unique opportunities for a study of southern right whale feeding behaviour.

SC/54/O18 described sightings of 22 southern right whales (comprising 15 schools) in Antarctic waters between 29 November 2001 and 9 March 2002. The vast majority of the individuals ($n = 18$) were sighted in the southern stratum of Area IV (west sector). Only two right whales were sighted in Area III.

Rosenbaum *et al.* (2001) described two sightings of right whales off the east coast of Madagascar. These sightings totalled three animals: one in Antongil Bay in the northeastern coast and the other of a mother and calf pair near Fort Dauphin on the southeastern coast. While there are detailed records of historical and recent whaling off southern Africa, historical catches in Madagascar's waters have been poorly documented. Richards and Du Pasquier (1989) stated that two ships took 29 right whales in 1789 while cruising off Madagascar and at anchor in Delagoa Bay (currently known as Maputo Bay and surrounding waters of Mozambique), though no indication is given as to how many whales were taken at each site.

There are no historical records showing calving of right whales along the coast of Madagascar. There are two possible explanations for right whale occurrence off the east coast. The individuals documented off Madagascar may represent long-distance migrants from the well-documented South African population. These southern right whales may alternatively be members of a small or remnant population from the Crozet Island feeding grounds. Whales from the Crozet grounds were intensely exploited during two different periods of exploitation: at least 1,000 in 1841-45 (Richards, 1990) and about 300 in 1962-1968 during the illegal Soviet expeditions. No historical whaling records suggest northern calving areas for animals found in the austral summer on the Crozet whaling grounds. The Crozet grounds (40-52°E) lie nearly 2,300km directly south of southern Madagascar and 3,400km south of Antongil Bay, and may serve or have once served as wintering grounds for this population. Regardless, it appears that some southern right whales may be using different parts of Madagascar's eastern coast during the wintering season between July and November.

The sub-committee recognised the potential importance of these areas off Madagascar for the small population of southern right whales, and strongly encourages that these investigations continue.

6. BOWHEAD WHALES

6.1 Bering-Chukchi-Beaufort Seas stock of bowhead whales

6.1.1 New scientific information

SC/54/BRG5 described the results of a bowhead whale census conducted near Barrow, Alaska from 5 April to 7 June 2001. The first whale was seen on 15 April and reports from hunters and a late season aerial survey indicated that some whales continued to pass Barrow after the census had ended. Observers recorded a total of 3,295 'new' (not seen before) and 532 'conditional' (possibly seen before) bowhead whale sightings during 1,130 hours of watch effort. Only half of the watch period (572 hrs) was scored as 'fair-excellent' visibility, compared to 74% in 1993. Persistent sea ice in the leads and fog were the principal environmental factors affecting visibility. The prior two census attempts (1999 and 2000) failed due to unstable ice and closed leads, respectively. The number of calves counted in 2001 ($n = 121$) was nearly double the 1993 count ($n = 66$) and the highest ever recorded. High calf production is considered an indicator that a balaenid stock is on a high nutritional plane. The 121 new calves seen comprised 3.7% of the new whales counted, and six conditional calves were also seen. Passive acoustic surveillance was also conducted for 1,084 hours, resulting in 30,934 'usable' locations of vocalising bowhead whales.

The estimated number of whales within 4km of the perch was 8,637 (SE = 1,019). The preliminary estimate of the proportion of whales within 4km of the perch was 0.876 (SE = 0.033). Combining these, the preliminary abundance estimate for 2001 was 9,860 (SE = 1,222; 95% CI = 7,700-12,600). Generalised least squares were used to estimate rate of increase (ROI), taking into account the correlations among the pre-2000 abundance estimates given by Punt and Butterworth (1999). The estimated annual ROI from 1978 to 2001 was 3.3% (95% CI 2%, 4.7%). This was almost the same as ROI estimated from 1978-1993 data (3.2%), but the addition of the 2001 estimate improved the precision. While the N_4 portion of the estimate will not change, further acoustic data and analysis may change the P_4 and variance estimates. Therefore, estimates of abundance and rate of increase should be considered preliminary, but are not expected to change substantially.

Ohsumi asked whether the calculation of ROI took removals from the hunt into account. Zeh replied that they had not attempted to reflect the reduction due to the harvest, but that it would be accounted for in the assessment.

M. Taylor expressed concern that global warming and the corresponding loss of sea ice could limit census activities in this area in the future. George agreed, noting that the 1999 census was cancelled late in the season because of thin ice and unsafe working conditions. Zeh noted that bowhead abundance had already been successfully estimated from photo-identification data using capture-recapture techniques (da Silva *et al.*, 2000), and aerial surveys to collect photographs would still be possible even if ice conditions prevented successful ice-based censuses. The sub-committee encouraged further photo-identification surveys near Point Barrow during the spring migration.

M. Taylor asked whether cycles related to synchronous ovulation and pregnancy might be a factor in the high calf count observed in 2001. The sub-committee discussed the possibility of a correlation between synchronous ovulation and pregnancy in females and low sea ice density. Greater feeding area availability, leading to better body condition of

females may partially explain the variable recruitment noted over past surveys. Brownell referred to SC/54/BRG12, noting that nutritional condition is an important factor in the reproductive capacity of females.

SC/54/BRG5 noted that it appeared to observers that whales moved further offshore in response to hunting. M. Taylor asked how this might have affected the number of whales passing within the 4km of the perch. George noted that no specific analysis had been done and so it was not clear whether a 'hunting effect' was significantly influencing the estimate. He also noted that vocalisations often pause after a strike. M. Taylor suggested that 'hunting effect' might be used as a covariate in future analyses.

It was noted that the Bayes empirical Bayes (BEB) estimate to be computed from the 2001 data will use the combined visual and acoustic data to estimate detection probabilities. In response to requests from the Scientific Committee in past years, analyses have been carried out to show that the same whales can be recorded visually and acoustically.

SC/54/BRG18 reported on the acoustic survey performed as part of the bowhead census off Point Barrow in 2001. The basic methods used to record and analyse array recordings were the same as in previous years. Arrays were operational for almost 45 days out of the entire 46-day period from 15 April through 31 May. *In situ* calibration of the visual and acoustic methods was conducted. Differences in bearings between visual and acoustic positions were always less than a degree, independent of range or bearing to a calibration site. Visual-acoustic range differences were on the order of 0.1-15%, while acoustic range errors were 5-9% of the visual range. There was a slight but consistent bias for acoustic range to underestimate theodolite range.

Analysis of 757 out of 1,044 hours of acoustic array data resulted in the detection of over 73,000 bowhead sounds and 26,606 reliable locations. Of these 13,622 were used to calculate the offshore distribution of vocal animals throughout the season. These results indicate that the majority (88%) of vocal whales were within 4km of the perch. This is slightly less than in 1993 (93%), a year with exceptionally good ice, visibility and acoustic conditions. The extent to which environmental conditions (e.g. ice coverage and current) influence the migration has implications for population assessment. From the acoustic analysis there were clues of environmental conditions influencing the migration on the time scale of days and spatial scale of kilometres.

C. Clark further noted that this represents the first time that acoustic data for an entire season set have been processed. This has implications for the final population assessment for 2001, as there will be very little uncertainty due to periods without acoustic locations. It will also provide a basis, independent of visual observations, for detecting and correcting for periods when environmental conditions modify whale distribution and rate of passage.

There was considerable discussion on the issue of visual validation of acoustic data. Bowhead whales are not known to have individually specific vocal signatures. However, an individual animal will produce a sequence of nearly identical calls. The locations of the whale when it produces these calls can then be used to track the animal as it migrates through the census area (Clark, 1989). Tracking individuals acoustically is therefore a matter of interpretation and must be done with great care. However, C. Clark commented that this is also the case in visual surveys since observers rely upon some of the same cues, such as consistency in the direction and speed of travel, to track an individual based on surfacings. Zeh

explained the BEB estimates calculated next year will account for errors in linking sounds with whales that are seen.

SC/54/BRG15 presented the results of the shore-based counts of bowhead whales along the Chukotka Peninsula, Russia between 1999 and 2001. The purpose of this work was to determine the number of whales migrating along the western shore of the Bering Sea where they were likely missed by counts from Point Barrow, Alaska. In spring 2001, 149 bowhead whales were counted, which is similar to the results from 1999 ($n = 115$) and 2000 ($n = 162$). Although the onset of migration can vary by as many as 30 days, it generally ends around 20 June. Taking into account that the whales passed by quickly and at great distances from the observation perch, the authors speculated that as many as 1,000 whales may have migrated through the Western Bering Strait between mid-May and mid-June. Many of these whales could not have been counted at Point Barrow before the end of the census. Thus, the animals observed in Chukotka were not included in the bowhead population estimate from Point Barrow.

In response to a query, Melnikov commented that he did not believe these to be a separate stock from the animals migrating past Point Barrow. Rather, he believed that these animals remain longer in the Gulf of Anadyr, taking advantage of the rich euphausiid concentrations in the spring.

SC/54/BRG19 investigated the possible differences in the phylogenetic and morphometric characteristics of an apparent morphological variant of the bowhead, recognised by Inupiat hunters as the *ingutuk*. The authors conducted phylogenetic analysis of molecular sequence data collected from both 'classic' bowheads and *ingutuk* morphotypes and found no differences between them. The *ingutuk*'s morphological differences appear to be related mostly to age-class (*ingutuks* are believed to be recently weaned bowheads) but may also be related to gender.

SC/54/BRG1 reported on a Bowhead Whale Health and Physiology Workshop held in Barrow, Alaska, 1-4 October 2001. Two hard copies and a CD of the near-final workshop report have been provided to the IWC Secretariat.

The sub-committee discussed the issue of climate change and its relevance to the bowhead whale assessment. Tynan summarised relevant climate trends and predictions for the Arctic, particularly changes in sea ice extent and area. On a large-scale, cyclicity of the Arctic Oscillation (AO) affects the movement, extent and concentration of Arctic sea ice (Thompson and Wallace, 1998; Wang and Ikeda, 2000). During a positive phase of AO (i.e. cyclonic circulation), strong westerlies transport sea ice off the Siberian Shelf, reducing sea ice concentration during summer in the Siberian and Chukchi regions. Conversely, ice increases in the Canadian arctic and eastern Beaufort Sea during positive AO (e.g. 1989-1992). During a negative phase of AO (i.e. anticyclonic circulation), ice tends to stay in the Arctic. Bowhead whales, a species closely linked to the dynamics and ecology of sea ice and ice-linked productivity, would be expected to show responses to oscillations in sea ice extent and concentration. Long-term trends of decreasing sea ice in the Arctic can be traced back to the 1950s. Ice extent has declined by approximately 2% per decade and ice area has declined by more than 3% per decade. An 11% decrease in sea ice area has occurred primarily in the Beaufort and Chukchi Seas. Sea ice models, such as that at the Hadley Centre, UK, examine the influence of global warming on sea ice and predict that by 2080 the Arctic

Ocean will be ice free, with only a 'speck' of seasonal ice in winter (Vinnikov *et al.*, 1999). Tynan emphasised that the large uncertainty of bowhead whale response to these climatological cycles and trends and predictions should be incorporated into ongoing assessments and models.

SC/54/E11 addressed predictions for this stock under scenarios of environmental change. Three main points were raised: (1) bias in estimates; (2) predictions about the reduction of sea ice; and (3) global warming scenarios should be considered in the AWMP. Evidence suggesting drastic changes in Arctic sea ice as a result of global warming were reviewed. The author suggested that this is likely to result in a declining prey supply, increased shipping and oil development, and other factors which increase average and episodic mortality risks. Environmental and demographic stochasticity were integrated into population simulations that show substantial population declines within the next 200 years. The declines were driven primarily by increases in early mortality, episodic mortality due to oil spills and reductions in carrying capacity. It was noted that the results of this model differed from AWMP trials showing a sustainable harvest of this stock under base-case scenarios. Finally, these scenarios were recommended for consideration in AWMP testing.

Givens stressed that the bowhead AWMP robustness trials investigated changes in productivity, carrying capacity, and mortality, as well as random episodic mortality events. He argued that the mortality rate structure used in SC/54/E11 was not justified by bowhead biology and included mortality rates that were several times higher than estimates (and outside the corresponding confidence limits) obtained from direct data from Zeh and her co-authors, or from full assessments like that of Poole and Raftery (1998). Givens also noted that it is not reasonable to conclude that some past surveys were probably biased because some survey estimates are higher/lower than others; rather, this is the natural outcome of sampling variability. Finally, Givens noted that despite the fact that catastrophic factors used in the SC/54/E11 analysis were extreme, especially in combination, few resulted in serious conservation consequences over the 200 years of the simulation.

Punt urged that modelling exercises like the one in SC/54/E11 must be carefully conditioned on available data and checked for realism before they are used to speculate about future stock status. Givens added that he and Punt had attempted to run a simplified version of the model used in SC/54/E11 starting from the initiation of commercial whaling in 1848 but found that this analysis showed a very poor fit to the abundance data or stock extinction in the late 19th century.

M. Taylor responded that actual catch would increase if need increases under candidate catch algorithms. It was also pointed out that available fitted estimates of adult mortality were used in simulations, but decomposed into different mortalities for males and reproductive or post reproductive females, to mimic known patterns of mortality in killer whales. It was argued that unlike many AWMP trials, the scenarios were more comprehensive and were based on plausible phenomena observed for other cetaceans, as well as available climate change models.

Punt noted that the design of a management scheme such as the AWMP should not be intended to reverse environmental changes, but to react to them. A well-designed management procedure will reduce the catch if future conditions merit. See Annex E (Item 2.2) for further discussion of SC/54/E11.

6.1.2 Catch information

SC/54/BRG20 reported catch information from the 2001 Alaskan Subsistence hunt; a total of 75 bowhead whales was struck, resulting in 49 animals landed. The efficiency (the ratio of the number landed to the number struck) of the hunt was 65.3%, which is less than the average efficiency over the past 10 years (76.5%). Thirty of the landed whales were males and 19 were females. Of the 19 females, two were presumably mature ($> 4.2\text{m}$ in length) but neither of these was closely examined to determine if they were pregnant. Since 1980, 27% of the landed females $> 4.2\text{m}$ in length were pregnant, although this value is likely an underestimate because not all females were examined closely for small fetuses. It was noted that hunting efficiency was likely affected by a combination of factors, particularly poor ice conditions.

In response to a query, Suydam commented that the length at sexual maturity used in this study (14.2m) was based on ovary examinations by Tarpley and Hillman (1999). Photogrammetry has suggested a smaller length at sexual maturity, although Suydam noted that harvested whales were likely stretched. The smallest landed female known to be pregnant was 12.6m (George *et al.*, 2000).

Ohsumi asked whether reproductive tissues could be collected from harvested animals for future laboratory analysis. The author noted that examinations and organ collection is performed at Barrow, where most of the whales are harvested, and at Kaktovik.

One female bowhead whale was harvested in the waters off of Chukotka, Russia in 2001 (SC/54/BRG21). The harvested whale was 15.2m in length and estimated at 46.8 tons in weight.

6.1.3 Management advice

The sub-committee noted that although the current catch limit ends in 2002, an in-depth assessment of this stock of bowhead whales is not scheduled until 2004. However, preliminary results from the successful new census conducted near Barrow indicate that the stock is larger than it has been in the last century and is still increasing. The sub-committee in addition noted that the development of an AWMP for bowhead whales should be completed at this meeting. Given this, the sub-committee **agreed** that there was no reason to change the management advice it had given last year, namely, that it is very likely that a catch limit of 102 whales or less would be consistent with the requirements of the Schedule.

The sub-committee reviewed data requirements for the up-coming bowhead assessment. In particular, there was a need to resolve the conflict between existing age data and the catch and abundance data. One member noted that photo-identification data, such as those collected near Point Barrow, and genetic data would assist with stock assessment. However, it was noted that the AWMP SWG has carried out a thorough review of the B-C-B sub-stock question and feels the single-stock hypothesis is most consistent with existing data.

6.2 Davis Strait/Baffin Bay and Hudson Bay/Foxe Basin stocks of bowhead whales

6.2.1 New scientific information

Fisheries and Oceans Canada provided an update on several areas of research on the Davis Strait/Baffin Bay and Hudson Bay/Foxe Basin bowhead stocks between April 2001 to March 2002 (SC/54/ProgRep Canada). One aerial survey

was performed in southern Prince Regent Inlet and the northern Gulf of Boothia; however, specific counts and sighting locations were not provided.

Four satellite tags were deployed on bowhead whales in the Hudson Bay/Foxe Basin stock. The maximum transmitting time of any tag was four days.

Two biopsy samples were collected from the Davis Strait/Baffin Bay stock and 46 samples were collected from the Hudson Bay/Foxe Basin stock. Tissue samples were also obtained from three stranded whales attributed to the Hudson Bay/Foxe Basin stock.

The sub-committee appreciated the offer by Cosens to provide information on the results of these studies at the next meeting.

It was reported that 10 bowhead whales out of a pod of about 30 were killed by a large, uncounted pod of killer whales near Qeqertarsuaq in Disko Bay during four days in late April 2002.

6.2.2 Catch information

The sub-committee was not advised of any bycatch or intentional removals from either bowhead whale stock.

6.3 Other stocks

The sub-committee received a report of a sightings survey performed by the All Russian Scientific Institute of Fisheries and Oceanography in the Sea of Okhotsk between 6 September and 13 October 2001 (Appendix 4). A total of 48 bowhead whales were reported out of 1,065 cetacean sightings. Unfortunately, it was noted that poor weather conditions precluded an adequate survey of the Shelikhova Gulf and coastal areas near western Kamchatka.

7. WORK PLAN

For 2003, the sub-committee decided to focus the discussions on new and/or conflicting biological information on bowhead whales, right whales and gray whales. For 2004, the sub-committee agreed to conduct an in-depth assessment of the B-C-B bowhead whale stock.

8. ADOPTION OF REPORT

The report was adopted on 5 May 2002.

REFERENCES

- Breiwick, J.M., Eberhardt, L.L. and Braham, H.W. 1984. Population dynamics of western Arctic bowhead whales (*Balaena mysticetus*). *Can. J. Fish. Aquat. Sci.* 41(3):484-96.
- Clark, C.W. 1989. Report of the sub-committee on protected species and aboriginal subsistence whaling, Appendix 2. The use of bowhead call tracks based on call characteristics as an independent means of determining tracking parameters. *Rep. int. Whal. Commn* 39:111-3.
- Cumbaa, S.L. 1986. Archaeological evidence of the 16th century Basque right whale fishery in Labrador. *Rep. int. Whal. Commn* (special issue) 10:187-90.
- da Silva, C.Q., Zeh, J., Madigan, D., Laake, J., Rugh, D., Baraff, L., Koski, W. and Miller, G. 2000. Capture-recapture estimation of bowhead whale population size using photo-identification data. *J. Cetacean Res. Manage.* 2(1):45-61.
- George, J.C., Suydam, R.S., O'Hara, T.M. and Sheffield, G. 2000. Subsistence harvest of bowhead whales by Alaskan eskimos during 1999. Paper SC/52/AS24 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- International Whaling Commission. 1998. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48:53-118.

- International Whaling Commission. 2002a. Chair's Report of the Fifty-Third Annual Meeting. Annex C. Resolutions Adopted During the 53rd Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2001:54-60.
- International Whaling Commission. 2002b. Report of the Scientific Committee. Annex F. Report of the Sub-Committee on Bowhead, Right and Gray Whales. *J. Cetacean Res. Manage. (Suppl.)* 4:178-91.
- Koblikov, V.N. 1986. Benthic communities on the continental shelf and upper part of the slope of the Okhotsk coast of Sakhalin Island. USSR Ministry of Fisheries, Pacific Research Institute of Fisheries and Oceanography (TINRO). 54pp. [In Russian].
- LeDuc, R.G., Perryman, W.L., Gilpatrick, J.W.J., Hyde, J., Stinchcomb, C., Carretta, J.V. and Brownell, R.L., Jr. 2001. A note on recent surveys for right whales in the southeastern Bering Sea. *J. Cetacean Res. Manage. (special issue)* 2:287-9.
- Malme, C.I., Würsig, B., Bird, J.E. and Tyack, P. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. pp. 55-73. In: W.M. Sackinger, M.O. Jefferies, J.L. Imm and S.D. Treacy (eds.) Vol. 2. *Port and Ocean Engineering under Arctic Conditions*. University of Alaska, Fairbanks, AK. 111pp.
- Perryman, W.L., Donahue, M.A., Perkins, P.C. and Reilly, S.B. 2002. Gray whale calf production 1994-2000: Are observed fluctuations related to changes in seasonal ice cover? *Mar. Mammal Sci.* 18(1):121-44.
- Poole, D. and Raftery, A.E. 1998. Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales using Bayesian and full pooling Bayesian synthesis methods. Paper SC/50/AS6 presented to the IWC Scientific Committee, April 1998 (unpublished). [Paper available from the Office of this Journal].
- Poole, M.M. 1984. Preliminary assessment of annual calf production in the gray whale, *Eschrichtius robustus*, from Pt Piedras Blancas, California. *Rep. int. Whal. Commn* (special issue) 6:223-31.
- Punt, A.E. 1999. Report of the Scientific Committee. Annex R. A full description of the standard BALEEN II model and some variants thereof. *J. Cetacean Res. Manage. (Suppl.)* 1:267-76.
- Punt, A.E. and Butterworth, D.S. 1999. On assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales (*Balaena mysticetus*) using a Bayesian approach. *J. Cetacean Res. Manage.* 1(1):53-71.
- Punt, A.E. and Butterworth, D.S. 2002. An examination of certain of the assumptions made in the Bayesian approach used to assess the eastern North Pacific stock of gray whales (*Eschrichtius robustus*). *J. Cetacean Res. Manage.* 4(1):99-110.
- Richards, R. 1990. The commercial exploitation of sea mammals at Isles Crozet and Prince Edward Island before 1850. *Polar Monograph 1* [Available from: Scott Polar Research Institute, Cambridge at www.spri.ac.uk].
- Richards, R. and du Pasquier, T. 1989. Bay whaling off southern Africa, c. 1785-1805. *S. Afr. J. mar. Sci.* 8:231-50.
- Richardson, W.J. 1998. Marine mammals and acoustical monitoring of BPXA's seismic program in the Alaskan Beaufort Sea, 1997. Final report. LGL report TA2150-3. Prepared for BP Exploration (Alaska) Inc. and National Marine Fisheries Service by LGL, Ltd. and Greeneridge Sciences Inc. Anchorage: LGL Ltd. [Available from: www.nmfs.gov].
- Rosenbaum, H.C., Egan, M.G., Clapham, P.J., Brownell, R.L., Brown, M.W., White, B.N., Malik, S., Walsh, P.D. and DeSalle, R. 2000. Utility of North Atlantic right whale museum specimens in assessing changes in genetic diversity. *Conserv. Biol.* 14(6):1837-42.
- Rosenbaum, H.C., Razafindrakoto, Y., Vahavy, J. and Pomilla, C. 2001. A note on recent sightings of southern right whales (*Eubalaena australis*) along the east coast of Madagascar. *J. Cetacean Res. Manage. (special issue)* 2:177-80.
- Tarpley, R.J., Hillmann, D.J. and George, J.C. 1999. Observations on ovarian morphometrics and morphology in the bowhead whale. Paper SC/51/AS7 presented to the IWC Scientific Committee, May 1999, Grenada, WI (unpublished). 45pp. [Paper available from the Office of this Journal].
- Thompson, D.W.J. and Wallace, J.M. 1998. The Arctic Oscillation signature in the wintertime geopotential height and temperature fields. *Geophys. Res. Lett.* 25:1297-300.
- Vinnikov, K.Y., Robock, A., Stouffer, R.J., Walsh, J.E., Parkinson, C.L., Cavalieri, D.J., Mitchell, J.G.B., Garrett, D. and Zakharov, V.F. 1999. Global warming and northern hemisphere sea ice extent. *Science* 286:1934-7.
- Wade, P.R. 1997. A revised gray whale analysis using both southbound total population counts and northbound calf counts. Paper SC/49/AS24 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 23pp. [Paper available from the Office of this Journal].
- Wade, P.R. 2002. A Bayesian stock assessment of the eastern Pacific gray whale using abundance and harvest data from 1967-1996. *J. Cetacean Res. Manage.* 4(1):85-98.
- Wade, P.R. and Givens, G.H. 1997. Designing catch control laws that reflect the intent of aboriginal subsistence management principles. *Rep. int. Whal. Commn* 47:871-4.
- Wang, J. and Ikeda, M. 2000. Arctic oscillation and Arctic sea-ice oscillation. *Geophys. Res. Lett.* 27:1287-90.
- Weller, D.W., Burdin, A.M., Würsig, B., Taylor, B.L. and Brownell, R.L. 2002. The western North Pacific gray whale: a review of past exploitation, current status and potential threats. *J. Cetacean Res. Manage.* 4(1):7-12.
- Witting, L. 2000. On the exploitation of populations selected by density dependent competitive interactions. Paper SC/D2K/AWMP6 presented to the Third Workshop on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP), December 2000, Seattle (unpublished). [Paper available from the Office of this Journal].
- Witting, L. 2001. On inertial dynamics in whale populations. The case of the eastern North Pacific gray whale. Paper SC/53/AWMP6 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].

Appendix 1

AGENDA

1. Opening remarks, election of Chair and appointment of rapporteurs
2. Adoption of agenda
3. Review of available documents
4. Gray whales
 - 4.1 In-depth assessment of eastern North Pacific gray whales
 - 4.1.1 Catch and stranding information
 - 4.1.2 New scientific information
 - 4.1.3 Assessment model results
 - 4.1.4 Management advice
 - 4.2 Western North Pacific stock of gray whales
5. Right whales
 - 5.1 North Atlantic right whales
 - 5.2 North Pacific right whales
 - 5.3 Southern right whales
6. Bowhead whales
 - 6.1 Bering-Chukchi-Beaufort Seas stock of bowhead whales
 - 6.1.1 New scientific information
 - 6.1.2 Catch information
 - 6.1.3 Management advice
 - 6.2 Davis Strait/Baffin Bay and Hudson Bay/Foxe Basin stocks of bowhead whales
 - 6.2.1 New scientific information
 - 6.2.2 Catch information
 - 6.3 Other stocks
7. Work plan
8. Adoption of report

Appendix 2

POPULATION PROJECTIONS FOR THE GRAY WHALES BASED ON THE INERTIA MODEL

Andre Punt

Fig. 1 shows time-trajectories of total (1+) population size (1993-2100) based on the variant of the inertia model that initiates the population projections in 1600, uses all of the historical catches in tables 1 and 2 of SC/54/BRG10 and which bases the density-dependent response and inertial dynamics on the exponential formulation. The future (post-2002) catches are set to 0, 128 (approximately the current catch), 256 (approximately twice the current catch) and 475 (approximately the lower 5th percentile of the posterior for Q_1 in SC/54/BRG7 and SC/54/BRG10). The population is predicted to decline from a maximum in 2010

even in the absence of future catches. This is not unexpected, however, because the equilibrium population size is estimated to be 10,095 [90% PI = 8,680-14,191] and the inertia model estimates the current population size to be well in excess of this. The extent of decline increases with increasing catches and, for a constant catch of 475, there is greater than 5% chance of resource extirpation by 2080. Nevertheless, a constant catch of 475 animals will maintain the population above the equilibrium level with high probability until about 2030.

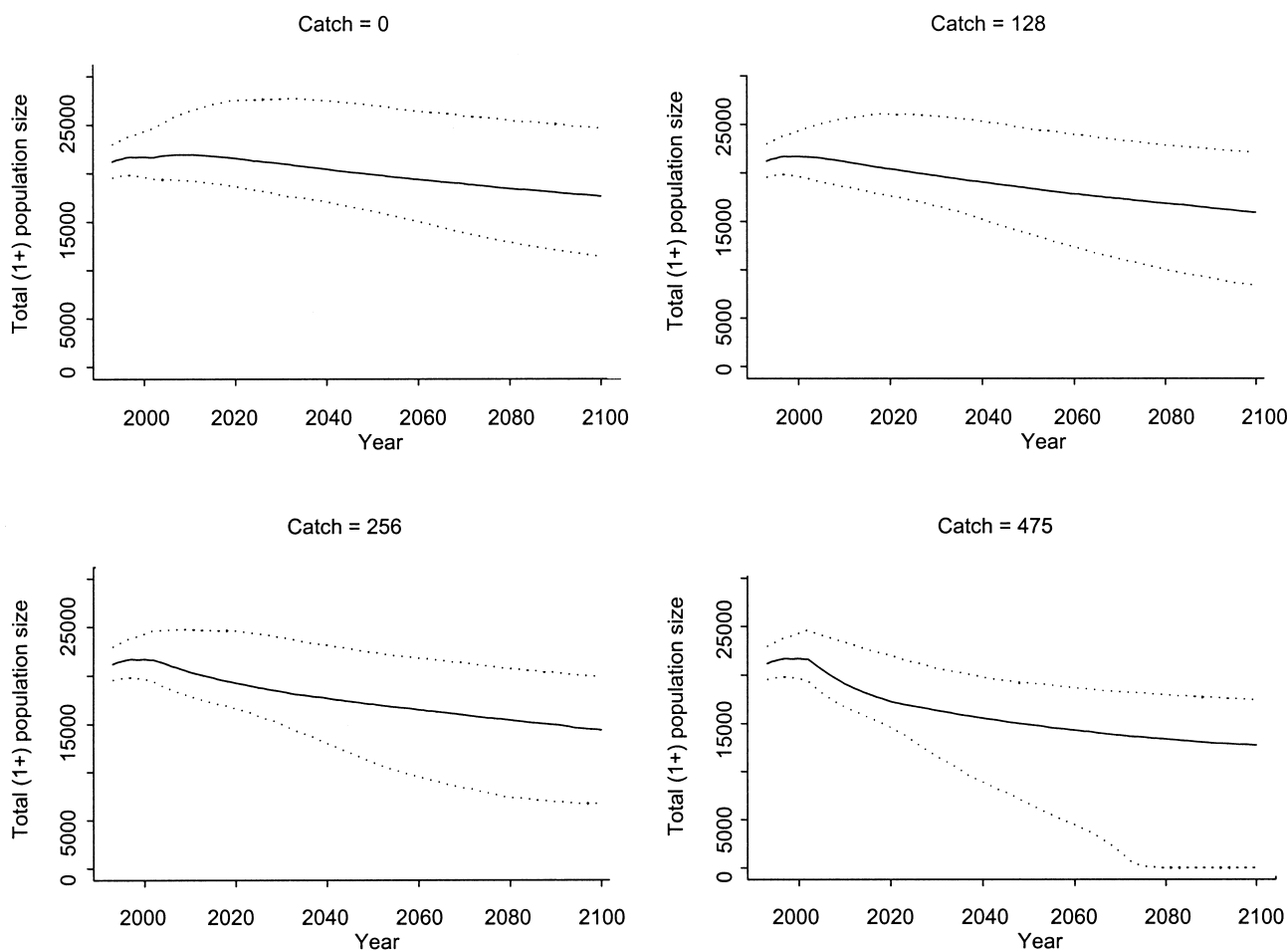


Fig. 1. Sensitivity of the time-trajectories of total (1+) population size (posterior medians and 90% probability intervals) for the eastern north Pacific gray whales (1993-2100) to the post-2002 catch.

Appendix 3

DIFFERENCES IN GRAY WHALE MOTHER/CALF COUNTS BETWEEN THE BAJA CALIFORNIA BREEDING LAGOONS AND CENTRAL CALIFORNIA, COMMENTS ON CHANGES IN ABUNDANCE, AND RECOMMENDATIONS FOR FUTURE RESEARCH

R.L. Brownell, L. Rojas Bracho, T. Schweder, S.L. Swartz, J. Urban-R and P.R. Wade

During the early 1980s, the total lagoon counts of cow-calf pairs was about 1,185 per year (Swartz and Jones, 1983). In 1980 and 1981, Poole (1984) on the central California coast

counted northbound cow-calf pairs, 691 and 768, respectively. The difference between them suggested a 31% decrease in the number of calves from mid-February in the

lagoons and mid-April to late May off Central California. These differences have been subject to discussion for many years without any resolution.

More recent cow-calf data have been collected in the Baja lagoons by various authors (SC/54/BRG11, SC/54/BRG16) and additional cow-calf counts were collected from Central California between 1994 and 2001 (Perryman *et al.*, 2002; SC/54/BRG3) (Table 1). These newer data show that in some years Baja lagoon calf counts are lower than counts of northward migrating mother calf pairs seen in Central California to the north.

Table 1

Comparisons of Baja California calf counts and calf deaths with estimated calf counts on their northbound migration off central California and normalised values of seasonal ice indices.

Year	Ojo de Liebre calf index ¹	Total Lagoon calves ²	Total dead calves ³	Central California calves ⁴	Ice indices ⁵
1980	324	1,185*	47	691	-1.5
1981	257	1,185*	8	768	1.1
1982	355	-	-	-	-0.1
1983	289	-	-	-	-0.3
1985	367	-	-	-	-0.3
1987	204	-	-	-	-1.8
1988	48	-	-	-	-1.3
1989	107	-	-	-	0.1
1990	26	-	-	-	-0.4
1991	52	-	-	-	-0.7
1992	215	-	-	-	-0.7
1994	-	-	-	945	-0.5
1995	-	-	9	619	1.3
1996	254	-	9	1,146	2.0
1997	287	910	18	1,431	1.5
1998	188	647	21	1,388	0.2
1999	-	286	12	427	-0.2
2000	-	345	12	279	-0.1
2001	-	422	2 ⁺	256	0.5
2002	-	670	6 ⁺	-	-

¹SC/54/BRG11; ²Swartz and Jones (1983) and SC/54/BRG16; ³Swartz and Jones (1983) and SC/54/BRG16; ⁴Poole (1984); ⁵Perryman *et al.* (2002) and SC/54/BRG4. ⁺Dead calves from only Baja California; *Mean of two years.

SC/54/BRG11 reported annual counts of gray whale calves for the period 1980-1998 in Laguna Ojo de Liebre, which represent the only available time series for the lagoon between 1982-1996. They noted that mother/calf pair counts declined markedly beginning in 1988 and remained low until 1991 (inclusive) after which they increased to levels comparable to before the decline (Table 1). No calf counts are available from Central California for 1982-1992 for comparison with the trend seen in Ojo de Liebre, but the Central California calf counts increased from 1994 to a high count in 1997, with the 1998 count being the second highest in the series from that counting station (Figs 1 and 2). Overall, the pooled count of mother/calf pairs in the three major breeding lagoons of Ojo de Liebre, Laguna San Ignacio and Santo Domingo Channel declined during the 1997 to 1999 period (SC/54/BRG16). In contrast, counts of northward migrating calves in Central California exceeded calf counts in the breeding lagoons during this time period. If mortality in the breeding lagoons alone was responsible for the reduction in calf counts in these areas, one would not expect to count greater numbers of calves in the Central California area within the same year.

An El Niño event occurred in 1998, and it has been suggested that SST changes from this event may have affected the distribution, mortality rate, and/or the length of

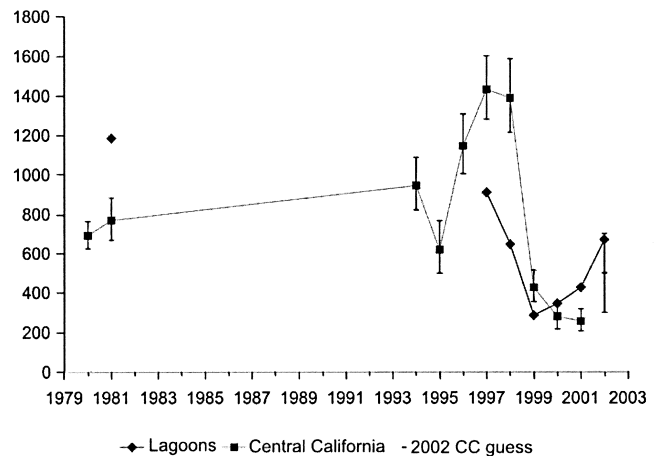


Fig. 1. Calf counts from lagoons and from survey in central California.

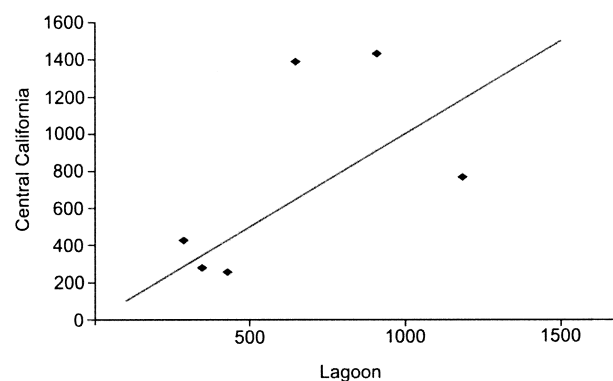


Fig. 2. Calf count in the lagoon versus in central California in the same year. Line is the 1:1 line (not a regression line).

time gray whales spend in their winter breeding range. Such a shift could affect the number of gray whales and calves counted within the breeding lagoons (SC/54/BRG16). For example, higher calf counts in Central California than in the breeding lagoons during the 1997 to 1999 period could be the result of a shift in the distribution of mother/calf pairs on the winter breeding grounds in the years surrounding the 1998 El Niño event. SC/54/BRG16 summarised evidence for such a shift in response to SST changes during the winter breeding-calving season. If fewer numbers of mother/calf pairs resided within the breeding lagoons in these years they would not have been available to be counted within the lagoons, but they would have been available to the Central California census.

If more mother/calf pairs are using the waters outside the breeding lagoons, for whatever reason, they would lose the advantages of the lagoon habitats and would be vulnerable to open ocean conditions (e.g. currents and storms), human activities (including entanglement in coastal fishing gear), predation (i.e. killer whales) and calf survival may be affected. Similarly, females may have become energetically stressed as a result of the 1998 El Niño event, and calves born in 2000 and 2001 may have been less fit and suffered a high mortality rate. This could account for the overall declines in the number of calves counted in all lagoon areas. Higher calf mortality between the breeding lagoons and Central California in 2000 and 2001 could account for a reversal from the 1997-1999 period, and a return to the historical trend of fewer calves being counted in Central California compared to the breeding lagoons. The 2002 breeding lagoon calf count of 670 (SC/54/BRG16) suggests

that the Central California calf count is expected to be less than this number. At the present time, the Central California raw count of calves is higher than the 1999-2001 and 1995 total counts, and the total count will probably be at least the same as the 2002 lagoon calf count.

SC/54/BRG4 presented the results of correlation tests conducted between the length of the feeding season and calf estimates for the spring breeding season immediately following the feeding season, and found a positive correlation between the duration of the feeding season and calf estimates. This would support the idea that in heavy ice years and/or El Niño years, pregnant females may become energetically stressed and produce less viable calves. In discussion it was noted that nutritional stress can act at several stages to affect pregnancy or result in poor survival of the calf: (1) ovulation; (2) problems with foetal development (e.g. a neonate may be a 'poor survivor'); (3) mother behavior and care for the calf (e.g. abandonment, less protection from predation, etc.); (4) increased age of sexual maturation (i.e. delayed); and (5) lactation (i.e. decreased quality and amount of milk). Jones and Swartz (1983) found support for lower survival of 'weaker' less fit calves by measuring the lengths of dead calves in the breeding lagoons. They found that the mean length of dead newborn calves in the lagoons was significantly less than near-term foetuses taken from pregnant females collected during the southward migration (Rice and Wolman, 1971), suggesting the dead lagoon calves were 'runts'.

Central California calf counts are not truly calf production but a product of the birth rate plus calf survival to ages three and four months. The relationship of the Central California counts to the actual calf production will vary year to year depending on various factors, including the mortality rate of calves in the winter range and along the migratory route, and the environmental effects of ice conditions on the summer feeding season for females that will affect the viability of their calves the following year.

To investigate these observed changes and differences in the counts of gray whales and particularly gray whale calves observed in the breeding lagoons and along their migration routes, and to better understand the factors that are influencing the productivity of this population, the sub-committee **recommends** that the following research activities be conducted.

General

- (1) An intersessional Workshop should be convened before the 55th meeting of the Scientific Committee to bring together the most recent information and historical records of gray whale abundance, mother-calf counts, seasonal distribution, and relative habitat information (e.g. prey base) for examination and analysis relevant to the dynamics of this population.

Breeding lagoons

- (2) Given the evidence of shifts in the winter distribution of gray whales using the breeding lagoons and near-shore coastal waters in recent years, surveys within the principal breeding lagoons (i.e. Ojo de Liebre, San Ignacio and Magdalena Bay Complex) and surveys of the coastal waters of Baja California need to be continued. It is especially important to determine the number of calves born in the southern breeding range for comparison with calf counts obtained in the central California counting station to reconcile the differences between estimates of calf production from annual surveys in both areas. This would best be accomplished

by continuing the mother-calf counts within the lagoon areas and the nearshore waters adjacent to the breeding lagoons, conducting an independent survey to estimate the number of cow-calf pairs migrating northward in northern Baja California, and continuing the surveys of northward migrating mother-calf pairs along central California for comparison with the calf counts within the winter range.

- (3) Preliminary analyses of the limited number of genetic samples suggest there may be some matrilineal fidelity to specific breeding lagoons in calving years, and this suggests there may be some structure to the population on the breeding grounds. Additional genetic samples need to be collected and analysed from major lagoon areas to examine this possibility.
- (4) Surveys within the lagoons represent 'snapshots' of the number of whales utilising these areas; however, radio tagging studies and shore based observations suggest that the whales are moving into and out of the lagoons throughout the breeding season. Evaluation of the use of the breeding lagoons by whales and the percent of the population utilising each area requires determination of 'turn-over' or the 'exchange rate' of whales within the lagoons. Additional radio tagging and photo-ID studies need to be conducted to obtain sufficient information to estimate the number of whales and percent of the population utilising the lagoons.
- (5) To address possible changes in the reproductive rate of the ENP gray whale population, additional photo-ID research concentrating on mature females is needed in all the major lagoon areas, and these results compared with photo-ID data collected in previous years (e.g. 1980s and 1990s). From these data, estimates of inter-birth interval, residency time within the lagoons, exchange between the lagoons and other life-history parameters may be examined and from this changes in the reproductive parameters within the population may be detected and evaluated.
- (6) There remains concern that whalewatching activities may affect the gray whales' use of some lagoon areas, but there are few data available to analyse trends in vessel activity within the lagoons. There is a need to monitor and gather quantitative data on vessel traffic – both whalewatching and other vessels (e.g. fishing and commercial) – within the breeding lagoons, and to compare these data with the results of annual surveys and trends in the use of the lagoons by gray whales. Existing programmes to gather data on the magnitude of vessel activities within the lagoons should continue and additional monitoring programmes need to be implemented in areas where they do not exist presently to document trends in vessel activity in these areas. This should include gathering data on whalewatching, fishing and other vessels.

Shore-based counts of southward migrating eastern gray whales have been conducted 22 times between 1967 and 2002 and other less standardised surveys were conducted before 1967. While this is probably the best studied baleen whale population, the two most recent counts of eastern North Pacific gray whales in 2000/2001 and 2001/2002 resulted in lower (preliminary) estimates than most (but not all) of the most recent estimates. The highest population estimate of 26,000 occurred in the survey conducted in 1997/1998, which leads to the appearance of a large drop in the population, although this is the only estimate higher than 23,100. Residuals in the abundance estimates from the

estimated trajectory have previously been this high in the gray whale time series. These results have raised concerns about the abundance estimation methods used in these surveys. In addition, the results of the last two eastern North Pacific gray whale surveys are confounded by unusually high range-wide strandings of gray whales in 1999 and 2000, and extremely lower calf counts in 1999, 2000 and 2001, noted above. These factors must have had some impact on the population but the actual impact can not be measured.

Two major issues in the surveys are: (1) continuing concerns about additional variance in the shore-based abundance estimates resulting from process error; and (2) the possibility that not all the whales migrate south of the counting station. With regard to the issues surrounding the resolution of changes in the autumn southward migration based abundance estimates from California, the sub-committee **recommends** that:

- (1) The southbound survey be conducted in 2002/2003 to better understand the status of the population.
- (2) At the completion of the next survey of the southward migration, conduct aerial, vessel, or land based survey (or some combination) effort to determine the relative number of whales present north of the Granite Canyon census site that might have not been included in the survey of the southward migrating whales.
- (3) Undertake additional statistical analyses to fully account for sources of variability in the abundance estimates based on the counts conducted during the southward migration.

Additional questions and problems exist related to issues concerning maximum abundance and carrying capacity for eastern North Pacific gray whales. Reilly (1981) concluded that a carrying capacity of 24,000 whales gave the best agreement with the available information on abundance and historical catches in his study. Butterworth *et al.* (2002) found that historic population sizes in the eastern North Pacific gray whales greater than 30,000 were possible under certain scenarios. SC/54/BRG7 estimated carrying capacity to be about 22,000 (95% CI = 19,000-35,000). Three issues related to the question of carrying capacity are: (1) the steep decline in the gray whale pregnancy rate as determined from whales harvested between 1987 and 1990; (2) the possible recent decline of gray whale prey (e.g. amphipods) in one or more of the major feeding areas; and (3) natural changes in environmental conditions that may be somehow stressing the whales, especially mature females.

The recent decline in pregnancy rates may be related to the timing and location of the catches over time depending on where female gray whales congregate on the summer feeding grounds. Any such sampling bias could produce this decline but this question has not been reviewed in any detail, and additional research is needed to investigate it. The reported recent decline in amphipod prey reported by Stoker (1990) in one of the major feeding areas of the eastern North Pacific gray whale could have been caused by over-exploitation by gray whales. However, the importance of this and other feeding areas to the over all feeding range of the eastern North Pacific gray whale is unclear.

Numerous recent papers have discussed changes in Arctic environmental conditions resulting from polar climate change. It has been suggested that populations close to carrying capacity may be more vulnerable to fluctuations in environmental conditions (SC/54/BRG7). It would be well worth investigating the hypothesis that recent strandings and poor calf production are due solely to environmental influences, versus due to a combination of being close to

carrying capacity and being more vulnerable to environmental changes. Climate change and its potential implications for gray whales need additional discussion and review.

With regard to improving the estimation of abundance of eastern North Pacific gray whales and to investigate environmentally related causal mechanisms that might be affecting changes within the population, the sub-committee **recommends** that the following questions be explored:

- (1) What was the most plausible historical carrying capacity of eastern North Pacific gray whales at the start of commercial whaling in the late 1840s?
- (2) Is the historical carrying capacity of the eastern North Pacific gray whale the same or different from the current carrying capacity?
- (3) Re-examine the available Soviet and Russian harvest data of eastern North Pacific gray whales to investigate the steep decline in pregnancy rates between 1987 and 1990 compared to earlier data from the Soviet aboriginal hunt.
- (4) Review available data on the status and trends of the prey (e.g. amphipod) food base for eastern North Pacific gray whales in the Bering Sea.
- (5) Review the major feeding areas and prey resources utilised by the eastern North Pacific gray whale and the dietary flexibility of this species in terms of the scope of the range of prey species/items utilised.
- (6) Review data on environmental conditions in the Bering Sea that may be impacting the amphipod and other prey populations, and those conditions that may impact these populations in the future.
- (7) Review available relevant data regarding whether calf production and survival are more or less variable at the current time.
- (8) Review whether the population is considered to be close to, or at carrying capacity at the present time.

REFERENCES

- Butterworth, D.S., Korrübel, J.L. and Punt, A.E. 2002. What is needed to make a simple density-dependent response population model consistent with data for the eastern North Pacific gray whales? *J. Cetacean Res. Manage.* 4(1):63-76.
- Jones, M.L. and Swartz, S.L. 1983. Gray whale reproduction, distribution, and duration of stay in Laguna San Ignacio, and inter-lagoon exchanges as determined from photographic identification data. Abstract, VIII Reunión Internacional sobre Mamíferos Marinos de Baja California, 17-19 March, La Paz, Baja California Sur. [Available from steven.swartz@noaa.gov].
- Perryman, W.L., Donahue, M.A., Perkins, P.C. and Reilly, S.B. 2002. Gray whale calf production 1994-2000: Are observed fluctuations related to changes in seasonal ice cover? *Mar. Mammal Sci.* 18(1):121-44.
- Poole, M.M. 1984. Preliminary assessment of annual calf production in the gray whale, *Eschrichtius robustus*, from Pt Piedras Blancas, California. *Rep. int. Whal. Commn* (special issue) 6:223-31.
- Reilly, S.B. 1981. Gray whale population history: an age structured simulation. Paper SC/33/PS8 presented to the IWC Scientific Committee, June 1981 (unpublished). 24pp. [Paper available from the Office of this Journal].
- Rice, D.W. and Wolman, A.A. 1971. *The Life History and Ecology of the Gray Whale (Eschrichtius robustus)*. American Society of Mammalogists, Special Publication No. 3, Stillwater, Oklahoma. viii+142pp.
- Stoker, S.W. 1990. Distribution and carrying capacity of gray whale food resources in the northern Bering and Chukchi Seas. Paper SC/A90/G13 presented to the special meeting of the Scientific Committee on the Assessment of Gray whales, Seattle, April 1990 (unpublished). 10pp. [Paper available from the Office of this Journal].
- Swartz, S.L. and Jones, M.L. 1983. Gray whale (*Eschrichtius robustus*) calf production and mortality in the winter range. *Rep. int. Whal. Commn* 33:503-7.

Appendix 4

BRIEF CRUISE REPORT OF THE RUSSIAN SIGHTING SURVEYS IN THE SEA OF OKHOTSK, 2001

N.V. Doroshenko and D.V. Ivannikov

Results of the cetacean ship-based survey in the Sea of Okhotsk

Using the research vessel *Krymskiy*, a sightings survey was conducted in the Sea of Okhotsk in September and October 2001 (Fig. 1). The research area covered the coastal area of the Sea of Okhotsk. Unfortunately, information on distribution and abundance of whales and dolphins in the Shelikhova Gulf and coastal area near Western Kamchatka could not be gained due to bad weather conditions (strong storms). The research vessel started from Nakhodka on 6 September and entered the port of Vladivostok on 13 October. The total distance was about 5,500 n.miles, and the total research distance was 2,852 n.miles. During the survey, 1,065 whales and dolphins were recorded (Table 1 and Fig. 1).

Table 1

Number of sightings recorded during the survey in the Sea of Okhotsk in September-October 2001.

Species	Number
Bowhead whale	48
Gray whale	41
Fin whale	4
Minke whale	57
Sperm whale	16
Killer whale	53
Baird's beaked whale	42
White whale	68
Dall's porpoise	637
Pacific white-sided dolphin	99
Total	1,065

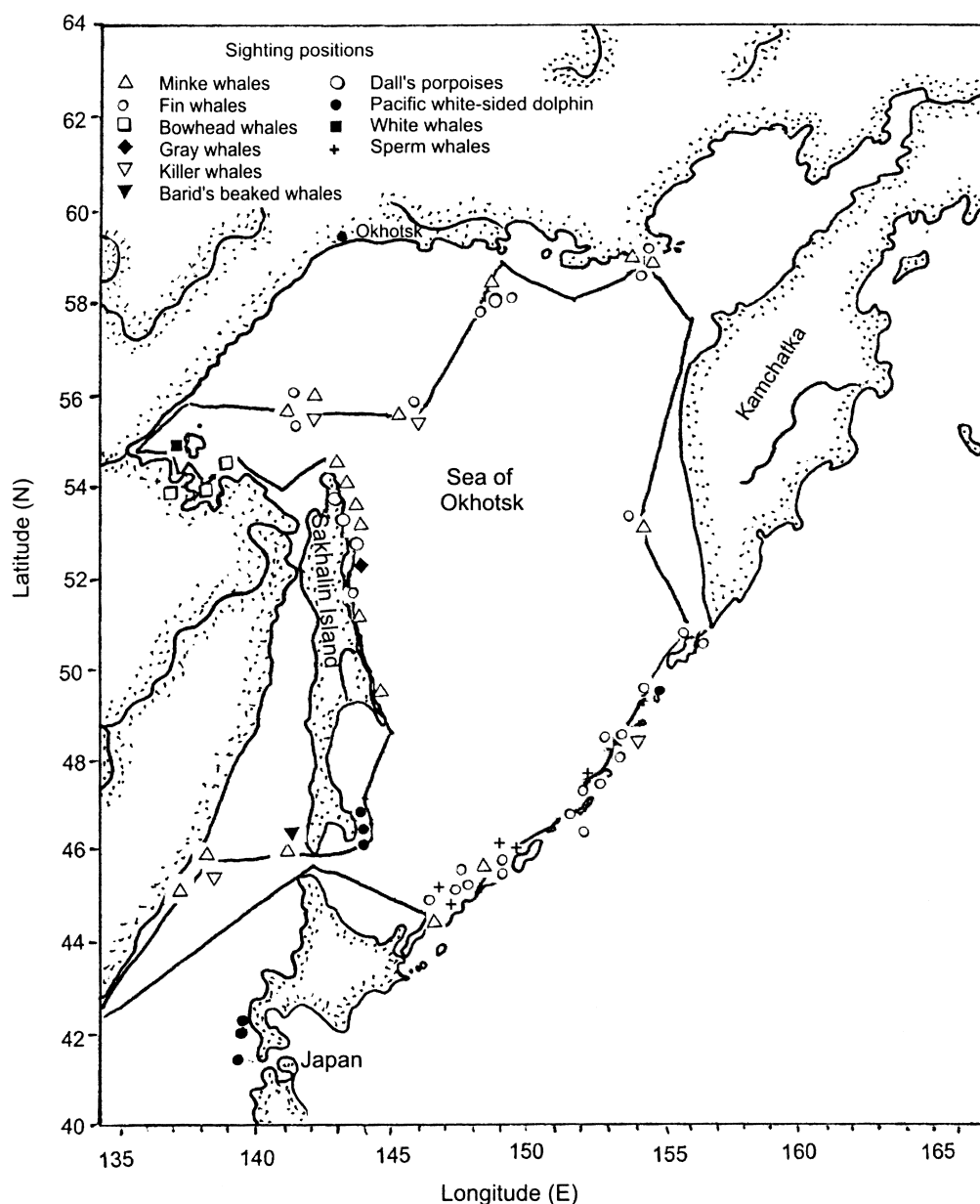


Fig. 1. Positions of cetacean pods sighted during the cruise of *Krymskiy*, 6 September-13 October, 2001.

Appendix 5

WORKSHOP PROPOSAL FOR THE WESTERN GRAY WHALE: MONITORING AND RESEARCH NEEDS

R.L. Brownell, S. Ohsumi, Z.G. Kim and R.G. Borodin

At previous meetings (IWC, 1997, p.91; IWC, 1998, p.94) the Scientific Committee has recommended that the Commission arrange to bring together scientists from countries with an interest in, or working within the range of, the western gray whale population in order to consider measures to maximise its chances for recovery. This recommendation was again discussed this year and again supported by the Committee.

Terms of reference

- (1) to consider the current status of the western gray whale population;
- (2) to develop the foundation for range-wide research on the population;
- (3) to update the 10-year research and monitoring plan presented to the Committee in 1999.

The Steering Group will consist of Brownell, Ohsumi, Kim and Borodin. The timing will be autumn (October) of 2002 (four days) in either Korea or Japan. Approximately 15 to 20 invited scientists will likely participate.

Draft agenda

1. Welcome and introductions
2. Arrangements for meeting
3. Election of Chair
4. Appointment of rapporteurs
5. Adoption of Agenda
6. Past exploitation of population
7. Current status in Russia
8. Current status in Japan
9. Current status in Korea
10. Current status in China
11. Potential anthropogenic threats to population
12. Ten-year research plan
13. Any other business
14. Conclusions/recommendations
15. Adoption of report

REFERENCES

- International Whaling Commission. 1997. Report of the Scientific Committee. *Rep. int. Whal. Commn* 47:59-112.
 International Whaling Commission. 1998. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48:53-118.

Appendix 6

PROGRESS ON RECOMMENDATIONS RELATING TO NORTH ATLANTIC RIGHT WHALES

Phil Clapham

Recommendation	Progress and actions undertaken
Conduct workshop on right whale genetics	Not conducted due to logistical and coordination problems.
Conduct genetic analysis on additional historical specimens	Samples from 16 th century Basque fishery in Labrador obtained and DNA extracted; analyses ongoing.
Expand biopsy sampling, especially for non-Fundy females	Some samples collected on the calving ground in 2002.
Examine genetic data with regard to habitat use, resighting probabilities, scar patterns and reproductive success	Work is ongoing.
Obtain data on length of individual whales	Aerial photogrammetry project conducted in summer 2000 and 2001 in Bay of Fundy; large sample size obtained for length; data being integrated with information from sighting histories of identified individuals.
Conduct coordinated studies of health status, and develop integrated database on reproduction, health and sightings	Project conducted in summer 2000 and 2001 combining reproductive endocrinology, toxicology and scarification analysis; database integration initiated.
Conduct feasibility of stress studies using biopsy samples	Initial feasibility study using animals of known health status suggests technique is useful as crude indicator of stress.
Conduct studies of contaminant burdens	Ongoing.
Collect data on body condition in live and dead whales	Data collected from live whales using ultrasound and measurements taken from stranded specimens; comparative study conducted on southern right whales.
Conduct study of reproductive success of tagged versus non-tagged animals	No apparent differences, but additional years of data required.
Reduce mortality from entanglements	Ongoing efforts through Take Reduction Teams and other fora; workshop on development of whale-safe fishing gear planned; dynamic and seasonal area closures to fishing gear enacted.
Reduce mortality from ship-strikes	Document summarising management options completed and being evaluated; tag- and playback-based research conducted to better understand right whale response to ships; technological approaches (passive detection, active sonar etc) being evaluated; shipping lane change in Bay of Fundy proposed to IMO; aerial surveys continuing to warn mariners of presence of right whales.
Produce document summarising right whale distribution, corrected for effort, for presentation to IMO	GIS-based analysis of sightings and effort now complete; used in proposal to move Bay of Fundy shipping lane.
Obtain better data on distribution of right whales relative to shipping and fishing gear	New information on ship tracks obtained from Mandatory Ship Reporting System in two right whale critical habitats; information on gear more difficult to obtain.
Provide annual survival estimates to Scientific Committee	Survival estimates through 2000 being calculated based upon updated sighting data, but resolution of some data issues is required, and heterogeneity in capture probabilities remains a problem.
Continue funding for North Atlantic right whale photo-id catalogue and database	Funding planned through at least 2005.

Annex G

Report of the Sub-Committee on the Comprehensive Assessment of Whale Stocks – In Depth Assessments

Members: Palka (Chair), Baba, Baker, Bando, Bannister, Berggren, Best, Bjørge, Borodin, Branch, Brandao, Bravington, Breiwick, Brownell, Burt, Butterworth, Carlson, Childerhouse, Clapham, Clark, C., Clark, E., Cooke, Diake, Donahue, Donovan, Ensor, Etylina, Fujise, Funahashi, Gales, Garrigue, Goodman, Goto, Guiste, Gunnlaugsson, Hakamada, Hammond, Hatanaka, Hedley, Hester, Ishikawa, Johnston, Kanda, Kato, Kawahara, Kell, Kim, Kingsley, Kock, Leaper, Lens, Matsuda, Matsuoka, Melnikov, Minton, Miyashita, Mori, Morishita, Murase, Nagahata, Nagatomo, Nishiwaki, Ohsumi, Øien, Okamura, Oosthuizen, Pastene, Perrin, Pike, Polacheck, Rademeyer, Rambally, Rennie, Ridoux, Robbins, Rogan, Rosenbaum, Rowles, Sadler, Sakamoto, Santamaria, Schweder, Shimada, Skaug, Smith, Sohn, Swartz, Tamura, Tanaka, Thiele, Tichotsky, Tomita, Tynan, Urban-Ramirez, Van Waerebeek, Vikiingsson, Wade, Wakako, Walløe, Weinrich, Williams, Witting, Yamamura, Yasunaga, Yoshida, Zeh, Zenitani, Zerbini.

1. OPENING REMARKS

Donovan and Morishita welcomed the participants to the meeting.

2. ELECTION OF CHAIR AND APPOINTMENT OF RAPPORTEURS

Palka was elected Chair. Bannister, Branch, Hedley and Kingsley agreed to act as Rapporteurs.

3. ADOPTION OF AGENDA

The adopted agenda is given as Appendix 1.

4. REVIEW OF AVAILABLE DOCUMENTS

The following documents were relevant to the work of the sub-committee: SC/54/IA1-31, SC/54/O3, SC/54/O6, SC/54/O8-O10, SC/54/O12, SC/53/IA6 and Murase *et al.* (2002).

5. MATTERS RELEVANT TO MORE THAN ONE STOCK

5.1 DESS: Progress with data entry and analysis options

Burt summarised progress on DESS and analysis options. Data from the 1999/2000 and 2000/01 SOWER surveys have been validated and included in DESS. Some final changes to

species codes have also been made so that code 39 refers to 'like minke' in all years. The latest version of DESS is '3.2 Revised'.

It was noted in Item 6.1 that the variance calculation in DESS uses each segment of survey mode on a transect as an independent sampling unit. The sub-committee **agreed** that there should be an option in DESS to use other sampling units. A feature that was **recommended** to be considered in future modifications of DESS was to include the surfacing data from sightings that were tracked during IO mode. These data would need to be entered into the database then the users need to be able to extract them. This would facilitate investigations into responsive movement and $g(0)$. It was also **recommended** that the default option for school size estimates be changed so that the size bias regression method was used even if the regression was not significant.

5.2 SOWER Circumpolar cruises

5.2.1 SOWER 2001/02

SC/54/IA2 presented the report of the 2001/02 IWC SOWER Circumpolar Cruise. Following the proposal made last year (IWC, 2002a, p.30), the cruise started approximately three weeks earlier than the six most recent previous surveys. This strategy was adopted to facilitate the temporal compatibility with earlier cruises (those prior to 1994/95), with the aim of ensuring that the survey took place during the peak migration period of minke whales. The planned survey area was the western half of Area V, south of 60°S to the ice-edge, between 130°E and 165°E. However, extremely poor weather was encountered, and so longitudinal coverage was restricted to the area between 130°E and 150°E, in which good coverage was obtained in both the northern and southern strata. As a consequence of the poor weather, it was not possible to carry out the feasibility study of biopsy sampling of minke whales, although the Estimated Angle and Distance Experiment (and training) were conducted.

Minke whales were the most commonly sighted species in the research area, with 123 groups comprising 358 animals seen. There were also a surprisingly high number of blue whales encountered (14 groups; 35 animals). Ten groups (26 animals) were approached and field identified as true blue whales from which 16 biopsy samples were obtained from 11-14 individuals, along with photo-identification images of 14 individuals and digital video footage of all individuals. The acoustic element of the blue whale research resulted in an unprecedented number of good quality recordings of sounds attributed to true blue whales. The report suggests that this area would likely be an excellent area for future blue whale research. Other notable sightings included five groups

of spectacled porpoise (comprising 15 animals). One of these groups was seen in the far north of the research area; the remaining four groups were seen on transit to the research area from Hobart.

Notwithstanding the numerous changes that have occurred during the course of the circumpolar cruises (e.g. reduced working hours, increased latitudinal coverage), a point of strategic concern was raised in discussion regarding the relative lack of longitudinal coverage compared to earlier cruises (20° on this cruise compared to 60° on earlier surveys, both with two vessels). However, it was emphasised that the weather on this survey was exceptionally poor, and that this constituted the main reason for the particularly low coverage attained, rather than any other change in procedure, such as trying to achieve a higher percentage of track line coverage in the northern strata. Whilst a high percentage of the planned track lines in the northern strata were covered on effort, this was attributed primarily to their relatively small latitudinal range in Area V West. Despite the predominantly poor weather, the coverage achieved was done so in good conditions, with only limited effort in marginally acceptable conditions. Conditions that are deemed unacceptable for surveying minke whales may, however, be acceptable for conducting blue whale research. On this survey, the vast majority of blue whale research was conducted in such conditions, and hardly impinged on potential minke whale research time. Nishiwaki noted that on previous JARPA surveys where the ice-edge was further south than expected (as seen on this survey east of 135°E), the surface water temperature in the vicinity of the ice was about 1°C, and that this appeared to affect the sighting rate of minke whales. Ensor commented that based on his experience, he had not noticed a marked difference in the distribution of minke whales on this survey compared to previous ones, despite the southerly position of the ice-edge.

The sub-committee expressed its gratitude to the Government of Japan for providing the vessels to conduct the survey. The sub-committee also thanked the officers and crews of both vessels, the Cruise Leader, Paul Ensor, and the researchers for their efforts during a difficult cruise.

5.2.2 Plans for future cruises

Because the survey area of the 2001/02 cruise was incompletely covered, SC/54/IA20 proposed a revised plan for the completion of the third circumpolar set of cruises, comprising coverage of the eastern area of Area V in 2002/03 and the western area in 2003/04.

Noting the importance of the IDCR/SOWER surveys to its work, and of completing the third set of surveys, the sub-committee expressed its gratitude to the government of Japan for the offer to make the survey vessels available for this purpose in 2002/03 and 2003/04 for a time period longer than usual.

The report from the *ad hoc* working group to plan logistic aspects of the proposed 2002/03 IDCR/SOWER cruise is given as Appendix 2. Some members were concerned about the simultaneous operation of SOWER and JARPA surveys in Area V and the possible effect that this could have on results. It was suggested that the two sets of survey tracks be planned such that: (1) a comparison of the resulting estimates of minke whale density from JARPA and SOWER is possible; and (2) disturbance effects are reduced by the SOWER vessels always preceding the whaling vessels in time and space. The sub-committee **agreed** that this was a feasible option, but details were left to the Tokyo planning meeting.

The remaining areas to be covered are disproportionate in size, with Area V East (which encompasses the Ross Sea) being much larger than Area V West (and especially the remaining unsurveyed area of Area V West). The plans outlined in SC/54/IA20 accommodate this concern to some degree by increasing the number of days allocated for research to 60, compared to the normal 40+ days. Nevertheless, Area V East is an important area, given the large proportion of minke whales that occur there compared to the remainder of the Antarctic management areas, and so good coverage in that Area is desirable. Noting the difficulty in surveying Area V East because of its wide latitudinal range, the sub-committee agreed that emphasis should be placed on surveying the southern (and mid-) strata in this Area. It was agreed that the survey should be designed to ensure full longitudinal coverage in these strata, but in order to accommodate this priority, the northern strata should be restricted to 20° longitudinal coverage in 2002/03, leaving the remaining 5° northern sector to be added to the area covered in the 2003/04 survey, although it should be attempted if the schedule of the cruise allowed.

5.3 NASS cruises

SC/54/O10 reported a vessel based sightings survey conducted in Icelandic and adjacent waters in June and July 2001. The coordinated international North Atlantic Cetacean Sighting Surveys (NASS) started in 1987 and has since been conducted in 1989 and 1995 (Sigurjónsson *et al.*, 1989; NAMMCO, 1998). In these surveys large areas of the northern North Atlantic have been covered simultaneously by up to 15 vessels and two aircraft with participation of up to five countries (NAMMCO, 1998). The fourth international sightings survey (NASS-2001) was coordinated by the NAMMCO Scientific Committee and was carried out during the summer 2001 by the Faroes, Norway and Iceland. While all cetacean sightings were systematically recorded, the primary target species of the Icelandic part of the survey were fin and minke whales as in previous NASS surveys. Special emphasis was placed on identifying 'like fin or blue' sightings to species.

The Icelandic survey area covered the seas between East Greenland and Iceland, including the traditional whaling grounds off West Iceland, coastal and offshore waters around Iceland and the waters northeast of Iceland as far north as 74°N. The continental shelf area around Iceland was covered by airplane (SC/54/O12) while offshore areas were surveyed by three vessels during 19 June to 29 July 2001. On two of the vessels an acoustic survey for redfish was conducted simultaneously without any particular conflicts.

The shipboard survey was conducted in BT mode (Buckland and Turnock, 1992) using the independent platform and tracking procedure. A total of 1,674 sighting (4,681 animals) were observed during a survey effort of 7,470 n.miles. Fourteen species of cetaceans were identified. The most common large whales were fin whales (890 animals in 556 sightings) and humpback whales (441 animals in 282 sightings). Abundance estimates for fin and sperm whales are reported in Items 8.1 and 8.2, and work on abundance estimates for minke whales and several other species is in progress.

The aerial survey component of NASS 2001 (SC/54/O12) covered the inshore areas of Iceland. This was the third NASS aerial survey carried out since 1987, using essentially the same survey design and procedures. The target species was the minke whale, but all cetaceans encountered were recorded. The survey used the cue-counting procedure for minke whales and standard line transect methodology for

other species. For the first time an independent secondary observer platform was maintained throughout to collect data for estimation of $g(0)$ and distance measurement error. A total of 537 sightings of 1,354 animals (comprising at least 9 species) was made, including 200 sightings of minke whales and 161 sightings of humpback whales. An estimate of the (uncorrected) abundance of humpback whales has been completed and was presented to the Scientific Committee (SC/54/H2), while calculation of an abundance estimate for minke whales is in progress. SC/54/H6 presented the trend in the relative abundance of humpback whales from all four aerial surveys since 1986.

The sub-committee welcomed the report of these surveys, however, due to lack of time, it was not possible to fully explore these methods and results. The sub-committee noted that sharing the survey platforms with the redfish survey on the Icelandic vessels had apparently been successful. It was noted that the international redfish surveys included a large area to the south and west of the NASS survey areas, had participation from Germany, Iceland, Norway and Russia, and will be carried out on a three-year rotation schedule. The sub-committee **recommended** that the nations participating in the next redfish survey incorporate a cetacean survey, as done on the Icelandic vessels, if feasible. This would extend the geographical range of the NASS surveys to cover a larger area of the North Atlantic.

6. ANTARCTIC MINKE WHALES – ABUNDANCE ESTIMATES

6.1 Review of new data

SC/54/IA3 presented estimates of minke whale abundance from the 1999/2000 IWC SOWER circumpolar cruise in Area I, which surveyed the area south of 60°S to the ice-edge, between 60° and 80°W. The analysis was conducted using standard IWC methodology (Branch and Butterworth, 2001a). Sample sizes were small, with 20 sightings in Closing mode and 20.4 in IO mode (after smearing and truncation at 1.5 n.miles). Therefore, the data were pooled over vessels and strata to obtain single effective strip half-width (esw) and mean school size estimates. The abundance estimate in Closing mode was 5,021 (%CV = 66.0) and in IO mode it was 5,857 (%CV = 39.1). To obtain a combined estimate, firstly, the Closing mode estimate was converted into a pseudo-passing mode estimate by dividing it by the estimate of R ($R = 0.826$, %CV = 8.9) and then a weighted mean average of the separate estimates was calculated. The combined estimate was 5,910 (%CV = 33.7) with a 95% confidence interval of 3,110–11,250. When ‘like-minke’ sightings were also included, the Closing mode estimate increased to 7,566 (%CV = 65.9). This 50% increase arose from the inclusion of only three additional sightings, and was mainly due to a decrease in the estimated esw. The corresponding IO abundance estimate increased by 26% to 7,403 (%CV = 40.5). These abundance estimates were multiplied by the factor m ($= 0.985$, CV assumed to be 0) to correct for movement, in contrast to the estimates in Branch and Butterworth (2001a) that did not incorporate this factor.

The sub-committee highlighted that the width of the western northern (WN) stratum spanned a large latitudinal range, thus likely spanned different minke whale densities too. It was noted that analyses in DESS are set up so that each survey mode segment on the long sections of transect between the latitudinal inter-stratum boundary and the northern boundary at 60°S represents an independent sampling unit. A reduction in the encounter rate with

decreasing latitude manifests itself as increasing the variability between sampling units in this form of analysis – an undesirable feature since this would tend to overestimate the variance in encounter rate (and thus abundance). The sub-committee **agreed** that this could be re-considered in future analyses.

Area I was previously surveyed in 1982/83, 1989/90 and 1993/94. Whilst the authors cautioned that a number of confounding factors render direct inter-survey comparisons unreliable in terms of trend estimation, the density estimates for the 1999/2000 survey are nonetheless lower than the previous estimates, particularly so in the southern strata. These comparisons and the confounding factors raised a number of questions related to longitudinal coverage compatibility. The sub-committee **recommended** that it was important to assess the longitudinal consistency of density estimates between surveys, and to gauge the scale at which different densities could be expected to be found, i.e. would a high density area seen one year on a longitudinal scale of 30° (say) be expected to be detected in another year, on the same scale, or is it more appropriate to compare densities on a smaller or larger longitudinal scale? This could be addressed by post-stratifying the data into different latitudinal strata and comparing the consistency of the resulting density estimates.

SC/54/IA4 presented estimates of minke whale abundance from the 2000/01 IWC SOWER circumpolar cruise in Areas I and VI, which surveyed the area south of 60°S to the ice-edge, between 110° and 140°W. As with that presented in SC/54/IA3, this analysis was conducted using standard IWC methodology. Small numbers of sightings in the northern strata meant that some pooling was necessary to obtain reliable estimates of esw and mean school size. Based on AIC, separate estimates of the esw and expected mean school size were obtained for each vessel. The plot of the detection function for *Shonan Maru No. 2* (SM2) in IO mode suggested that there was some evidence of rounding. Examination of the observed angles and radial distances showed that the radial distances had a more limited range (except for one sighting). This was reflected in the perpendicular distances, but there were no obvious reasons for the apparent clustering in the perpendicular distance distribution. The abundance estimate for Closing mode was 47,416 (%CV = 38.4) and in IO mode it was 28,505 (%CV = 43.5). The resulting combined Closing and IO estimate was 35,150 (%CV = 30.9) with a 95% confidence interval of 19,460–63,472. When ‘like-minke’ sightings were also included, the abundance estimate for Closing mode increased to 48,069 (%CV = 37.5) and for IO mode, it increased to 31,471 (%CV = 33.1). Previous surveys which overlap with the area surveyed in 2000/01 are 1982/83 and 1989/90 in Area I, and 1983/84 and 1990/91 in Area VI.

It was noted that there appeared to be a difference in the estimated detection functions in IO mode between the *Shonan Maru* (SM1) and the *Shonan Maru No. 2* (SM2). In principle, there should be little difference between these vessels since they have the same design and engine. However, over the years of the circumpolar surveys, the analyses presented have often found differences between the vessels, in particular a smaller estimated effective strip half-width for SM2 (Branch and Butterworth, 2001a). No operational differences between the vessels were known; neither was there thought to be differential experience between the observers on the two vessels. Nevertheless, the plots in SC/54/IA4 indicated a different searching pattern between the two boats, with SM1 observers apparently searching further ahead than those on the SM2. Best

remarked that perhaps there were more experienced observers on the SM1 than on the SM2, or the Upper Bridge observers (who would be expected to make sightings at greater angles from the track line than the topmen in the barrel) made a higher proportion of sightings on the SM2 than on the SM1. It was not possible to determine the cause of this difference, nor indeed whether the difference should be of concern at all, given the fairly low sample sizes, different observers and different conditions encountered during the survey imparting a composite effect on the fitted detection function. Some sub-committee members suggested it would be useful to look at the noise profiles of the two vessels from acoustic tests at different operational speeds to investigate whether the differences might be due to more vibration on the SM2 at typical survey speed (11.5 knots). This is of particular importance as it could provide evidence of responsive movement being the cause of the differences between vessels seen in the analyses.

Appendix 3 provides updated estimates of Antarctic minke whale abundance from the 1978/79 to 2000/01 IDCR/SOWER surveys. Three additional surveys (1998/99, 1999/2000 and 2000/01; Burt and Stahl, 2001; SC/54/IA4) have been analysed since the results in Branch and Butterworth (2001b) were published. This appendix incorporates estimates from the surveys in 1998/99 and 2000/01 into an estimate for the third circumpolar set of surveys (CPIII) but does not include the 1999/2000 survey, which re-covered a subset of the area covered by the 1993/94 survey. The third circumpolar series of surveys now encircles the Antarctic, although the surveys in Area V do not extend completely from the ice-edge northwards to 60°S. The percentage of ice-free area between 60°S and the ice-edge covered by CPI, CPII and CPIII is 63.1%, 79.5% and 91.1% respectively. The updated estimate of abundance for CPIII is 312,000 (CV = 0.086). With the additional surveys it is now possible to present estimates for comparable areas from the three CPs, similar to those in Branch and Butterworth (2001b), except that no assumptions are needed to account for differences in the longitudinal coverage between the CPs. The comparable estimates for CPIII are 43% of those in CPII. If the 'like-minke' sightings are additionally included in the comparable-area estimates, the CPIII estimate is 46% of that in CPII. Both these comparisons indicate a decrease in estimates from CPII to CPIII that is statistically significant at the 5% level, a similar result to that obtained in Branch and Butterworth (2001b).

6.2 Methodological issues that may influence abundance estimates and their trends

6.2.1 Effective search half-width and school size estimation

Discussions were divided into issues directly related to the standard method of analysing the IDCR/SOWER data and issues related to new methods that could be used to analyse these data. Issues related to the standard method are reported first.

6.2.1.1 POOLING

Last year, for biological and practical reasons, it was agreed that pooling might be done longitudinally instead of pooling by vessel, but this option needed to be investigated. Several papers address this issue (SC/54/IA5, SC/54/IA13 and SC/54/IA15).

SC/54/IA13 presented the results of an investigation aimed at assessing the effect of different pooling strategies on the estimation of abundance of Antarctic minke whales, using data from CPII and CPIII. The analysis focused upon

a comparison of results from pooling strata longitudinally in each latitudinal stratum with other pooling approaches. This pooling strategy may be preferred *a priori* on the grounds of biological evidence; it is also a plausible strategy to adopt since the two survey vessels (SM1 and SM2) are operationally very similar. Analyses of variance (ANOVAs) were conducted to test for significant differences in perpendicular sighting distance or school size between groups stratified by survey mode, vessel, year or stratum (North or South). Whilst stratum was found to have a significant effect on both perpendicular sighting distance and school size, there were no significant differences between the survey vessels (except in the 1985/86 and 1986/87 surveys when an additional vessel, the *Kyo Maru* No. 27, was used). The authors concluded that, except in these two surveys, data may be pooled longitudinally in each latitudinal stratum rather than pooled by vessel. Minke whale abundance estimates were calculated using this pooling option, and were compared with previous estimates (Branch and Butterworth, 2001a; Burt and Stahl, 2001). The revised estimates differed by a factor of -9.2% up to 46.6% of the previous estimates, providing an indication of the effect on estimation when different pooling strategies are adopted. The authors suggested that inappropriate stratification was a contributing cause for the underestimation of minke whale abundance in the third circumpolar survey.

SC/54/IA15 reported revised minke whale abundance estimates for the 1998/99 circumpolar cruise in Area IV, which surveyed the area south of 60°S to the ice-edge, between 80° and 130°E. Because of the low number of sightings, the previous estimates (Burt and Stahl, 2001) had been calculated by pooling across both vessel and strata, yielding an abundance estimate of 7,140 (%CV = 34.5). Adopting the pooling strategy suggested in SC/54/IA13, the revised estimate increased by 47% to 10,470 (%CV = 35.0). As noted previously, there are environmental and biological reasons why this strategy may be generally more plausible than pooling strata across latitudes.

SC/54/IA5 also examined the effect of different pooling strategies (and other analysis options) on the minke whale abundance estimate for the 1998/99 IDCR/SOWER survey. Two pooling options were considered: pooling by vessel and strata to obtain a single estimate; and pooling strata longitudinally as in SC/54/IA15 (for estimation of esw and of mean school size). Other options investigated were different perpendicular distance truncation distances (1, 1.5 and 2 n.miles) and different functional forms for the detection function (half-normal, hazard-rate and uniform, allowing cosine adjustments to improve the fit as required). Estimates of the average school size and the size-bias regression estimate were obtained for individual strata, by pooling over vessel and strata, and by pooling northern and southern strata. One problem with the size-bias regression method was that in some cases, the estimate of expected school size was less than one. This occurred when the detection function model was based on very few sightings. The changes in the abundance estimates from the estimates of a standard analysis, which was presented in SC/53/IA3, ranged from 0% to 23% in Closing mode and from -3% to 18% in IO mode. However, these changes in the abundance estimate are small considering the variance of the estimates.

Although SC/54/IA15 and SC/54/IA5 analysed the same data, the abundance estimates were substantially different. The reason for this can be explained by the different way in which mean school size was estimated. In SC/54/IA15 it was

estimated using the mean (average) of the observed confirmed school sizes in Closing mode from each stratum (because the regression of $\log(\text{school size})$ against estimated detection probability yields a mean school size of less than unity, a biologically implausible result). In SC/54/IA5, the size bias regression estimates of mean school size by stratum were used. It can be argued that a model that produces a biologically implausible estimate should not be used; this is particularly true when a single 'best' estimate is the objective. However, if the objective is a comparison of a series of estimates over time, then similarly one could argue that biologically implausible estimates are occasionally acceptable so that the distribution of parameter estimates is not biased.

SC/54/IA32 presented AIC estimates for different pooling options for the IDCR/SOWER surveys. AIC values were obtained from the fit of the hazard rate model for sightings with confirmed and unconfirmed school sizes. The following pooling options were compared: no pooling; all strata separate; by vessel (strata surveyed by the same vessel pooled together); north vs south strata; and east vs west strata. Three pooling strategies based on these options were also examined: use of the minimum AIC in Closing mode; preferentially pooling by vessel when sample sizes were too small; and preferentially pooling by north vs south when sample sizes were too small. The last two strategies had very similar overall AIC values, and it was shown that the north vs south strategy, with minor modifications, performed better than the vessel strategy based on AIC. The changes in pooling using the north vs south strategy only increase the ratio of abundances from CPIII/CPII by a multiplicative factor of 1.04 compared to the estimates using the standard method (vessel strategy).

In conclusion, the sub-committee noted that whilst different analysis options may produce different point estimates, it would be unlikely that these differences would generally be substantial, even if they happened to be so for a particular dataset. It endorsed the view that decisions regarding general methodology should be based upon data from more than one survey, and pooling should not solely be based upon statistical criteria, but also on biological or environmental evidence, when available. Sometimes, this strategy should be adopted even if it leads to higher variance estimates.

6.2.1.2 POTENTIAL COVARIATES

SC/54/IA17 investigated the effects of sighting conditions (school size, sighting cue, latitude and sea state) on Antarctic minke whale abundance estimation parameters (effective search half-width, sighting forward distance and mean school size). As school size decreased, the effective search half-width and the sighting forward distance decreased. Cues from schools of size one or two were usually body, which is generally considered more difficult to find in high sea states as compared to blow cues. The proportion of schools of size one or two increased with decreasing latitude. Small school sizes and bad weather conditions prevailed in the northern part of the survey area. Because the survey area was extended northwards in the third circumpolar survey, the effects of small school size and bad weather conditions were substantial. Assuming that the maximum dive duration of the Antarctic minke whale was 7.33 minutes (Joyce, 1982), the sighting survey vessels were estimated to steam 1.4 n.miles during the diving time. Because the sighting forward distance of schools of size one and two is usually less than 1.4 n.miles, a portion of diving animals will be missed by the

observers. This is supported by differences in $g(0)$ (SC/54/IA10) and in the number of duplicate sightings (SC/54/IA16) between these schools and larger ones. Therefore, the assumption is that $g(0) = 1$ is not appropriate, at least for schools of size one or two. Current abundance estimates for the Antarctic minke whale make this assumption, and are thus negatively biased. Although an effect of Beaufort sea state was also indicated in SC/54/IA17, the proportion of sighting effort allocated to a given Beaufort sea state is not known. The authors therefore suggest a change in DESS that enables extraction of the sightings and effort data by weather conditions, so that the extent of the effect may be compared between the second and third circumpolar sets of surveys.

While the sub-committee agreed with the conclusion that the proportion of schools with one or two animals appears to have increased in the northern strata, it also noted that the proportion of these schools in the southern regions has also apparently increased. Prior to completion of the third circumpolar survey, it is difficult to interpret some of these results as presented, because they may be strongly influenced by a particular survey area. For example, Area V East has not yet been surveyed, and this Area contributes a large proportion of the sightings at high latitudes. The sub-committee noted that a comparison of the effects based on distance from the ice-edge rather than latitude would have produced more meaningful comparisons. This is highlighted by the higher number of sightings in the latitudinal band between 60-62°S in CPII compared to the number in that band in CPIII. Further investigation revealed that the reason for this is that 68% of the sightings in that band from CPII were from Area II, where the ice-edge extended much farther north than it did when the vessels surveyed there in CPIII. The increase in the number of body cues between the two sets of surveys was interesting; whilst it was agreed that this could be due to the increased number of solitary animals, it was also noted that there were other plausible explanations. The authors concluded that the higher proportion of like-minke sightings in CPIII was due, at least in part, to a shorter forward sighting distance, particularly for those schools of size one or two. This is one reasonable explanation, but the fact that these schools also have a higher probability of a body detection cue also means that they are less likely to be identified as like-minke (since the classification to like-minke is usually because only the blow has been seen and not the body). Nevertheless, sightings detected close to the ship can also be cued by a blow, although this is less common than a body cue.

There was discussion about which additional covariates might be useful. Glare has always been recorded (but the method used to record it changed in CPIII), and sea state is recorded in CPIII. Visibility of minke whale blows (recorded in n.miles) may be a better covariate than sightability (subjective, coded 1-5). Sightability was recorded by whaling vessels before the IDCR/SOWER surveys and was therefore continued for consistency. Some members believed that this subjective covariate would not be useful for explaining heterogeneous detectability. Others considered that no covariate should be excluded *per se*, and that such decisions should be data driven. Zeh commented that a similar subjective covariate recorded on the shore-based bowhead whale surveys had been more useful in explaining heterogeneity than any single objective covariate, or combination of these. There was also discussion about whether combining factors into a 'synthetic sightability' value might be the best variable to input into analysis methods. There was no *a priori* reason as to which type of

covariate was most appropriate, regardless, it was agreed that the IDCR/SOWER data should be used to determine which covariate or group of covariates provides the best estimate of optimal sighting conditions and should be included in a method to estimate abundance. The sub-committee **recommended** that a synthetic sightability variable be investigated.

In concluding the discussion, the sub-committee **agreed** that SC/54/IA17 provided evidence supporting the assertion that $g(0)$ could be less than one, at least in some of the circumstances investigated, and covariates that should be considered in future analyses include sighting cue, observer experience, survey mode, sightability, Beaufort sea state, school size, distance from ice and stratum (North or South).

6.2.1.3 METHODS TO INCORPORATE COVARIATES

Five papers (SC/54/IA1, SC/54/IA10, SC/54/IA21, SC/54/IA23 and SC/54/IA29) presented new methods that incorporate covariate information into the estimation of school size and effective strip half-width. Three of these papers (SC/54/IA1, SC/54/IA10 and SC/54/IA21) presented methods that incorporate covariates and estimate density, and are discussed under Item 6.2.3.

SC/54/IA29 explored the use of the covariate estimation framework available in Distance 4 (Thomas *et al.*, 2001) for improving detection function estimation in the computation of minke whale abundance estimates for the IDCR/SOWER surveys. Survey stratum is used as a covariate to admit some variation in the scale parameter of the hazard-rate detection function when data have to be pooled across strata as a result of small sample size, but this failed to improve the fit (i.e. reduce the AIC). Appendix 4 looks at data from the second circumpolar set of surveys, and shows that including covariates when estimating the search half-width improved the fit in all cases except when weather was included. In all cases, the AIC value was lower for the hazard-rate model than for the half-normal. A correlation matrix was obtained between all the covariates; although most factors were significant, correlations >0.2 were only obtained for sightability with weather and wind speed, and confirmed sightings with Closing mode.

The sub-committee suggested that at least for analyses using the 'standard methodology' (Branch and Butterworth, 2001a), other factors could be investigated in the regression. In particular, because of differences in environmental conditions in minke whale density and school size distributions between the northern and southern strata, a stratum factor (or an equivalent descriptor such as distance from ice) might be expected to have an effect. Whilst the sub-committee agreed that stratifying by circumpolar set was a viable option when using the standard methodology, the density-dependence of the source of the bias from the Closing mode survey suggests alternative stratification options should also be investigated.

SC/54/IA23 investigated generalisations of size bias regression methods for estimating school size from line transect data. Currently, the most robust method is to regress the logarithm of observed school sizes ($\ln(ss)$) against the estimated detection function, $\hat{g}(x)$, where x is the perpendicular sighting distance. The following four generalisations of this methodology were considered: (1) increasing model flexibility in perpendicular distance models (using generalised linear models (GLMs) and generalised additive models (GAMs)); (2) including a regional factor such as stratum as a scale parameter in the

detection function, and then regressing $\ln(ss)$ against the resulting estimated detection probability, $\hat{g}(x, stratum)$, where *stratum* was a two-level factor representing northern and southern strata; (3) an extension of (2) to include a factor denoting the confirmed/unconfirmed status of a sighting; and (4) fitting a detection function based on x only (with obvious extensions to include other covariates), but including spatial covariates in a GAM-based size bias regression model to obtain a spatial surface for school size.

The methods were illustrated using data from the 1999/2000 and 2000/01 IDCR/SOWER circumpolar surveys. There appeared to be little gained from applying GLMs or GAMs in the perpendicular distance based model. However, the inclusion of a regional effect in the detection function did provide improvement over the perpendicular distance only approach, yielding increased precision, and possibly more reliable estimates. Including unconfirmed sightings did not appear to work well. One possible reason for this is that the methods assume certain detection on the track line, which may not be valid for these sightings, but further investigation is required. The spatial model for school size was provided for illustrative purposes only, but it seemed to produce biologically plausible results, and this method may potentially be of use in combination with spatial models of school density.

The sub-committee saw this as a promising way to extend the standard method that could produce less biased abundance estimates and could be incorporated relatively easily into DESS. However, the method would have to be evaluated with respect to its robustness and accuracy.

Further discussion on these two methods is reported in Item 6.2.3.

6.2.2 Closing-IO mode correction factor

The general purpose of estimating the Closing-IO mode density ratio (R) is to correct for bias caused by surveying in Closing mode rather than Passing (here, IO) mode. In Closing mode, there is no observer in the IO platform; this reduction in effort is likely to increase the likelihood that the $g(0) = 1$ assumption is not met, producing negative bias. Additionally, depending on the local clustering of whales, bias can occur in opposite directions (Haw, 1991). Usually negative bias is induced: this situation arises when (secondary) sightings are made during confirmation of a primary sighting, and these secondary sightings are 'lost' from the analysis, since they were not made from the trackline. Positive bias is induced when Closing on a primary sighting draws the vessel towards animals that would not otherwise have been seen from the track line, but are seen (and may be recorded as primary sightings) when the vessel has finished confirming the original primary sighting and has resumed full search effort.

Using regression methods, SC/54/IA26 investigated possible changes in R for minke whales on the IDCR/SOWER surveys with: (1) time; (2) the inclusion of like-minke sightings; and (3) whale density. It was shown that estimates of (average) R for minke whales (which ignore any whale density effect) were generally identical for CPII and CPIII, but lower (though not significantly so) for CPIII when like-minke sightings were also taken into account. Analyses suggested that R for minke whales decreases with increasing whale density, but this effect is not significant. For pragmatic reasons, the authors suggest that adopting different R estimates for specific time periods (e.g. one estimate for CPII and one for CPIII) avoids the problem of

continual updating of the historic abundance estimates as more data by which to calculate this ratio become available. The sub-committee **agreed** with this conclusion.

6.2.3 $g(0)$

SC/54/IA16 investigated whether evidence exists that $g(0)$ does not equal one, and what factors influence the estimate of $g(0)$. SC/54/IA10, SC/54/IA21 and SC/54/IA1 discussed new methods designed to estimate density by incorporating effects of covariates and by assuming $g(0)$ does not equal one.

SC/54/IA16 compared duplicate sighting rates for minke, blue, humpback and southern bottlenose whales. The first part of the analysis used generalised linear models (GLMs) to explore the effect of different factors on the probability of a duplicate sighting of that species; the second part investigated any change in these probabilities between the second and third circumpolar surveys. It was found that the effect of school size on the probability of duplicate sightings was statistically significant for minke, humpback and southern bottlenose whales; the larger body size and highly conspicuous blow of blue whales meant that even solitary animals could be easily detected. For minke whales, the probability of a duplicate sighting for schools of size two was 1.56 times larger than for solitary animals (95% CI = 1.21-1.78), and for schools of three or more animals, it was 1.84 times larger (95% CI = 1.68-1.93). Thus, there is strong evidence that $g(0)$ depends on school size.

For minke whales, the duplicate sighting probability was generally about 20% smaller in the third circumpolar survey compared to the second, with this effect being more appreciable for the northern strata. One reason for this may be because solitary whales constitute a greater proportion of the schools in the northern regions, and survey effort was extended northwards in the third circumpolar survey. A similar reduction was found for humpback whales; this suggests the possibility that humpback and minke whales have similar habitat preferences.

Further computations by Mori and Butterworth along the same lines set out in SC/54/IA16 suggested that as the visibility improves, the probability of a duplicate sighting tends to increase, and the trend is significant at the 5% level. There is a similar (but decreasing) trend with sea state, though this is not significant, and a weaker trend with sightability, for which variation may not change in a systematic manner. It was noted that in excellent sighting conditions, whale surfacing behaviour changes in such a manner that they become more difficult to observe. This may confound analyses based on Beaufort sea state.

In discussion, there was agreement that $g(0)$ differs by school size, but the difficulty remained of how this issue should be dealt with in analyses. The issue is complicated by the fact that in IO mode (which has traditionally been the mode used to estimate $g(0)$), there is negative bias in the size of recorded schools – a large proportion of which are unconfirmed. It was noted that data from Closing mode, for which the recorded school sizes are thought to be unbiased, could be used to calibrate the recorded IO mode school sizes.

SC/54/IA16 also provided further evidence that even after correcting for school size effects, there were residual effects impacting on detection probability between CPII and CPIII. As noted above, these effects are likely, at least in part, to be caused by the areal coverage being further north (and thus generally encountering worse weather) in CPIII. This is illustrated, for example, by a decrease in relative duplicate sighting probability of humpback whales between the

southern and northern strata (since the school size distribution of humpback whales between these strata is more similar than that of minke whales).

SC/54/IA21 introduced a new method for estimating abundance designed to account for variations in $g(0)$ caused by size bias, changes in school size distribution, and changes in sighting conditions. The method (the 'Big Beautiful Model') assumes that $g(0)=1$ for large ('Big') schools irrespective of sightings conditions (up to some threshold), and also that $g(0)=1$ in good ('Beautiful') conditions irrespective of school size. For every other combination of school size and sighting conditions, $g(0)$ is estimated from comparisons between frequency distributions of school size, subject to a set of ordering constraints which ensure that estimates of $g(0)$ cannot increase as schools get smaller or conditions worsen. The frequency distribution of school size is estimated simultaneously, as a spatially-varying probability distribution. The basic idea is that if $g(0)$ is constant, then frequency distributions of observed school size within any small area of sea should be the same under all sighting conditions, after correcting for strip width estimated from a conventional line transect analysis stratified by school size and conditions. With IDCR/SOWER data however, the ratio of large minke whale schools to small minke whale schools increases as conditions worsen, even after allowing for strip width. This change in ratio allows $g(0)$ to be estimated by school size, at least relative to 'Beautiful' conditions. At the same time, the strip-width-corrected frequency distribution from 'Beautiful' conditions within a small area of sea provides an unbiased estimate of the true school size frequency in that area. In practice, sample sizes are very limited within small patches of sea, and 'Beautiful' conditions are not found everywhere, so the simultaneous calibration of $g(0)$ together with estimation of school size exercise must be turned into a formal statistical procedure that allows school size distribution to change continuously but slowly with location.

The relevant estimates from this part of the modelling are mean school size (varying with location), and effective strip width for schools. The esw is averaged across the local distribution of school size frequency, and so will vary with location as well as sighting conditions along the trackline. Continuously-varying esw can be used as a covariate in a spatial model of school sighting rates (Bravington, 2000a; b) to estimate a school density surface, which can then be multiplied by the mean school size surface and integrated over location to estimate total abundance.

The Big Beautiful Model provides estimates of $g(0)$ independent of double-platform data (conditional on assumed values of $g(0)$ under 'Beautiful' conditions or for 'Big' schools), and to that extent avoids some of the complexities and sensitivities associated with double platform estimation. If double-platform methods can provide reliable independent estimates of $g(0)$, these can be inputs to the model instead of outputs, with school size distribution still being estimated, to give spatially-varying school strip widths and mean school sizes as the ultimate outputs. Prior distributions on $g(0)$ can be accommodated similarly. The Big Beautiful Model and double-platform methods may be viewed as complementary approaches, and are useful for cross-checking estimates.

Stratification by school size and conditions should remove most of the factors that influence year-to-year variability in strip width, so for strip width purposes it is reasonable to apply the Big Beautiful Model to data from several years and strata simultaneously, perhaps including terms to

accommodate vessel and activity mode effects. The final step of the modelling (school density estimation) needs to be applied separately to each year.

Currently, the method assumes unbiased estimates of school size, and is therefore potentially sensitive to the underestimation of school size known to occur in Passing Mode. It is possible to estimate school size distribution based on Closing Mode data alone. However, since Closing and Passing modes are liable to have different strip widths because different platforms tend to be used, further work would be required to develop unbiased strip width estimates for Passing Mode stratified by true school size, which are required for estimating school strip widths.

With a stratified survey design, it is also possible to replace the spatial school density estimation step of the Big Beautiful Model by a Horvitz-Thompson-like estimator of total abundance, which should be roughly unbiased under the 'Big' and 'Beautiful' assumptions. Although in theory this should be less efficient than a full spatial density estimator, it may avoid some of the practical difficulties associated with choosing the scale of smoothing and misbehaviour of smoothing functions near the edges of the region of estimation.

The sub-committee welcomed this approach, noting that it introduced methodology for estimating abundance when $g(0)$ was less than unity, from either single or double platform data.

Butterworth inquired as to why spatial modelling methods appeared to provide little or no improvement in precision compared to stratified approaches, at least for analyses of IDCR/SOWER minke whale data. There was some discussion on this issue, but it was generally agreed that it is not really possible to make that assertion at present, since the methods have not yet been compared using simulated data (when the true variance is known). It was suggested that comparing the magnitude of (unknown) variance estimates was not in itself an appropriate way to evaluate different methodologies; rather, the accuracy (unbiasedness) of estimates from different methods was also an important consideration. Bravington remarked that spatial modelling potentially provides a better insight into true uncertainty than stratified estimation, since the latter tends to yield fluctuating estimates of variance. However, in his experience, developing well-behaved spatial estimators can be difficult. Five linked issues requiring further work were raised.

- (1) Estimating variance (dealing with clustered sightings, and incorporating uncertainty from earlier steps in the analysis, e.g. in effective search half-width).
- (2) Choosing the scale of smoothing, when sightings are clustered on small spatial scales.
- (3) Allowing for spatial variation in the scale of smoothing, perhaps linked to localised environmental factors.
- (4) Changing the form of the underlying smoother, e.g. to accommodate non-smooth changes in density.
- (5) Restricting the fitted density surfaces to realistic values in regions of rectangular strata that are far from the zigzag track.

The sub-committee **encouraged** further intersessional work on these issues.

SC/54/IA10 introduced a relatively simple hazard probability model using perpendicular and forward distance data for double-platform line transect surveys in which the independent observers have the same visual searching area. This model can provide an abundance estimate of diving animals without the assumption of $g(0)=1$, and takes

account of unmodelled heterogeneity derived from the whales' surfacing behaviour. The likelihood function of the proposed model is an extension of that in Skaug and Schweder (1999). As in Cooke (2001), the proposed hazard probability method needs explicit distinction between simultaneous and delayed duplicates, and this enables the mean surfacing rate to be estimated without any additional external data. The proposed model may be viewed as an integration of the Skaug and Schweder (1999) and Cooke (2001) approaches, but is more general and tractable. It may be easily extended to a model with only perpendicular distance data or to include data from incompletely independent observers (such as the front or upper bridge observers on IDCR/SOWER surveys). Furthermore, additional covariates may be incorporated into the parameters of the hazard probability function, providing increased flexibility in the model. Parameter estimates for the detection function are obtained via maximum likelihood and estimation of abundance is based on the Horvitz-Thompson estimator.

A simulation study and an application to IDCR/SOWER sightings data suggested that the proposed method performed well. In particular, simulation tests indicated that using other available data, such as incompletely independent observer sightings data and mean surfacing rate estimated from external data, performance of the model can improve. The ability to utilise the incompletely independent observer data is important because these data can be collected at little extra cost to the survey, and in almost the same setting as conventional line transect surveys. The provisional results from applying the model to IDCR/SOWER minke whale sighting data when $g(0)$ is assumed to be one and when it is not, yielded considerably different abundance and trend estimates. Evidently, the development of reliable methods to estimate abundance when $g(0)$ is less than one is important for accurate trend estimation.

SC/54/IA30 examined the discrepancy in whale density between the true value and an estimate assuming that $g(0)=1$, using a simple mathematical equation. Whale density was defined as the product of the school density estimate and mean school size. Estimates of $g(0)$ from the 1989/90 and 1993/94 IDCR/SOWER surveys (SC/54/IA10), stratified by school size class (1, 2, 3+), were assumed to apply for all years in CPII and CPIII surveys respectively. This approach was taken for illustrative purposes only; clearly it is preferable to estimate $g(0)$ separately for each survey. The discrepancy between density estimates which assumed that $g(0)=1$, and those which used $g(0)$ stratified by school size class, ranged from -18% to -39%. The authors noted that precision would be expected to decrease when abundance was estimated using the stratified estimates of $g(0)$, this approach was considered to provide an unbiased estimate of abundance of the whole stock size. They therefore concluded that some development of methods for estimating mean school size was necessary.

The sub-committee **agreed** that SC/54/IA10 and SC/54/IA30 provided further evidence that $g(0)$ does have a large effect on estimation, and that estimates which fail to incorporate this may be unreliable.

Some details of the simulations specifically conducted in SC/54/IA10, and the analyses therein, were discussed. The results presented were considered preliminary by the authors, the main aim of the paper being to introduce the methods. The key points raised were: (1) the improvement in precision obtained when the IO Platform data were added to the model was likely to be an artefact of increasing sample size (since a common detection function was assumed across

all platforms); (2) school size was not included in the current simulation (although this is planned – with simultaneous surfacing of all animals in a school); it is however presently incorporated as a covariate in the model; (3) the reversal of the trend in abundance estimates seen when comparing those from the proposed methods and those from Branch and Butterworth (2001b) was not fully understood – in particular, neither the difference in the methods used to estimate school size, nor $g(0)$ estimation, were thought to be responsible – it seemed most likely that the reversal was a result of different stratification options used in the analyses; and (4) the apparent gain in precision using the proposed methods compared to the standard methods was due to assuming independence between sightings, which is invalid in the presence of clustering.

SC/54/IA1 reported progress on development commissioned last year (IWC, 2002b, pp.224-225) of methods for: (1) estimating strip width without the assumption $g(0)=1$; and (2) estimation of additional variance. Estimation of strip width was based on the method described and tested in SC/53/IA31, which the sub-committee had recommended last year for application to these data (IWC, 2002c, p.199). The two tasks were addressed together using the integrated modelling framework outlined in Cooke and Leaper (1998). The method for treating the three platforms on IDCR/SOWER cruises was similar to that used in SC/54/IA10. The data collected in IO mode are necessary for the estimation of $g(0)$, but school sizes estimated in this mode appear to be biased low, hence a method was developed for allowing for school size bias in the estimation. The strip width and school size estimation was linked with an estimation of a whale density surface for derivation of abundance estimates and covariates that were input into a model for the estimation of additional variance.

The sub-committee noted that this method looked very attractive because it would likely be able to extrapolate to unsurveyed areas, simultaneously accounting for all the potential covariates that have been discussed. However, it was uncertain whether this method performed well. Technical issues of concern included: how was the changing ice-edge in the non-symmetrical Antarctic study area incorporated into the Fourier series; was there a conflict between estimating the overdispersion term and automatically selecting the terms for the smoothing function; what should the most appropriate scale for smoothing be; should that scale vary depending on the amount of variability in a region (i.e. more is going on near the ice-edge) and the distance from an edge (which can cause problems with smoothers)? After discussion, it was concluded that further work should be able to resolve these technical issues.

The sub-committee welcomed all the new methods, encouraged further development and simulation testing of these (and any other) methods, and looked forward to seeing the results from applying them to the IDCR/SOWER data.

It was also **agreed** that the performance and robustness of any new method should be evaluated. Some new simulation datasets will have to be created for this purpose, since they were originally designed for testing North Atlantic minke whale analysis methods, and these data are collected in a somewhat different way from IDCR/SOWER data. Some of these changes will be minor: a detection function to simulate upper or front bridge observers' sightings, for example. Other changes would require more thought: an appropriate way to generate Antarctic minke whale school size distributions and surfacing patterns (as well as detectability based on school sizes and other covariates). Best informed

the sub-committee that there are empirical data available on Antarctic minke whale surfacing rate, but not on dive times obtained from telemetry studies. Furthermore, he cautioned that in reality, the *cue rate* of minke whale surfacings would be weather dependent, since most distant sightings are blow cues, and these can become less visible in good weather (when body cues predominate). To further complicate matters, the fact that recorded school sizes in IO mode tend to be negatively biased estimates of true school size was raised, and its effects should be considered and if possible, accounted for. A more complete description of factors to be included in the simulated datasets is given in Appendix 5.

The sub-committee **recommended** that simulated datasets be used to evaluate any method that might be used to analyse the IDCR/SOWER data, including the standard method. In addition, the sub-committee **recommended** that further development of the standard method is, at this time, lower priority than evaluating the performance of the new methods. The sub-committee also **agreed** that when all the circumpolar data are available, these data are analysed by the standard method, and by any new methods found to be robust to the heterogeneities introduced into the simulated data. Also, the sub-committee **recommended** that results of methods when applied to both simulated and actual IDCR/SOWER data be presented at next year's meeting.

6.2.4 Observer effects

SC/54/IA16 investigated the effect of observer experience on duplicate sighting probabilities. When inexperienced observers (those with experience of less than five surveys) were observing from the IO platform, the duplicate sighting probability was 20% less than when observers with at least five years experience were there. This effect was not statistically significant, but sample sizes were quite small.

Whilst recognising that differential observer experience is a quite plausible explanation for changes in the duplicate sighting probabilities, the sub-committee noted that, as in analyses presented last year, the effect is difficult to tease out from the data. This is because (1) there is a deliberate strategy to try to avoid having inexperienced observers in the IO Platform; and (2) there appears to be little difference in sighting efficiency from the barrel between two experienced observers, and an inexperienced observer combined with an experienced observer. In conclusion, the sub-committee **agreed** that the hypothesised observer experience effect contributes less to differences in $g(0)$ than school size does, but observer experience (or team experience) should remain under investigation.

6.3 Inter-year comparisons

6.3.1 Timing of the surveys

SC/54/IA12 presented information from JSV data in Areas III, IV and V using GLMs to determine the migration pattern and extrapolate the abundance estimate into the northern unsurveyed area. Following the suggestion from the 2001 Scientific Committee, the 1960s data were excluded because minke whales were not always reported in those years. The analysis included data from 1971/72 to 2000/01, adding new data from the more recent IDCR/SOWER and JARPA surveys to estimate the mean probability of presence. Five factors were considered as covariates: latitude; longitude; time; season and Beaufort wind force. AIC was used to select the final model. The authors concluded that in the 1970s, the peak of migration was in late January; in the 1980s, it was bimodal, in mid-January and mid-February; and in the 1990s, it was also bimodal, in late December and mid-February. The paper suggests that the migration peak is

now later in the year than it was in the 1970s, but this may be due to the distribution of search effort changing over the period considered.

Kato noted that an earlier study by Shimadzu using a dataset from the 1970s found that CPUE changes showed a consistent peak of migration in January, which is somewhat different than the results of this analysis.

There was general discussion about potential problems with this analysis, including the differing nature of the data sources. JSV data from the 1970s are in the form of daily presence/absence records that are collected in Passing mode. Sightings were recorded from sunrise to sunset. This source has more substantial effort north of 60°S during January and February, the time of the IDCR/SOWER surveys. In contrast, the IDCR/SOWER survey (1980s and 1990s) is conducted in Closing mode and the JARPA data from the same period is a mixture of Passing and Closing mode. These latter sources of data were collected only during transits to and from the Antarctic, have generally poor coverage north of 60°S during January and February, and had a maximum of 12 hours of sighting effort per day. In addition, there were different numbers of observers so it is difficult to compare density estimates from one data source to another. It was suggested that including a covariate for JSV vs IDCR vs JARPA might help make the analysis more robust. Nevertheless, because of data source problems, any results would necessarily be rough.

SC/54/IA28 presented a GLM analysis of minke whale density estimates on a daily basis from IDCR/SOWER surveys from 1978/79 to 1997/98. The effects of survey mode, latitude, year and Management Area are included, to attempt to determine the trend in minke whale density in the Antarctic during the austral summer season. Results for this pattern are smoother than were obtained from the analyses of Butterworth *et al.* (2001), which considered the density data on a coarser per-stratum basis only. Nevertheless they do not confirm the pattern suggested by earlier CPUE and sightings analyses of a drop in density from late January. Rather, a drop was seen only after mid-February. The magnitude estimated for this drop is only 20%, but a larger real drop may be masked by a possibly confounding year effect. It was suggested that the inclusion of a year-date interaction term might help with this confounding effect.

SC/54/IA7 noted that this shift in timing of migration was in the December to January period when the annual decrease in sea-ice extent is most rapid and divergent. The author indicated that inter-annual climatological oscillations that affect variability in ice coverage may have indirectly affected the timing of the minke whale migration through changes due to, for example, prey availability or changes in the relative amounts of open water, ice-edge and pack ice habitats.

The reason the timing of the minke whale migration was being investigated was to determine if the recent change in timing of the IDCR/SOWER surveys affects the estimated abundance (IWC, 2002c, p.199). Given these new results, the sub-committee concluded that changes in survey timing likely had only a small impact on abundance estimates.

6.3.2 Dealing with variable partial coverage

6.3.2.1 EXTRAPOLATION TO UNSURVEYED REGIONS

Discussion of this topic is covered below.

6.3.2.2 USING JSV DATA

SC/54/IA12 extrapolated densities from the IDCR/SOWER (south of 60°S) area to northern areas covered by the JSV cruises (30°S-60°S). Assuming no difference in conditions,

such as weather, the extrapolation rate was calculated as the ratio of the index of abundance between the northern area and the area south of 60°S. This ranged from 5% to 18%. Using estimates from CPII, the population in the northern area is estimated to be about 320,000 in Areas III, IV and V. This may be positively biased, because the sightings in the northern area may include both Antarctic and dwarf minke whales. The authors conclude that a large number of minke whales are in the area between 30°S-60°S that is not surveyed by the IDCR/SOWER vessels.

6.3.2.3 USING JARPA DATA

SC/54/IA14 compared trends in Antarctic minke whale abundance between JARPA and IDCR/SOWER surveys in Areas IV and V. It reported that the trend in abundance estimates from the JARPA surveys (Hakamada *et al.*, 2001) in both Area IV (six surveys examined for the period 1989/90 to 1999/2000) and Area V (six surveys examined for the period 1990/91 to 2000/01) were not significantly different than zero. In contrast, abundance estimates from IDCR/SOWER surveys showed a negative trend in these Areas, but the time period extended from several years earlier (1978/79 for Area IV; 1980/81 for Area V) and the surveys were less frequent. The authors suggest that JARPA surveys may better reflect the trend in abundance for minke whales in these Areas for the following reasons: (1) the estimates of abundance from the IDCR/SOWER surveys in the third circumpolar survey are negatively biased estimates of true minke whale abundance and thus the downward trend is exaggerated; (2) there have been more JARPA surveys in these Areas than IDCR/SOWER surveys; and (3) there is more consistency among JARPA surveys than among IDCR/SOWER surveys in terms of the survey method, and geographical and temporal coverage of the surveys.

SC/54/IA11 re-emphasized that $g(0) < 1$ and $g(0)$ depends on the school size, weather conditions, the sighting cues and other factors. These factors appear to have changed between circumpolar periods. These changes could have occurred due to survey design or to biological changes, such as an indirect effect of other baleen whales or environmental changes. The authors pointed out that estimates of abundance in Areas IV and V by JARPA data are much more stable than those from the IDCR/SOWER data for the reasons stated above. They also suggested that frequent and consistent surveys were a necessity to obtain reliable abundance estimations.

The sub-committee considered that the temporal incomparability and survey design differences between the IDCR/SOWER and JARPA surveys rendered direct comparisons between their trend estimates inappropriate. Another reason is that the previous discussions on $g(0)$ and covariates relate to the abundance estimates of both IDCR/SOWER and JARPA, however it is unknown if the effects are similar for the two types of surveys. However, the greater consistency of the JARPA surveys suggests that they may not only provide useful trend data for the period over which they took place, but may also provide information on additional variance for analysing other datasets. For example, the sub-committee noted that until the 1999/2000 JARPA survey, the estimates from Area IV showed evidence of a decline. However, the 1999/2000 abundance estimate was more than double the estimate of that from the previous survey in 1997/98. The reason for the differences in the estimates can largely be attributed to different areal coverage: in the 1997/98 JARPA survey, Prydz Bay was inaccessible due to pack ice, whilst in 1999/2000, the ice had retreated much further south. This example highlights the need for an assessment of which data are required when

interpreting trend, so as not to over-interpret significant differences in estimates which may have a physically plausible explanation.

6.3.2.4 USING OTHER DATASETS

The potential utility of data from other Antarctic surveys in relation to estimating density (or density indices) of minke whales south of the southern boundary of the IDCR/SOWER surveys (traditionally referred to as the 'ice-edge') was discussed. This is reported in Item 6.3.3.1.

6.3.3 Other factors that may influence inter-year comparisons

6.3.3.1 ANIMALS WITHIN THE PACK ICE

The survey ships used to collect IDCR/SOWER data cannot survey within the pack ice at normal survey speed. It is known that minke whales are within the pack ice during the time period that the IDCR/SOWER surveys are conducted. Therefore, the IDCR/SOWER surveys do not cover the entire minke whale habitat. However, it is not known what the magnitude nor inter-annual variability of the abundance in the pack ice is. The sub-committee attempted to quantify these unknowns using a variety of data sources.

The term 'ice-edge' as defined in relation to the IDCR/SOWER surveys is different than that used by sea ice modellers. For clarity, the following definitions are used in this section: 'Marginal ice-edge zone' (MIEZ) is the region where algal blooms occur, krill congregate and minke whale abundance is highest; 'Pack ice' is a complex structure of patches of ice and open water and does not just have a simple edge; 'Ice-edge' is merely the southern boundary of the IDCR/SOWER survey region, and is defined by a level of ice cover that prevents the survey from being conducted at normal survey speed (11.5 knots).

SC/54/IA7 provided a general overview of the relationship between ice coverage and climatological indices. The author of SC/54/IA7 noted that present Antarctic minke whale assessments cannot be deemed comprehensive since the IDCR/SOWER surveys were conducted in open water areas only. Inter-annual and decadal variability, as well as longer-term trends in climate could contribute to changes in abundance estimates for Antarctic minke whales in open water. Trends in Antarctic sea-ice are highly regionally specific, and therefore the response of minke whales is also likely to be highly regionally specific. For example, trends of warming and loss of ice are greatest in the Antarctic Peninsula region (Bellinghausen Sea and Amundsen Sea) and part of the Ross Sea. Ice extent is partly due to linkages between extrapolar climate and the Southern Oscillation (SO) and the El Niño-Southern Oscillation (ENSO). The author proposed that surveys should be conducted in both the pack ice and open water to determine the percentage of minke whales in the ice, relative to open water, under different regional conditions of ice extent and ice coverage. Because of these uncertainties, the author advised a precautionary approach to Antarctic resource management.

Additional information was provided on climatological indices and their linkage to Antarctic sea ice. Twice annually, the circumpolar trough of low pressure that encircles Antarctica expands and weakens from March-June and from September-December; it contracts and intensifies from June-September and December-March. This is the SAO (Reuter, 1936; Van Loon, 1967). Years with weak SAO include 1968, 1969, 1981, 1985, 1989, 1993 and 1998. Years with strong SAO include 1964, 1974, 1975, 1976, 1977, 1982 and 1990. By the late 1970s the magnitude of

SAO had decreased. The Antarctic Oscillation Index (AOI) (Gong and Wang, 1999) is the normalised zonal mean sea level pressure difference between two latitudes (40°S and 65°S). The Southern Oscillation Index (SOI) (Kwok and Comiso, 2002) is the see-saw in the surface pressure anomalies between the Indian Ocean-Australian region and the southeastern tropical Pacific on a seasonal and inter-annual time scale. The El Niño Southern Oscillation (ENSO) had four main episodes in 1983, 1987, 1992 and 1998, with an unprecedented event from 1990-1995.

A list of environmental covariates available from satellite imagery for the period November 1978 to August 1987 was also provided: Scanning Multichannel Microwave Radiometric (SSMR); and from June 1987 to the present, Special Sensor Microwave/Imager (SSM/I). The list of covariates includes, in addition to the climatological indices summarised above, the following indices:

- (1) Sea ice-edge: e.g. monthly mean sea ice-edge, equator-most position of the 30% isopleth of ice concentration in each degree of longitude (Yuan and Martinson, 2000).
- (2) Sea ice-edge anomaly: monthly, removes seasonal cycle, contains inter-annual and longer-term variability as well as linear trends (Yuan and Martinson, 2000).
- (3) Ice concentration: 25km × 25km grids.
- (4) Ice area.
- (5) Sea ice motion.
- (6) Ice thickness.

The sub-committee agreed that this information introduces some hypotheses for changes in open water abundance of minke whales; however, more research and data from the pack ice is needed to test the hypotheses. In the meantime, correlation analyses between open water abundance estimates and environmental factors (e.g. ice extent, ice coverage) may help to develop functional/biological connections between climate, ice, productivity (e.g. chlorophyll) and minke whale abundance.

SC/54/IA6 presented results of an analysis of the annual Southern Ocean Cetacean Ecosystem Program (SOCEP) cetacean survey, which was conducted from the *R/V Aurora Australis* together with the Australian APIS survey. The survey was conducted from 3-28 December 1999 within the pack ice starting at (64°23'S 150°50'E) and travelling westwards through the pack ice to Davis Base (68°34'S 77°50'E). The target species was seals, not cetaceans. Three observers surveyed for both seals and cetaceans. Total effort was 218 hours with distance on effort in the pack ice of 652 n.miles. Vessel speed in ice was highly variable. A total of 18 minke whale sightings (26 animals, school size 1-3) were made while on effort. Sightings made off effort were excluded from the analysis. Most minke sightings were made in large lead systems with low ice concentrations surrounded by heavier pack ice and all on-effort sightings were recorded east of 98°E longitude. Polygons representing ice categories (in tenths) were developed by comparing shipboard ice observations collected during the survey, with satellite imagery. Shipboard records included ice cover in tenths along the survey route for the visible area surrounding the ship, as well as extensive descriptions of patterns of ice distribution. Overlays of whale sightings have been made completely independent to the development and truthing of the large-scale distribution of ice types.

While the APIS survey was not designed to survey whales, it provided a useful platform for reliably recorded whale sighting data. The potential to make inferences about densities in the pack ice is clearly limited, but the data

collected are of a high quality. The APIS cruise track also allowed sightings to be made in a wide range of local ice conditions. The authors noted that the spring/summer ice retreat does not occur along a simple ocean/ice interface (i.e. a clear 'ice-edge').

The sub-committee noted that the timing of the APIS survey was before the main peak of minke whale migration into open water, and before most of the IDCR/SOWER surveys started. Thus, the sub-committee was uncertain about how applicable the results from the APIS surveys were to the IDCR/SOWER surveys. Thiele noted that krill specialists considered that the general pattern of krill movements is that they move out from the pack ice into the marginal ice-edge zone (MIEZ) in summer (SC/54/IA6). Therefore, a lower density of minke whales within the pack ice might be expected during the IDCR/SOWER survey times than were recorded in SC/54/IA6. However, the retreat of the ice occurred in a complicated manner with a range of pockets inside connected by thin ice, with marginal ice-edge zone processes occurring in many places. The sub-committee noted that no minke whales were sighted on-effort west of 98°E during the later part of the survey and questioned whether this was because they had moved into open water. Thiele agreed that this could be possible and explained that this region was the area of greatest ice extent in winter and the MIEZ and associated gyre system that maintains phytoplankton production extended over a wide latitudinal band in this area as reported in Nicol *et al.* (2000) and Thiele and Chester (2000).

Ensor questioned whether there was good sightability of whales along the survey. In his experience it was sometimes difficult to sight whales in areas of heavy ice development, where pressure ridges could form. The main cues used to detect minke whales as reported in SC/54/IA6 were body cues and not blows. The sub-committee noted that some of the assumptions made in line transect analyses would be violated when using data collected during surveys within the ice, for example, the constantly changing ship speed, highly variable conditions that affect sightability, and variable amount of water that can be searched due to obstructions like ice bergs and pressure ridges. The sub-committee recommended that methods to estimate unbiased, precise abundance estimates using data collected in the ice pack be developed. Progress on this matter was being developed in the Standing Working Group on Environmental Concerns (Annex J, Appendix 3).

SC/54/IA18 presented a qualitative analysis on the relationship between the distribution of Antarctic minke whales and Antarctic sea ice coverage in the austral summer using meteorological satellite data for the second (1988/89) and the third (1998/99) IDCR/SOWER circumpolar surveys in the waters between 80°E and 130°E in Area IV. Factors were compared between 1988/89 and 1998/99. Monthly sea surface temperature, area of sea ice less than 40% of ice concentration, sea ice condition in the Ross Sea and Prydz Bay in January, the southern boundary location and area of continental slope covered by sea ice suggested that the 1998/99 season was colder than the 1988/89 season in this area, and may explain the differences in minke whale distribution pattern between those years in Area IV. Annual change in sea ice concentrations may affect abundance estimates from the open sea because some minke whales may be present in the pack ice when the ice extent is greater. Estimated abundance of the Antarctic minke whales in 1998/99 was very much lower than that in 1988/89. Where did the minke whales go in 1998/99? On either sides of this study area, the Ross Sea and Prydz Bay were both closed in

January 1998/99, though they are well known to be high-density areas of Antarctic minke whales. Though it is possible that minke whales scattered widely in the northern stratum, the abundance here was lower than the southern stratum (Burt and Stahl, 2001). Therefore, the authors concluded that many minke whales went into the pack ice region in 1998/99 where the research vessels could not go.

It was noted that the 1998/99 survey did not extend into the longitudinal range of Prydz Bay (80-90°E), which had been covered in the 1988/89 survey, making it difficult to compare abundance between these two surveys. This analysis has already been presented for all areas in all years in Shimada *et al.* (2001).

The sub-committee noted that a similar result had been found from the JARPA data (Appendix 6). Data from the 1997/98 and 2001/02 JARPA cruises were used to determine the relationship between ice condition and the number of Antarctic minke whale sightings. In the 2001/02 cruise, a substantial number of minke whales were sighted in the SE stratum and in Prydz Bay. Minke whales were concentrated near the ice-edge, similar to the pattern observed in the 1999/2000 JARPA survey conducted in the same area. In contrast, in the SE stratum in the 1997/98 JARPA survey there were few minke whale sightings. According to the NIC satellite information, there were many ice-free areas south of the ice-edge in 1997/98 where research vessels could not enter. SC/53/IA13 presented the time-series of sea ice coverage for 20 years in all areas in January. The results suggested that sea ice in Area IV was largest in 1997/98. Abundance in the SE stratum in 1999/2000 (similar to 2001/02) was estimated to be nearly eight times the 1997/98 abundance. It has previously been documented that pregnant minke whales tend to gather near the ice-edge in the Antarctic summer, but the sexual maturity rate in the SE stratum in 1997/98 was only 5% while in 2001/02 it was 74%. The authors suggest that the most plausible explanation of this difference is that in 1997/98, the mature female minke whales in the SE stratum were in the ice-free areas south of the ice-edge. From this, the authors concluded that for future precise estimation of minke whale abundance, the timing of surveys should consider the timing of the retreat of the ice-edge, and also ensure that it is possible to survey the ice-free areas.

It was brought to the sub-committee's attention that a previous paper (Fujise *et al.*, 1999) also noted this pattern of abundance changing with ice extent, and further showed that body fat condition index and fattiness both indicated that there was plenty of food available in 1997/98.

There was discussion about the reliability and appropriate scale of the satellite data on ice percentage. Ishikawa confirmed that satellite ice information matched well with observations from the JARPA 1997/98 cruise.

SC/54/IA19 presented estimates of the abundance of minke whales in unsurveyed regions within the pack ice for three scenarios based on previous surveys of sightings within the pack ice. The area of sea ice south of 60°S was calculated for each sector of 10% ice concentration using satellite data from the same time as the survey period. The Closing mode density of Antarctic minke whales was obtained from the southern stratum of each sector from 1978/79 to 1997/98 in Branch and Butterworth (2001b). This density from the ice-edge to 30 n.miles was applied to the open waters inside the pack ice using data from Kasamatsu *et al.* (2000). The three scenarios were based on papers giving the relationship between ice concentration and whale density. Scenarios 1, 2 and 3 used that in 1979 of Naito (1982), combined the 1979 and 1981 data in Naito (1982) and that of Ainley (1985),

respectively. The estimated abundance (for each scenario) within the pack ice in CPII was 18%, 102% and 51% of that in the ice-free area; in CPIII the percentages were 28%, 159% and 72% respectively. The area within the pack ice region in CPII was 123% of that in CPIII. Estimated total abundances in CPII were 100%, 99% and 110% of that in CPIII. This suggests that there is no substantial difference between CPII and CPIII. The authors suggested that the Antarctic minke whale abundance within the pack ice was not negligible when compared to total abundance.

The sub-committee noted that there are very few surveys on densities of minke whales within the pack ice, and that this paper was useful in presenting calculations of the possible proportion of minke whales in the pack ice. However, incompatibilities that made interpreting these results difficult include: the density estimates in the pack ice were not from the same areas as the open water density estimates, and the timing of surveys within the pack ice did not overlap the entire time period of the IDCR/SOWER open water surveys.

The sub-committee discussed where the minke whales could have gone during years when the open water abundance estimates were low, for example, the 1997/98 JARPA estimate in Area IV. Hypotheses included: into the pack ice, north of 60°S, and east or west. Unfortunately, there are no data available to directly address these hypotheses. Butterworth noted that it would be easy to provide a coarse estimate of the proportion of whales in the pack ice using changes in sexual maturity rates from the 1997/98 JARPA data in Area IV compared to other years with higher abundance estimates. Appendix 7 presents results from this analysis.

Hakamada noted that in the 1997/98 austral summer, the pack ice in Area IV extended further north than usual and, according to NIC information, there were many ice-free areas south of the ice-edge, which were not accessible to the JARPA vessels. In 1997/98, a low proportion of mature females were sampled. Because mature females tend to be near the ice-edge, it was hypothesised that the missing animals were distributed in the pack ice. To test this hypothesis, the typical proportions of mature females were compared with the proportion observed in 1997/98. Using abundance estimates from JARPA surveys, it was estimated that the number of mature females south of Area IV in the pack ice was 2,876 (Appendix 7). Hakamada pointed out that this figure was probably an underestimate of the total number of minke whales in the pack ice, as the estimate does not include males or immature females.

Appendix 8 notes that for mature animals, the proportion of animals that are males in Area IV always exceeds that observed in Area V, i.e. greater than about 0.60 in Area IV for all years compared to about 0.50 in Area V. This is consistent with the above discussion about the differences in ice conditions in Area IV and V. They also noted a substantial variability in the proportion of mature males among years (i.e. a difference of about 0.25 between the maximum and minimum proportions). In Area IV, the variation appears to be inversely proportional to the JARPA abundance estimates, while in Area V there appears to be little or no relationship. The absence of any relationship in Area V and similar levels of variation in the sex ratios in Area IV and V suggests that either the change in ice cover may not be the explanation for the observed data in Area IV or that different factors are the source of the variation in Area V. Appendix 8 also provides estimates of the number of mature and immature animals in Areas IV and V, by sex and year. These were obtained by multiplying the observed

proportions from the JARPA samples, for each Area, by the abundance from the respective Area as estimated from the JARPA data. The authors concluded that the pattern of abundance estimates cannot be explained simply by increasing proportions of females within the ice, and that if increase in ice is the explanation for the declines, then both males and females must be entering into the ice zone.

During further discussion, Hakamada pointed out that the analyses in Appendix 8 estimated abundance by using Area-specific proportions of mature females, and suggested that an alternative approach would be to use estimates of abundance by stratum within an Area. Polacheck agreed that this would provide further information for the sub-committee to consider, should these strata-specific data be available.

Ensor linked the patterns of proportions of mature females with patterns of ice conditions. In Area IV, Ensor noted that the pattern of ice melt is characterised by the southward recession of the ice-edge and (based on satellite predicted estimates) the development of ice-free areas inside the pack ice, near the Antarctic coast. In a 'normal' year the main ice-edge recedes southward, and especially at longitudes corresponding to the ice-free areas inside the pack ice. During the survey period, some, but not all, of the ice-free areas inside the pack ice become contiguous with the open sea to the north, and characteristically they form bays in the main ice-edge. The pattern of ice melt was considered 'normal' in the following seasons: 1989/90, 1991/92, 1993/94 and 1999/2000. The proportions of mature females in the catch data from the southern stratum for these years were 31.1%, 39.1%, 27.6% and 42.8%, respectively. The pattern of ice melt was 'abnormal' in 1997/98 when the ice-edge was farther north than usual. Based on satellite predicted estimates, extensive ice-free areas were present inside the pack ice this year. The percentage of mature females in the catch was substantially lower (7.1%).

In Area V, Ensor noted the pattern of ice melt is characterised by the southward recession of the ice-edge and (based on satellite predicted estimates) the development of an ice-free area in the Ross Sea. In a 'normal' year the main ice-edge recedes southward, and the ice-free area in the Ross Sea increases in extent until, in the north western part of the Ross Sea, an opening in the ice develops and the Ross Sea is ice-free and contiguous with the Southern Ocean. At this stage of the melt, satellite predicted estimates can indicate that the occurrence of ice-free areas inside the pack ice in Area V are unusual. The pattern of ice melt was considered 'normal' in the following seasons: 1990/91, 1992/93 and 1996/97. The proportions of mature females in the catch data from the southern stratum for these years were 56.7%, 42.1%, and 71.2%, respectively. The pattern of ice melt in Area V was considered 'abnormal' in 1998/99. Satellite imagery indicated that although the Ross Sea was mainly ice-free (as in 'normal' years), it remained inaccessible to the vessels due to a barrier of pack ice. The percentage (27.9%) of mature females in the catch in the southern stratum during this year was lower than in the 'normal' years. There were 'abnormal' ice conditions in Area V in the 1994/95 season. The ice-edge in the western part of Area V was farther north than usual. For this season also, the percentage of mature females in the catch was lower (37.1%).

As an aside, in Area IV, Ensor noted that in a season with a 'normal' ice recession there was often a relatively high sighting rate of minke whales observed in the vicinity of where the main ice-edge joins with ice-free areas inside the pack ice. The ice-free areas in the pack ice have consistent inter-annual locations and it appears their formation is linked

to strong oceanic processes; as a result they may be areas of relatively higher production and their occurrence may influence the distribution of minke whales. In conclusion it was noted that in both Areas IV and V, the proportion of mature females in the catches was higher when ice-free areas south of the main ice-edge were absent or restricted in extent (based on satellite predicted estimates). Conversely, in both areas, when satellite predicted estimates indicated extensive ice-free areas inside the pack ice, the percentage of mature females in the catches from the open waters outside of the pack ice was lower. In 'normal' ice years the proportion of mature females in the catches was higher in Area V compared with Area IV. This may be due in part to differences in the characteristics of the pack ice (in Area IV in 'normal' years there are usually at least some ice-free areas inside the pack ice; while in Area V it is unusual for extensive ice-free areas to exist within the pack ice).

The above observations support the hypothesis that the 'missing' mature females are possibly distributed in the pack ice, but do not preclude other hypotheses, such as longitudinal movement out of the Areas. More work is needed to fully explore these ideas.

Despite the difficulties with interpreting all these results the sub-committee agreed that there could be large numbers of minke whales within the pack ice, quite possibly some 10's of percent of the open water IDCR/SOWER abundance estimates, at least for certain areas. But potential biases and paucity of surveys in the pack ice made it difficult to be more definitive about the abundance and trends of minke whales in the pack ice. The sub-committee **recommended** the ice-edge information in the analyses of Shimada *et al.* (2001) be used to give a simple annual index of the week or month of greatest ice cover and the percent ice coverage for the times and areas of the IDCR/SOWER and JARPA surveys. In addition, it was **recommended** that the IDCR/SOWER and JARPA data (which covered a longer time series) be used to investigate if there is a correlation between open water abundance and ice coverage.

6.3.3.2 WORK PLAN

In the light of current uncertainty about the density and distribution of minke whales in the pack-ice, and to what extent this might affect our interpretations about trend from the IDCR/SOWER and JARPA surveys, the sub-committee agreed that little further progress could be made on this issue without new data and analyses being presented. Therefore it sought to identify potential existing sources of data, and to make recommendations on what data would be useful to collect from vessels that operate in the pack ice.

It was noted that the most useful data were those from dedicated cetacean observer platforms, particularly those platforms on which the observations were made both in open water and in the pack ice, such as the 1995/96 BROKE survey (Nicol *et al.*, 2000), and SO-GLOBEC cruises with cetacean observers onboard (SC/54/E12). Other potential data sources that were identified included: APIS data; data collected during transits to and from Antarctic bases; surveys in Area III conducted by Australian SOCEP; and data collected during ice navigation modes during the IDCR/SOWER and JARPA surveys. Concerns were expressed regarding the usefulness of the APIS aerial survey data, given that these surveys were primarily aimed at surveying seals (hauled out on to the ice), and hence would not have consistent search effort for whales. Some of these aerial surveys also had dedicated cetacean observers onboard so cross-validation with corresponding dedicated shipboard cetacean observations data would be useful.

Different views were expressed regarding the applicability of conventional line transect estimation methods to data from within the pack ice. However, it was agreed that sighting distance and angle data may have a role to play in any future analyses, and that these data should be collected where possible. The sub-committee also **recommended** that consistent and regular descriptions of the ice characteristics (and other factors affecting the detectability of minke whales) were important, and **supported** the development of standardised methodology for the collection of ice data being considered by the Standing Working Group on Environmental Concerns (Annex J, Appendix 3). Furthermore, the sub-committee **recommended** that data corresponding to where the IDCR/SOWER 'ice-edge' would have been located should be recorded where possible. It was also suggested that satellite telemetry should be used to provide information on the movement of minke whales between pack ice and open water (the IDCR/SOWER survey area).

The sub-committee made the following additional recommendations to facilitate progress on identifying available data sources and to encourage the collection of new data within the pack-ice region:

- (1) The Secretary should make an official request to the APIS coordinators inquiring about availability and access to any cetacean data that their member countries may have collected within and outside the pack ice.
- (2) Relevant members of the Scientific Committee should approach individuals whom they know to have been involved with the APIS surveys with the same enquiry as in (1) above. Thiele offered to coordinate this effort, with assistance from Gales.
- (3) Requests should be made to countries that use ice breakers in the Antarctic to conduct dedicated cetacean observations from their vessels. These countries currently include Australia, France, Germany, Japan, South Africa, the UK and the USA. Thiele offered to coordinate this effort, and to ensure that the data would be collected in a standardised format.

6.4 Trends in abundance

6.4.1 Population dynamic models

SC/54/IA25 applied the ADAPT VPA methodology of Butterworth *et al.* (1999) to refined and/or extended catch-at-age and abundance information (from both IDCR/SOWER and JARPA programmes) for minke whales in Areas IV and V. The results suggest statistically significant increases in minke whale recruitment until a peak in the late 1960s, followed by a drop and then stabilisation for more recent years. Total (1+) population trends over the past two decades show slight declines of about 1% per annum, but these are not statistically significant. The Area IV population is, however, estimated to have declined over the 1970s. Further, JARPA data forthcoming since the time of the Butterworth *et al.* (1999) analyses secure an appreciable improvement in the precision of estimates of natural mortality (M) and trends in population components. Estimates of M for the two Areas range from 0.046-0.070 per year, and are statistically compatible. This suggests that this ADAPT methodology might be applied to estimate population trends for minke whales in the other Areas through input of common estimates of M and selectivity derived for Areas IV and V, though such trends would not be as precise as those attainable for the two Areas considered here.

Some preliminary results were also presented which extrapolated backwards from 1944 (the earliest time considered in SC/54/IA25) to 1930, when the age-structure of the populations was assumed to correspond to an unexploited equilibrium for the level of recruitment at that time. This adjustment did not qualitatively change the results, at least from the mid-1950s onwards. Populations in both Areas IV and V increased until the 1970s, but the models indicate a reduction in recruitment has occurred since then. The authors suggest that these results are consistent with super-compensation (with the population having expanded beyond its current carrying capacity), and subsequent reductions in that carrying capacity (the population having rapidly increased earlier the last century). The suggestion of only a slight decline in abundance (about 1% per year, or 20% over the timeframe of the IDCR/SOWER surveys) initially appears to contradict the results from the IDCR/SOWER surveys that show an appreciable decrease in abundance estimates between the second and third sets of circumpolar surveys. Examination of abundance estimates from standard analyses (Branch and Butterworth, 2001a) of the IDCR/SOWER surveys showed that estimates from Areas IV and V decreased from 351,000 in CPII to 203,000 in CPIII (a ratio of 0.58). This supports the results from this model. However, the estimates from the remaining Areas I, II, III and VI decreased from 561,000 to 200,000 (a ratio of 0.36), a much greater reduction. The difference in circumpolar estimates between CPII and CPIII raised in Branch and Butterworth (2001b) is therefore not completely addressed by SC/54/IA25. However, the IDCR/SOWER survey estimates have wide confidence limits, and so are not statistically incompatible with the VPA results that integrate the survey results with other information.

In discussion, several members argued that other plausible scenarios existed to explain these results. In particular, the analyses presented implicitly require some subjective decisions to be made, fixing some parameters to enable estimation of others. For example, some concerns were expressed about the plausibility of the extent of the increase in population until the 1970s; such an increase would not follow if the natural mortality rate (M) was as high as 0.1. Opinions differed on how realistic a rate of 0.1 for M was, but Butterworth pointed out that it exceeded the confidence limits of the estimates of M provided by the VPA.

Concerns were raised about the selectivity constraints in the VPA model and lack of fit to the age distribution in the plus group. Though some concerns about the selectivity constraints had been addressed in Butterworth *et al.* (1999) further consideration of fit to the age data for older animals was needed in Area IV. Another concern raised was the need to consider the implication of uncertainty about stock structure on the VPA results.

Possible reasons for the estimated decrease in abundance in the late 1960s were discussed. It was noted that the large harvests in Area IV likely contributed. However, it is unlikely that these trends could be explained by super-compensation alone; the postulated decrease in carrying capacity was also essential to explain the observed patterns (unless the current estimates of abundance from the IDCR/SOWER surveys were very negatively biased). Other suggested explanations for the observed changes in population size include an inertial dynamics model, and changes in carrying capacity that were climatologically driven. However, the inertial dynamic model would not be able to predict the initial increase in recruitment seen in these models. To

investigate these ideas, the VPA model could be used to estimate how these populations might have behaved in the absence of commercial catches, but this would require the assumption that the relationship linking stock recruitment over time still applied. One possible approach to link the results from such VPA analyses to climatic factors had been presented in Butterworth *et al.* (2001).

It was pointed out that the stock recruitment relationships estimated by the VPA for minke whales in Areas IV and V (particularly the recent large drops in per capita recruitment) do not appear to be supported by some of the biological evidence available from commercial catch and JARPA data. No trends in the apparent pregnancy rates of minke whales from Areas IV and V were found from samples from either commercial catches or JARPA data (Shimada *et al.*, 2001). A negative trend for age at first ovulation was found in commercial samples from Area VI, but no trends were apparent in the JARPA samples from that Area. In Area V, no trends were apparent from either the commercial or the JARPA samples. If recruitment estimates by VPA are truly representative of minke whale recruitment in these two Areas, and pregnancy rate and age at first parturition are without trend, then some other mechanism(s) must be postulated to account for a variable stock/recruitment relation. One possible explanation is a decrease in juvenile survival rate (lactation having higher demands on females than pregnancy). The sub-committee agreed that an estimate of body condition, perhaps derived from data on whale length, weight and blubber thickness, as well as apparent pregnancy rate and age at first ovulation, might be a useful diagnostic for future results from VPA or other integrated models. The historical catch records also include data (e.g. oil yield, blubber thickness) that might be useful in determining an appropriate condition factor.

Ohsumi noted that the 1997 JARPA Review meeting had confirmed that blubber thickness had decreased since the JARPA programme began in 1987. He also expressed the view that blue and humpback whales were increasing in the Antarctic, and that consequent competition effects might be restricting the carrying capacity of minke whales.

The sub-committee noted that whilst the combined three-year-three-age catch-at-age data from these Areas is published, the sensitivity and robustness of the results in SC/54/IA25 could only be independently investigated if the corresponding data on a one-year-one-age basis were also available to interested members of the Scientific Committee. Kato reminded the sub-committee that the Institute of Cetacean Research, which owns the JARPA data, established data policies during the JARPN Review Meeting that are applicable in this case (see IWC.SC.24 dated 30 June 1999 available from IWC Secretariat). Furthermore, Polacheck commented that details on how the catch-at-age matrices are constructed were necessary, of which some were provided in Butterworth *et al.* (1999). To address some of the concerns about this VPA analysis, Polacheck agreed to convene an intersessional e-mail group comprised of Butterworth, Cooke, Leaper, Punt, Tynan and an as yet unnamed Japanese scientist. The terms of reference of this group are to: (1) request the needed summary data following the established data policies; (2) make a list of the concepts that need to be addressed in further analyses (i.e. alter the model structure, incorporate other biological data and stock structure alternatives, and investigate model robustness); and (3) coordinate individuals to pursue analyses to address these concerns.

6.4.2 Power of detecting a trend

No papers were submitted for consideration under this agenda item. The sub-committee briefly discussed the possible effects of longitudinal migration on the power to detect a trend. If there is migration it will worsen the power to detect any trends, but if not, then it is easier to detect a trend especially if there is a trend in localised populations. Butterworth noted that a paper by Wada (1984) looked at mark-recapture positions and concluded that only 1 out of 35 whales moved more than 60° longitudinally before recapture. In addition, Kato *et al.* (1993) used mark-recapture data to show that the crude average distance of longitudinal movement between mark and recovery after two or more years was 30°, when corrected for geographical bias of the whaling operation. These two papers indicate that the size of the strata used could affect the degree of movement between strata and therefore the power of detecting a trend. The sub-committee **recommended** that the power of different approaches to detecting a trend be investigated, including a simple regression on abundance estimates, the integrated approach suggested in SC/54/IA1, and the VPA approach (Butterworth *et al.*, 1999).

6.5 Plans for completion of minke review

6.5.1 Design issues

Design issues related to the completion of the IDCR/SOWER cruise were discussed under Item 5.2.2.

6.5.2 Work plan

Appendix 9 details the tasks identified by the sub-committee to further the review of Antarctic minke whale abundance estimates, together with an indication of priorities for the next year. Noting the need to explain why the estimates of abundance using the standard methods for the third circumpolar set of surveys are appreciably lower than estimates for the second CP, the sub-committee **strongly recommended** that substantial progress be made on all tasks given high priority by the 2003 meeting of the Scientific Committee.

To successfully complete its review of the IDCR/SOWER abundance estimates and trends, and to address Resolution 2001-7 (IWC, 2002d), resources are required to complete the last two years of the IDCR/SOWER survey and to develop and test new analytical methods that result in less biased abundance estimates and trends. Financial details of the IDCR/SOWER cruises have been discussed in Appendix 2. Details (including financial implications) of contracts to develop and test new analytical methods have not yet been discussed. The sub-committee **agreed** to bring to the attention of the Committee that further discussion of these issues is required, including the need to make the Commission aware that unless resources are made available, it is unlikely that the review will be completed in 2003.

6.6 List of plausible hypotheses that may explain the apparent decline in abundance – Response to Resolution 2001-7

Resolution 2001-7 requests the Scientific Committee to provide to the Commission at IWC 54:

- (i) a list of plausible hypotheses that may explain this apparent population decline; and
- (ii) the possible implications that such a decline in abundance may have for the management of minke whales in the Southern Hemisphere, and for ecologically-related species, in particular other cetaceans, and the state of the Antarctic marine ecosystem.

The sub-committee noted the estimates of abundance using the 'standard methods' of Branch and Butterworth (2001b) for the third circumpolar set of surveys are appreciably lower

than estimates for the second circumpolar set of surveys. The sub-committee has provided a set of hypotheses that may explain (or exacerbate) this difference (Appendix 10).

6.7 Possible implications of abundance trends to management of Antarctic minke and to the state of the Antarctic marine ecosystem – Response to Resolution 2001-7

Given the wide range of plausible hypotheses identified above, it is premature to comment on the equally wide range of potential management implications. The sub-committee **agreed** that the most appropriate time to fully address this issue would be after completing its work on reviewing the IDCR/SOWER abundance estimates.

6.8 Other

SC/54/IA9 presented an update of the mitochondrial DNA (mtDNA) RFLP analysis in Antarctic minke whales from Areas V and VIW. The analysis used all the available samples from these Areas (1988/89-2000/01 JARPA surveys). Samples were divided arbitrarily as follows: Area V Western (130°-165°E), Area V Eastern (165°E-170°W) and Area VI Western (145°W-170°W), with two temporal periods (Early and Late). A total of 2,228 samples was examined in six longitudinal/temporal groups as follow: VWE, $n = 215$; VWL, $n = 703$; VEE, $n = 200$; VEL, $n = 844$; VIWE, $n = 194$ and VIWL, $n = 72$. Quantification of the geographical and temporal mtDNA differentiation was carried out using Analysis of Molecular Variance (AMOVA). Both haplotype (Fst) and sequence (PHIst) statistics were used. Following an examination of yearly variation, a hierarchical analysis by AMOVA was conducted for the total samples. Overall, no significant mtDNA heterogeneity was found in Areas V and VIW. Each of the longitudinal/temporal groups in Areas V and VIW differed significantly from an out-group sample from Area IVWE in both Fst and PHIst statistics.

In relation to the work of this sub-committee, it was suggested that information on any geographical and temporal differences in stock structure in the Antarctic Areas could be incorporated into integrated models (such as the VPA presented in SC/54/IA25). Pastene agreed, but cautioned that results of this study are not yet conclusive about the stock structure of minke whales in these Areas. He informed the sub-committee that a new study covering Areas III-VI is underway using nuclear DNA in addition to mtDNA, and that information from such a study could be used in this context. Results from SC/54/IA9 re-emphasised the importance of collecting genetic samples from minke whales in putative breeding grounds in lower latitudes. Such samples are important for a better interpretation of the pattern of genetic variation observed in the Antarctic. The sub-committee **recommended** that attempts be made to collect samples from lower latitudes, recognising that the exact locations of the putative breeding grounds are at present unknown. In this regard, it was **recommended** that the use of satellite telemetry to track whales between the Antarctic and lower latitudes should be investigated.

7. SOUTHERN HEMISPHERE BLUE WHALES – PLANS FOR ASSESSMENT

7.1 Abundance estimation

SC/54/IA27 addressed the estimation of effective search half-width for blue whales in the IDCR/SOWER surveys. An attempt had been made to improve the precision of blue

whale abundance estimates by using data for all circumpolar sets of cruises combined, instead of separately as at present, to estimate effective search half-width. The program DISTANCE 4 can accommodate this by fitting hazard-rate form detection functions for which the scale, although not the shape, parameter may change between circumpolar sets of surveys. In terms of the AIC model selection criterion, however, the attempt was not successful. The probable reason is that the shape of the detection function differs appreciably for the three circumpolar sets of surveys. The number of sightings is still so low that the data do not contain sufficient information to distinguish the numerous factors affecting the shape of the fitted distributions.

The sub-committee noted that the Cooke model used for minke whales (SC/54/IA1) could in principle be applied to blue whale analyses but has yet to be tested in practice.

Appendix 11 presents updated estimates for blue whales from the IDCR/SOWER surveys from 1978/79 to 2000/01. The methods of Branch and Butterworth (2001a) were used. The 1999/2000 survey was not included because it covered a sub-area of the region covered in the 1993/94 survey. The ice-free areas south of 60°S covered by the three circumpolar sets of surveys (CPI, CPII and CPIII) were 63%, 80% and 91%. Resulting abundance estimates, CVs and 95% confidence intervals are given in Table 1. When comparable areas are considered, the point estimate of abundance in CPIII is appreciably higher (280%) than that in CPI and CPII; this difference is more marked (330%) when 'like-blue' sightings are also included in the comparable-area estimates. However, because of the high CVs associated with these abundance estimates, the CPII and CPIII estimates for comparable areas are not statistically significant at the 5% level.

In discussion, the sub-committee concluded that there has been little change in school size over the period, particularly between the second and third circumpolar surveys. SC/54/IA16 showed that, in any case, $g(0)$ for blue whales appears not to change (as it does for minke whales) with school size. Owing to their large body size blue whales are easier to sight, regardless of school size or weather conditions, than minke whales, and $g(0)$ is likely to be much closer to one for blue whales than in the case of minke whales. The relatively large number of 'like blue' sightings in the third circumpolar survey (compared with none in the earlier two surveys) may arise from two causes: full introduction of the 'like blue' code only at the start of the third circumpolar survey; and an increase in blue whale sightings. In the latter, as the numbers encountered increase, there is less time available to investigate outlying blows, leading to an increase in the number of 'like blues' recorded.

The point estimates for each of the three circumpolar sets of surveys (Table 1, column 1) show an appreciable increase over the period 1991/92-2000/01, but the differences are not

significant at the 95% level. The above estimates refer to animals sighted south of 60°S, and are therefore likely to refer largely to 'true' blue whales. Given the results in SC/54/IA8 (see below) no more than 7% of such animals are likely to be pygmy blue whales. The abundance estimates are derived from a very small number of primary sightings (fewer than 100 over 20 years), as is reflected in the coefficients of variation in Table 1.

Mikhalev cautioned the sub-committee to regard blue whale estimates with scepticism, on the basis of two Soviet Antarctic searching vessel cruises (1973/74, 1974/5) covering the entire Pacific sector from 40°S to the ice-edge. During that time not a single true blue whale had been observed.

Due to time constraints the sub-committee could not complete its review of the abundance and trends of blue whales in the Antarctic. Therefore, the sub-committee **recommended** the review be completed after the Antarctic minke whale review (see Item 7.4).

7.2 Progress on sub-species differentiation

7.2.1 Behaviour and morphology

SC/54/IA8 presented information obtained mainly on IWC/SOWER cruises in the period 1995/96-2000/01. A total of 362 video sequences of 28 hours 36 minutes and 146 photographs of 52 animals had been examined to provide distinctive external morphological keys for sub-species discrimination of blue whales during shipboard surveys. For comparison of morphological keys and surfacing behaviour between sub-species, in the absence of an appropriate genetic marker, the sampling location of blue whales in mid-summer was used, with animals north of 55°S being identified provisionally as pygmy blue whales, and those south of 55°S as true blue whales. A statistically significant trend that pygmy blue whales submerge without showing the dorsal fin and keel was confirmed. Relative body proportions and external morphology of the blowhole are now available for discrimination between the two sub-species. From analyses reported in SC/54/IA8 and earlier, a 'tadpole' shape typifies pygmy blues and a 'torpedo' shape true blue whales, while in pygmy blues the anterior tip of the central blowhole groove extends beyond the anterior tip of the nostrils. Furthermore, there were statistically significant differences in dorsal hump type between the two sub-species. Bayesian analyses indicated the reliability of the keys in combination for discriminating between the sub-species. Preliminary mtDNA analyses using biopsy samples collected earlier indicated statistically significant differences in haplotype frequency between the provisional sub-species, although no specific haplotype peculiar to either sub-species was detected. The morphological analyses indicated that some animals with keys specific for pygmy blue whales are found among true

Table 1

Point estimates of abundance, CV and 95% confidence interval (CI) for blue whales in the Antarctic, from the baseline analysis ('baseline'), when estimates from comparable areas are considered ('comparable areas') and when like-blue sightings are additionally included ('comparable + like blue').

Circum. set	Baseline			Comparable areas			Comparable + like blue.		
	Abundance	CV	95% CI	Abundance	CV	95% CI	Abundance	CV	95% CI
I	400	0.41	200-940	500	0.41	250-1200	500	0.41	250-1200
II	500	0.48	230-1300	700	0.51	270-1700	700	0.51	260-1700
III	1,700	0.42	760-3700	1,900	0.42	860-4200	2,300	0.38	1100-4600

blue whales. The proportion of such animals was calculated as 2.3 and 6.9%. These values could be a measure of the mixing rate of pygmy blue whales south of 60°S.

The sub-committee thanked Kato and his colleagues for their comprehensive analysis. The sub-committee **recommended** the following:

- (1) Take still or video-photographs of the blowhole region in blue whales at every opportunity.
- (2) Conduct genetic analyses on the sample materials available from the IDCR/SOWER cruises. Include microsatellite analyses, taking account of information for each sampled whale on the three morphological criteria developed in SC/54/IA8 for sub-species differentiation.

Mikhalev stated that over 30 whaling seasons, Soviet whalers had identified 50-55°S as the southern limit of pygmy blue whales.

7.2.2 Acoustics

Clark reported that analysis of calls recorded so far on SOWER cruises indicated that all recordings made in high latitudes (from three areas over four years) were identical to themselves but differed from those made in mid-latitudes, i.e. from Madagascar, Chile and Western Australia, which were themselves different from each other. Calls recorded on the most recent (2001/02) cruise were identical to those recorded earlier in high latitudes, and are presumed to be made by males as part of a reproductive display. The results so far do not contradict the hypothesis that high latitude animals are different from those for which calls have been recorded in mid-latitudes. He noted however that so far only 75% of the tapes from earlier SOWER cruises have been made available.

Since 2000, the sub-committee has recommended that serious consideration be given to archive and examine the acoustic data from blue whales already obtained on SOWER cruises. Last year Clark reported on the results from the preliminary analysis of 507 hours out of approximately 710 hours of acoustic recordings from winter 1996 through spring 2000 (IWC, 2002c, p.206).

For the past two years the sub-committee has also recommended convening a workshop specifically on blue whale acoustics to: (1) review the sounds recorded on SOWER cruises in the context of known blue whale sounds; (2) reappraise the value of acoustics for distinguishing between the two sub-species; and (3) make recommendations on future acoustic work to address the sub-species issue. Participants will be people with experience in blue whale acoustics, including Clark (USA), Doherty (USA), Ljungblad (USA), McDonald (USA), McCauley (Australia), Shimada (Japan), Rankin (USA), Stafford (USA).

Clark reported that the workshop had yet to take place, but that plans were underway to hold it during summer 2002, prior to the SOWER 2003 Planning Meeting.

Thiele referred to SC/54/O3, which described acoustic detection of baleen whales near the Antarctic Peninsula using passive acoustic recording packages (ARPs). The aim is to provide information on seasonal occurrence, distribution and minimum population size for, *inter alia*, 'true' blue and fin whales. Preliminary analysis of data retrieved from seven out of eight ARPs deployed revealed numerous 'Antarctic-type' blue whale calls, detected year-round. Calls on the shelf-break were apparently louder than those detected on the shelf. Future analyses will

incorporate data with other oceanographic and ecological data to provide an understanding of distribution and ecology calling whales.

7.3 Other

Mikhalev presented information on a catch of pygmy blue whales obtained in a limited area south of Australia in late January 1965. The Soviet fleet *Sovietskaya Ukraina* took 177 animals in a small area centred on ca 39°S, 125°E, south of the Great Australian Bight, between 24 January and 1 February. Because animals were taken indiscriminately as encountered, their biological characteristics represent a random sample of stock structure prior to commercial whaling. Of these samples, 99 animals (55.9%) were male and ranged in length from 14.2-22.1m (mean length 19.7m). Of the 78 females, 41 were examined and ranged in length from 15.5-22.8m (mean 19.9m); 12 (29.3%) were immature, including one calf. Sexually mature females measured from 18.6m. A plot of the individual catch locations indicated the compactness of the aggregation.

The sub-committee welcomed this important new information. In response to a request from the sub-committee, Mikhalev stated that he would attempt to obtain additional information on catches by the same fleet earlier in the season, for example east of Amsterdam/St Paul Islands in the Indian Ocean, for presentation at next year's meeting.

Kato noted that the biological data are very similar to those reported by Ichihara (1966) for pygmy blue whales, apart from the proportion of mature females pregnant, which was less in the Soviet data. The largest foetus in the Soviet data, measured at 655cm, is larger than any recorded by Ichihara. In discussion of the possibility that the two sub-species might associate together, Kato noted that the two had been recorded in the same months and at the same time in Chilean waters, by Aguayo, but that the data on which the observations were based had not been published in any detail. Ichihara recorded that the two sub-species appeared in separate schools. The sub-committee **recommended** that the Chilean and Japanese governments be urged to make any data available from the blue whale catches from the 1960s. An effort is needed to resolve the question that both sub-species were taken from Chilean land stations.

SC/54/IA22 reported on the current status of an ongoing ecological study of blue whales aggregating in the Bonney Coast region of southeast Australia. The study, on animals found along the continental shelf between 139°E and 143°E, has focused on links between climate, physical oceanography, biological oceanography, krill and blue whale distribution and ecology. Between early 1998 and April 2002 there have been 346 blue whale sightings, primarily from aerial survey. The earliest sightings have been in early December (4 Dec 1998) and the latest in late May (19 May 1999). Mean school size is 1.49 (SD = 0.792, range 1-7) with most (64%) observed as single animals. Cow/calf pairs have been observed on six occasions. Feeding or defecation was observed in 31.5% ($n = 109$) of sightings. Analysis of biopsy samples, using nuclear genetic markers, has provisionally placed the animals in an 'Indian Ocean' group rather than within a 'Southern Ocean' group. Acoustic recordings have yet to be obtained.

7.4 Work Plan

The sub-committee noted that it was impossible to conduct the review on the IDCR/SOWER analysis methods and complete an in-depth assessment of blue whales. Therefore, the sub-committee recommended the assessment of blue

whales start in 2005, the year after the completion of the IDCR/SOWER review. However, to ensure the necessary materials are available by the review the sub-committee identified the following as important tasks to be addressed before 2005.

- (1) Acoustic sub-species identification.
 - (a) Continuation of acoustic work at Cornell (Clark *et al.*, 2001).
 - (b) Obtain genetic samples and morphological data from vocalising blue whales.
 - (c) Obtain outstanding acoustic tapes held by Ljungblad.
- (2) Abundance estimation methodology and trend.
 - (a) Estimation of sources of variation over and above sampling variance.
 - (b) Extrapolation north of 60°S based upon JSV data.
 - (c) Improve extrapolation methods used to estimate abundance between 60°S and the northern boundary of IDCR/SOWER surveys.
 - (d) Investigate other methods for detecting trend over time (e.g. use of GLMs with year and Area factors).
 - (e) Effect of use of other than hazard rate form for detection function, including possibility of incorporating environmental covariates.
 - (f) Attempt to evaluate $g(0)$.
 - (g) Consideration of alternative approaches to take account of spatial distribution suggested during the meeting.
- (3) Prepare historic catch data for use in assessment (Secretariat), including request all catch data available from the Japanese and Chilean governments (particularly those from the 1960s).
- (4) Prepare for a stock assessment (including possible interactions with other species).
- (5) Consider feasibility of satellite-tagging Antarctic blue whales to establish location of breeding ground.
- (6) Continue sub-species differentiation by genetic markers, using the morphological keys.
- (7) Undertake analyses of IDCR/SOWER identification photographs.

The sub-committee suggested that number five (satellite-tagging) be discussed next year. To ensure the success of this discussion it was **recommended** that the appropriate tagging experts be invited to next year's meeting. The sub-committee urged the Secretariat to encode the historic catch data that it already has.

8. OTHER SPECIES

8.1 Fin whale

SC/54/O9 presented a standard line transect analysis of the Icelandic and Faroese vessel data from the NASS-2001 survey for fin whale abundance. For the first time, the survey was conducted in BT mode. But on inspection it was noted that using the double platform data to make a small correction for $g(0)$ was not found to be worth the resulting increase in variance. An estimate of 25,352 (CV = 0.13) was calculated for the survey area. The CV is considered to be under-representative due to possible movement of animals over the survey period and irregularities in the realised effort. The sighting rate was generally higher than in earlier NASS surveys (1995, 1989 and 1987) and sightings were more evenly distributed, particularly in the Iceland-Greenland area. The 2001 estimate does not include

areas farther to the south, as were covered in 1989. The estimates for comparable areas have been steadily increasing at a rate that is by an order of magnitude higher than expected due to the cessation of whaling in the area. Methodological improvements are considered unlikely to explain the whole difference. Spillover from stocks recovering elsewhere in the North Atlantic is suggested among other things that need further consideration.

8.2 Sperm whale

SC/54/O8 presented a novel protocol that was used with sperm whale sightings and abundance estimation from the NASS 2001 survey. Sperm whales were tracked to determine the point of deep dive (fluking). To avoid confusing a deep dive with a reaction to the vessel the protocol called for not coming closer to the whale than 0.5 n.mile before the whale was expected to come abeam of the vessel. This required the vessel to slow down or stop for a maximum of 3 minutes. Independent duplicate effort was therefore not maintained in the case of sperm whale sightings. The deep dives recorded before the animal was expected to come abeam of the vessel were used for a cue count estimate, while the animals on the surface abeam gave a traditional line transect estimate of the number of animals on the surface at any one moment and thus needs to be scaled up by dividing by the average proportion of time on the surface. A nice feature of this method is that the estimates are negatively correlated in that if a sighting is misclassified, one estimate goes up while the other goes down. The average is thus not so sensitive to such errors.

Detailed dive cycle information for all male (mostly single) sperm whales in this area is lacking but based on reported figures the value of two surfacings per hour and 20% of the time on surface was considered likely. Based on this, the total weighted average estimate for the whole area was 9,477 (CV = 0.34). This large CV is primarily caused by a large part of the sightings occurring on a single leg in the Jan-Mayen block. The corrected line transect surface estimate was significantly higher than the cue count estimate, implying either that the assumed cue rate was too high or the proportion of time on the surface too low, or that some animals were misclassified as still being on the surface abeam. The estimate is 1.41 times higher than a conventional uncorrected line transect estimate based on the same data using all sightings. A correction based on this survey may not apply to other surveys with different effort characteristics.

The sub-committee commended the authors of this paper for attempting to estimate $g(0)$ for sperm whales but regretted there was not enough time to explore this unique method.

SC/54/O6 presented a global review of sperm whale estimates and a historical abundance trajectory for sperm whales worldwide. Published population estimates were obtained from the literature, and a correction factor of $g(0) = 0.87$ was applied for animals missed on the trackline. Scaling to habitat areas produced a global estimate of 360,000 (CV = 0.36) which is just 1/5th of the numbers produced from whaling-based estimates. A population model indicated that pre-whaling numbers were 1,110,000 (95% CI = 659,000-1,460,000) and the population was at 71% of its original levels in 1880 and at 32% of its original level in 1999.

The sub-committee discussed several assumptions used by the author that may not be globally valid. One such assumption was $g(0) = 0.87$. It was noted that this value may

be too high for some areas, particularly where groups are usually small, i.e. in the Southern Ocean.

The assumption of the maximum rate of increase equalling 1.1% (range 0.7% to 1.5%) was also questioned. The implied MSYR was about 0.5 to 1.0% which is less than that assumed for the AWMP. It was pointed out that so low a maximum rate would hardly allow the population to recover, and that a more reasonable value could substantially change the estimates of current depletion.

The sub-committee also questioned the habitat definitions and therefore the extrapolated density estimates. For example, it was noted that the western North Pacific survey estimate used in SC/54/O6 did not cover the entire area indicated in the paper.

It was noted that uncertainties about 20th century catches by the Soviet Union are not adequately addressed. The issue was also raised that these catches usually preferentially targeted males, and that the resulting unbalanced sex ratio may have affected the productivity of the stock. A sex-specific model may therefore be more useful.

Given the uncertainties identified for this analysis, the sub-committee cautioned that substantial further development would be required to obtain results. The sub-committee noted that commercial whaling for sperm whales ceased 14 years ago and that it was perhaps time to consider assessing the current status of sperm whale stocks. The sub-committee therefore endorsed the idea to plan for an in-depth assessment of sperm whales. The sub-committee agreed it would be possible to get the available needed information organised and reviewed in the next few years and so conduct the assessment some time after that. It was realised the workload of the IA sub-committee was heavy but the time needed next year for the planning of the assessment would probably only be two sessions. The sub-committee **recommended** that the planning for an in-depth assessment of sperm whales start next year.

9. PUBLICATIONS

Authors of papers submitted to the meeting were invited to submit them for consideration for publication in the *Journal of Cetacean Research and Management*, where they would be subject to the normal review process.

10. ADOPTION OF REPORT

The report was adopted as amended at 14:00 on 6 May 2002. The sub-committee expressed its appreciation to the Chair and rapporteurs.

REFERENCES

- Ainley, D.G. 1985. Biomass of birds and mammals in the Ross Sea. pp. 498-515. In: W.R. Siegfried, P.R. Condy and R.M. Laws (eds.) *Antarctic Nutrient Cycles and Food Webs*. Springer-Verlag, Berlin. 700pp.
- Branch, T.A. and Butterworth, D.S. 2001a. Southern Hemisphere minke whales: standardised abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys. *J. Cetacean Res. Manage.* 3(2):143-74.
- Branch, T.A. and Butterworth, D.S. 2001b. Estimates of abundance south of 60°S for cetacean species sighted frequently on the 1978/79 to 1997/98 IWC/IDCR-SOWER sighting surveys. *J. Cetacean Res. Manage.* 3(3):251-70.
- Bravington, M. 2000a. Coping with clustered sightings. Paper SC/52/RMP15 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- Bravington, M.V. 2000b. Covariate models for continuous-time sightings data. Paper SC/52/RMP14 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- Buckland, S.T. and Turnock, B.J. 1992. A robust line transect method. *Biometrics* 48:901-9.
- Burt, M.L. and Stahl, D. 2001. Minke whale abundance estimation from the 1998/99 IWC-SOWER Antarctic Cruise in Area IV. Paper SC/53/IA3 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Butterworth, D.S., Punt, A.E., Geromont, H.F., Kato, H. and Fujise, Y. 1999. Inferences on the dynamics of Southern Hemisphere minke whales from ADAPT analyses of catch-at-age information. *J. Cetacean Res. Manage.* 1(1):11-32.
- Butterworth, D.S., Rademeyer, R.A. and Brandao, A. 2001. First attempts to quantify some factors that potentially confound temporal comparisons of minke whale abundance estimates from the IWC/IDCR-SOWER surveys. Paper SC/53/IA27 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Clark, C.W., Best, P.B., Donovan, G. and Kindlay, K. 2001. Report of the Scientific Committee, Annex H. Appendix 2. Blue whale acoustic recordings: some new approaches, and a proposal for analysing existing records. *J. Cetacean Res. Manage. (Suppl.)* 3:227-8.
- Cooke, J.G. 2001. A modification of the radial distance method for dual-platform line transect analysis, to improve robustness. Paper SC/53/IA31 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Cooke, J.G. and Leaper, R. 1998. Results of simulations studies of a hazard probability approach to estimation of whale density and effective strip width. Paper SC/50/RMP20 presented to the IWC Scientific Committee, April 1998 (unpublished). [Paper available from the Office of this Journal].
- Fujise, Y., Tamura, T., Ichihashi, H. and Kishino, H. 1999. Further examinations of the segregation pattern of minke whales in the Antarctic Area IV using a logistic regression model, with considerations on the pack-ice distribution. Paper SC/51/CAWS18 presented to the IWC Scientific Committee, May 1999, Grenada, WI (unpublished). 18pp. [Paper available from the Office of this Journal].
- Gong, D. and Wang, S. 1999. Definition of Antarctic oscillation index. *Geophys. Res. Lett.* 26(4):459-62.
- Hakamada, T., Matsuoka, K., Nishiwaki, S., Murase, H. and Tanaka, S. 2001. Abundance trend of Southern Hemisphere minke whales in Areas IV and V using JARPA sighting data. Paper SC/53/IA12 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Haw, M.D. 1991. An investigation into the differences in minke whale school density estimates from passing mode and closing mode survey in IDCR Antarctic assessment cruises. *Rep. int. Whal. Commn* 41:313-30.
- Ichihara, T. 1966. The pygmy blue whale, *Balaenoptera musculus breviceauda*, a new subspecies from the Antarctic. pp. 79-113. In: K.S. Norris (ed.) *Whales, Dolphins and Porpoises*. University of California Press, Berkeley and Los Angeles. xv+789pp.
- International Whaling Commission. 2002a. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 4:1-78.
- International Whaling Commission. 2002b. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on the Comprehensive Assessment of Whale Stocks — In-Depth Assessments. Appendix 10. Tasks to further the Southern Hemisphere minke review. *J. Cetacean Res. Manage. (Suppl.)* 4:224-5.
- International Whaling Commission. 2002c. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on the Comprehensive Assessment of Whale Stocks — In-Depth Assessments. *J. Cetacean Res. Manage. (Suppl.)* 4:192-229.
- International Whaling Commission. 2002d. Chair's Report of the 53rd Annual Meeting. Annex C. Resolutions Adopted During the 53rd Annual Meeting. Resolution 2001-7. Resolution on Southern Hemisphere minke whales and special permit whaling. *Ann. Rep. Int. Whaling Comm.* 2001:57.
- Joyce, G.G. 1982. Blow patterns as sighting cues for censusing minke whales in Antarctic waters. *Rep. int. Whal. Commn* 32:787-90.
- Kasamatsu, F., Matsuoka, K. and Hakamada, T. 2000. Interspecific relationships in density among the whale community in the Antarctic. *Polar Biol.* 23:466-73.
- Kato, H., Tanaka, E. and Sakuramoto, K. 1993. Movement of southern minke whales in the Antarctic feeding grounds from mark-recapture analyses. *Rep. int. Whal. Commn* 43:335-42.

- Kwok, R. and Comiso, J.C. 2002. Southern Ocean climate and sea ice anomalies associated with the Southern Oscillation. *Journal of Climate* 15:487-501.
- Murase, H., Matsuoka, K., Ichii, T. and Nishiwaki, S. 2002. Relationship between the distribution of euphausiids and baleen whales in the Antarctic (35°E-145°W). *Polar Biol.* 25:135-45.
- Naito, Y. 1982. Sightings records of minke whales in the pack ice and adjacent waters off the coast of Enderby Land. *Rep. int. Whal. Commn* 32:929-33.
- NAMMCO. 1998. *Annual Report 1997*. North Atlantic Marine Mammal Commission, Polar Environment Centre, N9296, Tromsø, Norway. 260pp.
- Nicol, S., Pauly, T., Bindoff, N.L. and Strutton, P.G. 2000. 'BROKE' a biological/oceanographic survey off the coast of East Antarctica (80-150°) carried out in January-March 1996. *Deep-Sea Res. II* 47:2281-98.
- Reuter, E. 1936. Die synoptische Darstellung 1/2 jährigen Druckwelle. *Veroff. Geophys. Inst. Univ. Leipzig* 7:257-95.
- Shimada, H., Murase, H., Segawa, K. and Kimura, N. 2001. Analyses on Antarctic sea ice coverage in the austral summer 78/79 to 00/01 using the SSMR and SSM/I satellites data, with some notes on relationship between ice coverage and abundance estimation. Paper SC/53/IA15 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal.]
- Sigurjónsson, J., Gunnlaugsson, T. and Payne, M. 1989. NASS-87: Shipboard sightings surveys in Icelandic and adjacent waters June-July 1987. *Rep. int. Whal. Commn* 39:395-409.
- Skaug, H.J. and Schweder, T. 1999. Hazard models for line transect surveys with independent observers. *Biometrics* 55(1):29-36.
- Thiele, D. and Chester, E.T. 2000. Cetacean distribution off Eastern Antarctica (80-150E) during the austral summer of 1995/96. *Deep-Sea Res. II* 47:2543-72.
- Thomas, L., Strindberg, S., Marques, F.F.C., Borchers, D.L., Buckland, S.T., Anderson, D.R., Burnham, K.P., Hedley, S.L. and Pollard, J.H. 2001. Distance 4.0. Beta 4. Research Unit for Wildlife Population Assessment, University of St Andrews, UK. [<http://www.ruwpa.st-and.ac.uk/distance/>]
- Van Loon, H. 1967. The half-yearly oscillations in middle and high southern latitudes and the coreless winter. *J. Atmos. Sci* 24:472-86.
- Wada, S. 1984. Movements of marked minke whales in the Antarctic. *Rep. int. Whal. Commn* 34:349-55.
- Yuan, X. and Martinson, D.G. 2000. Antarctic sea ice extent variability and its global connectivity. *Journal of Climate* 13:1697-717.

Appendix 1

AGENDA

1. Opening remarks
2. Election of Chair and appointment of rapporteurs
3. Adoption of agenda
4. Review of documents
5. Matters relevant to more than one stock
 - 5.1 DESS: progress with data entry and analysis options
 - 5.2 SOWER Circumpolar cruises
 - 5.2.1 SOWER 2001/02
 - 5.2.2 Plans for future cruises
 - 5.3 NASS cruises
6. Antarctic minke whales – abundance estimates
 - 6.1 Review of new data
 - 6.2 Methodological issues that may influence abundance estimates and their trends
 - 6.2.1 Effective search half-width and school size estimation
 - 6.2.1.1 Pooling
 - 6.2.1.2 Potential covariates
 - 6.2.1.3 Methods to incorporate covariates
 - 6.2.2 Closing-IO mode correction factor R
 - 6.2.3 $g(0)$
 - 6.2.4 Observer effects
 - 6.3 Inter-year comparisons
 - 6.3.1 Timing of surveys
 - 6.3.2 Dealing with variable partial coverage
 - 6.3.2.1 Extrapolation to unsurveyed regions
 - 6.3.2.2 Using JSV data
 - 6.3.2.3 Using JARPA data
 - 6.3.2.4 Using other datasets
 - 6.3.3 Other factors that may influence inter-year comparisons
 - 6.3.3.1 Animals within the pack-ice
 - 6.3.3.2 Work plan
- 6.4 Trends in abundance
 - 6.4.1 Population dynamic models
 - 6.4.2 Power of detecting a trend
- 6.5 Plans for completion of minke review
 - 6.5.1 Design issues
 - 6.5.2 Work plan
- 6.6 List of plausible hypotheses that may explain the apparent decline in abundance – Response to Resolution 2001-7
- 6.7 Possible implications of abundance trends to management of Antarctic minke and to the state of the Antarctic marine ecosystem – Response to Resolution 2001-7
- 6.8 Other
7. Southern Hemisphere blue whales – plans for assessment
 - 7.1 Abundance estimation
 - 7.2 Progress on sub-species differentiation
 - 7.2.1 Behaviour and morphology
 - 7.2.2 Acoustics
 - 7.3 Other
 - 7.4 Work plan
8. Other species
 - 8.1 Fin whale
 - 8.2 Sperm whale
9. Publications
10. Adoption of report

Appendix 2

REPORT OF THE AD-HOC WORKING GROUP TO PLAN LOGISTIC ASPECTS OF THE PROPOSED 2002/2003 IWC/SOWER CIRCUMPOLAR CRUISE

Members: Best (Convenor), Burt, Ensor, Hedley, Hughes, Kato, Matsuoka, Murase, Nagatomo, Nishiwaki, Sakamoto, Shimada.

1. BACKGROUND AND TERMS OF REFERENCE

Best introduced the terms of reference of the meeting. Although the main task of the group was to discuss logistic aspects of planning for the cruise (especially those that had budgetary implications), the sub-committee had specifically referred the issue of possible conflict with the JARPA programme in Area V to the group.

2. ELECTION OF CHAIR AND RAPPORTEURS

Best was elected Chair, and acted as rapporteur.

3. ADOPTION OF AGENDA

The agenda was adopted.

4. RELEVANT DOCUMENTS

Documents SC/54/IA2 and SC/54/IA20 were considered. Inventories of IWC-owned acoustic, biopsy and computer equipment remaining after the 2001/2002 cruise were presented, including an assessment of the cost of new and replacement items required for the cruise.

5. PLANNING FOR THE 2002/2003 CRUISE

5.1 Number and identity of vessels offered

Kato reported that the Japanese Government would offer the two dedicated research vessels *Shonan Maru* and *Shonan Maru No. 2*. Although last year the sub-committee had pointed out that a third vessel would greatly assist in obtaining adequate coverage of this area, Kato reported that this had unfortunately not been possible. The group expressed its gratitude for the generous offer from the Japanese Government.

5.2 Length of cruise

The total cruise (southern home port to southern home port) would be 74 days, with 60 days in the research area. This extended time in the research area was possible this year because refuelling (from a visiting tanker) would take place in the research area. Such extended research time would greatly help in achieving survey coverage of this large and important sector. Kato reported that some further extension of the survey length (by up to six days) might be possible if required.

5.3 Selection of research area

Following the reduced coverage achieved by the 2001/2002 survey, the remaining area to be surveyed to complete the third circumpolar set of surveys was substantial (150°E-170°W and including the Ross Sea). It would therefore be necessary to survey the remaining area over two years, rather than the planned one. It was proposed to survey the eastern half of the remaining area (165°E-170°W) in 2002/2003. Because this half contained the Ross Sea it was

substantially larger than the western half, so the group accepted the sub-committee's suggestion that the northern sector of this half should be reduced to 170°E-170°W. The research area would be divided into three latitudinal strata, with two strata in the Ross Sea, as in CPII. Following the advice of the sub-committee, the development of a contingency plan in case the Ross Sea should not be open was referred to the planning meeting.

5.4 Itinerary

The group accepted in principle the itinerary given in SC/54/IA20. However, a substantial amount of equipment had been left in Hobart after last year's cruise, so the group felt that this would be a more convenient home port than Wellington. The implications that this change would have for the schedule in SC/54/IA20 were not immediately apparent. The direction in which the survey would be carried out (eastwards or westwards) would be left to the Planning Committee to decide. As currently envisaged, the vessels will leave Japan on 28 November and arrive in Hobart on 17 December. The vessels will leave Hobart on 20 December, and reach the survey area on 29 December. The survey will cease on 24 February 2003. The vessels would arrive back in Hobart on 3 March and leave for Japan on 6 March, arriving home on 25 March. This itinerary will be finalised at the planning meeting.

5.5 Survey methodology

5.5.1 Minke whale assessment

The group recommended that the same survey methods and experiments used in previous years be adopted for the 2002/2003 cruise, to ensure comparability with estimates made in CPII surveys.

5.5.2 Blue whale assessment

The group recommended that the same protocol as in 2001/2002 be used (acoustics, dive times, photography for morphology, biopsy and photo-identification), although video taping of behaviour should be kept to a minimum as a large amount of material was already available. The feasibility of the recommendation from last year, that the acoustic work should be focused on trying to obtain genetic and morphological data from a calling blue whale, was referred to a meeting of acoustic specialists planned for August 2002.

5.6 Time allocation for the two components

The group agreed that, due to potential problems of achieving adequate survey coverage, priority should be given to obtaining minke whale density estimates. Blue whale research would be conducted on an *ad hoc* basis, at the cruise-leader's discretion, depending on progress, and up to a cumulative amount of two days for the whole survey.

5.7 Interaction with JARPA

Traditionally, the IDCR/SOWER-circumpolar surveys have avoided operating in proximity to whaling operations, to avoid conflicts of interest and possible adverse effects of whaling on the behaviour of whales in the immediate vicinity. However, with only a relatively small area left to

survey, some simultaneous operation of the JARPA and SOWER-circumpolar programmes is inevitable, and will occur in 2002/2003. Under these circumstances, attempting to maintain the previous policy, and separate the vessels in space and time, would only be possible if major changes to the normal deployment of the SOWER-circumpolar survey vessels are made. This could lead to incompatibility of the results with those from CPII, so should be avoided.

On the other hand, the comparability of estimates arising from SOWER-circumpolar and JARPA has been discussed at previous Scientific Committee meetings. An alternative option would therefore be to plan the two sets of survey tracks such that: (1) a comparison of the resulting estimates of minke whale density from JARPA and SOWER-circumpolar is possible; and (2) disturbance effects are reduced by the SOWER-circumpolar vessels always preceding the whaling vessels in time and space. Trial protocols suggested that this option is quite feasible, but details were left to the planning meeting.

5.8 Priority of research items

The group agreed that the research priorities would be the same as last year, including minke whale biopsy feasibility trials in the northernmost stratum, but that it had to be realised that the opportunities were likely to be less this year because of the extremely tight survey schedule.

5.9 Participants

A total of four participants can be accommodated on each vessel. Kato announced that Japan would allocate one scientist to each vessel. The group recommended that if the Japanese participant should be the acoustician on board, then consideration should be given to appointing another Japanese researcher on that vessel. Ensor agreed to act as cruise leader. The group recommended that the application for other researchers be advertised as usual with the formal choice of participants being made at the planning meeting. Because of the complexities inherent in the forthcoming cruise, the group strongly recommended that mainly experienced personnel be chosen.

5.10 Planning meeting

It was agreed that the planning meeting should take place in Tokyo, for four days, in September. Besides the cruise leader, captains and relevant crew members, the group recommended that the meeting should at least include Bannister, Brownell, Donovan, Hedley, Kato and an acoustician. A Steering Group comprising Donovan,

Bannister, Best, Brownell, Childerhouse, Ensor, Hedley and Kato was established. Kato was requested to convene the meeting. The group stressed the importance of the prior meeting of acoustic specialists, scheduled to take place in August 2002.

5.11 Home port(s) and responsible person(s)

The home port for the start and end of the cruise would be Hobart; Bravington was asked to be responsible for arrangements.

5.12 Review of recommendations

The following recommendations had arisen following last year's cruise (SC/54/IA2).

- (1) More powerful shipboard computers, two per vessel, one preferably weatherproofed for use on the upper bridge (the latter might be available as a loan from a collaborative institution rather than purchasing). This was referred to the Planning Meeting, although provision was made in the budget for two new computers per vessel.
- (2) Direct data acquisition system, or at least a real-time mapping programme, should be provided for use during IO mode. Despite a reasonably strong recommendation from the cruise, some group members felt that the existing data acquisition system should be retained until at least CPIII was completed. The four portable GPS required for the tracking programme should already be held by the IWC.
- (3) The IWC computers need maintenance. As these were currently in Hobart, Ensor agreed to be responsible for this.
- (4) The *Larsen* guns need maintenance. These were also currently in Hobart, so Ensor agreed to be responsible.
- (5) Purchase two Tasco spotting scopes. These were added to the budget.
- (6) Purchase 50 new *Larsen* darts. These were added to the budget.
- (7) The acoustic recommendations were passed to the acoustic specialist meeting.

Following discussions in the sub-committee, it was felt that the installation of a buzzer to alert the upper bridge when a sighting was made in IO mode by the IOP would greatly facilitate field identification of duplicate sightings.

5.13 Budget

The preliminary cruise budget is given in Table 1.

[Table 1 on following page]

Table 1
Preliminary budget, 2002/03 cruise (values in pounds sterling).

Researchers	Grant	Travel	Ship	Other	Gun repair, maintain	Acoustics, freight, etc.	Computers	SC/55	Ice data	Bank charges	Planning meeting	Total
C/leader	11,320	900	1,075	300				1,100		55	1,300	16,050
S/Scientist	8,810	2,700	1,075	300						55		12,940
Other	6,810	2,700	1,075	300						55		10,940
Other	6,810	2,700	1,075	300						55		10,940
Other	6,810	2,700	1,075	300						55		10,940
Other	6,810	2,700	1,075	300						55		10,940
Japan 1		2,700										2,700
Japan 2												0
Bannister											1,600	1,600
Childerhouse											1,300	1,300
Donovan											1,800	1,800
Hedley											1,700	1,700
Acoustician											1,500	1,500
									500			500
Total	47,370	17,100	6,450	1,800	1,080	3,450	6,060	1,100	500	330	9,200	94,440
2 Tasco telescopic sights						500						
15 Larsen darts and 10 cutting heads						450						
16 Armpoint spare batteries						30						
Repair one gun, maintain two						100						
Air freight 50 sonobuoys*							3,450					
4 new onboard computers								6,060				

*A substantial saving could be made if these were sent by surface rather than air freight, although this would require prompt despatch to Hobart.

Appendix 3

UPDATED CIRCUMPOLAR ABUNDANCE ESTIMATES FOR SOUTHERN HEMISPHERE MINKE WHALES INCLUDING RESULTS FROM THE 1998/99 TO 2000/01 IDCR-SOWER SURVEYS

T. Branch

Introduction

Standardised methods have been used to provide abundance estimates for Southern Hemisphere minke whales from the IWC's IDCR (International Decade for Cetacean Research) and SOWER (Southern Ocean Whale and Ecosystem Research) programmes. The 'apparent population decline' for the more recent surveys is one of the reasons for the current in-depth review of the methods used to analyse these surveys (IWC, 2002).

The IDCR and SOWER programmes encompass 24 surveys which fall into three circumpolar sets (1978/79 to 1983/84; 1985/86 to 1990/91; and 1991/92 to 2001/02). Estimates of abundance have been provided for the 1978/79 to 2000/01 surveys. The 1984/85 survey is conventionally excluded since it was mostly devoted to experiments; and the 2001/02 survey has not yet been validated and entered into the IWC's Database Estimation System Software (DESS 3.2; Strindberg and Burt, 2000).

Providing comparable estimates of abundance from the three circumpolar sets of surveys (CPs) has not been easy. Comparability is problematic because of the different latitudinal coverage: only the third set covers the entire range from the ice-edge northwards to 60°S (except for Area V); and the third circumpolar set had not completed a full circuit

around the Antarctic until the 2000/01 survey. In addition, the percentage of 'like-minke' sightings has increased over time. Branch and Butterworth (2001) provide comparable estimates of abundance (up to the 1997/98 survey) from the three CPs using a three-step process:

- (1) Pro-rate downwards the estimates from CPI and CPII wherever the longitudinal range was not covered in CPIII.
- (2) If there were unsurveyed areas between the northern strata and 60°S in any survey, assume that the density in such an unsurveyed area is the same as that in the corresponding northern stratum.
- (3) Include 'like-minke' sightings in the estimates.

Since the Branch and Butterworth (2001) analysis, three more surveys have been analysed (Fig. 1a) which effectively complete the full longitudinal range of the Antarctic for CPIII. All areas have now been covered, except that Area V was not completely surveyed to 60°S in 1991/92 (Fig. 1b). Area V is being completely re-surveyed by the 2001/02 to 2003/04 SOWER cruises.

The incomplete latitudinal coverage of Area V notwithstanding, it is now possible to make much more defensible comparisons between CPI, CPII and CPIII than

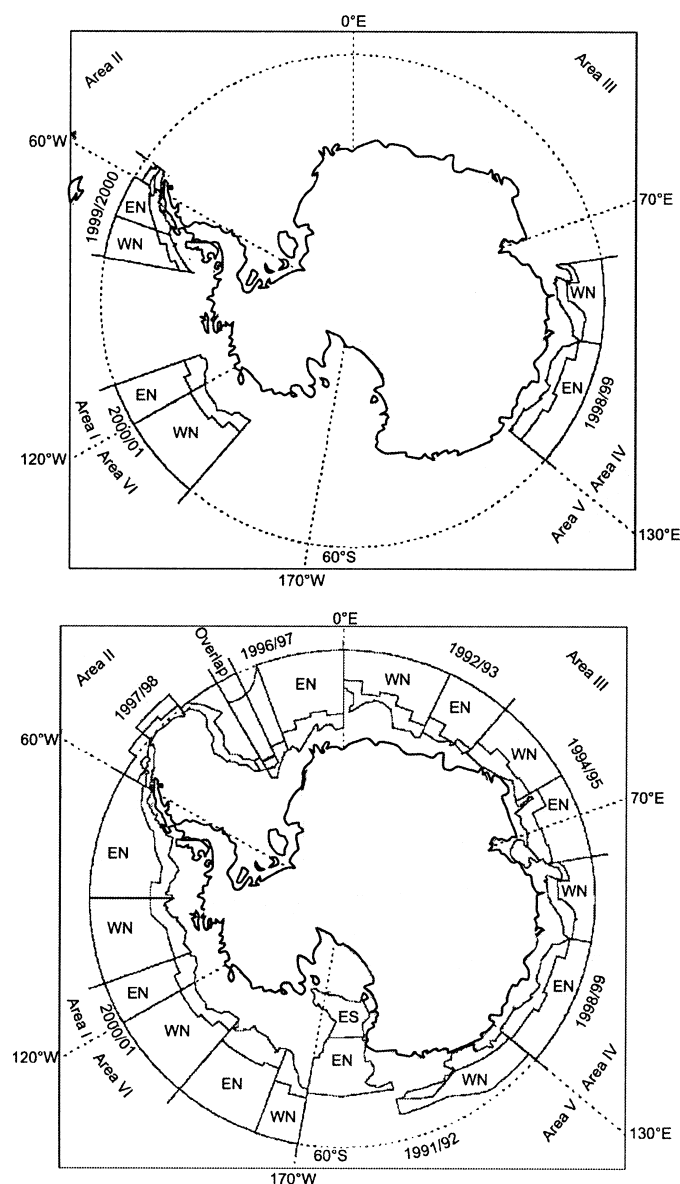


Fig. 1a. Map of the area covered by the 1998/99, 1999/2000 and 2000/01 surveys. Fig. 1b. Areas surveyed during the third circumpolar set of surveys (1991/92 to 2000/01). The surveys are delineated by short solid lines extending northwards from 60°S. The longitudinal strip between 30°W and 25°W ('Overlap') was surveyed in both 1996/97 and 1997/98. The 1999/2000 survey is not shown in this figure; this survey was between 55°W and 80°W and overlapped with the 1993/94 and 1997/98 surveys. Note that the only areas not yet covered south of 60°S are in Area V and a small sector in Area II.

were possible in Branch and Butterworth (2001). The first step in their procedure can be omitted because it is no longer necessary to pro-rate downwards the estimates in CPI and CPII to account for longitudinal ranges not covered in CPIII. In addition, tentative first estimates can now finally be provided for CPIII.

Methods

Abundance estimates were obtained from Branch and Butterworth (2001) for the 1978/79 to 1997/98 surveys; from Burt and Stahl (2001) for the 1998/99 survey; from SC/54/IA3 for the 1999/2000 survey and from SC/54/IA4 for the 2000/01 survey. Branch and Butterworth (2001) did not adjust for whale movement (multiplicative factor $m = 0.985$), whereas the other papers did make this adjustment. In this analysis, estimates from the other papers are divided

by $m = 0.985$ to make these estimates comparable to those in Branch and Butterworth (2001). All estimates are for minke (code 04) plus undetermined minke (code 91). No primary sightings were recorded under codes 90 or 92 during these surveys, though such sightings would have been included in the analysis if they had been recorded. When 'like minke' are considered, sightings for code 39 are additionally included.

Stratum areas are obtained from Branch and Butterworth (2001); these were in turn based on earlier values presented in Butterworth *et al.* (1994). Surveys in CPI and CPII cover the full longitudinal range but incompletely span the latitudes from the ice-edge north to 60°S. Surveys in CPI cover strata totalling 3,441,558 n.miles², plus an additional 60,893 n.miles² north of 60°S, but leave 888,852 n.miles² unsurveyed. Surveys in CPII cover 2,822,799 n.miles² plus 74,162 n.miles² north of 60°S but do not survey 1,649,220 n.miles².

The surveys in CPIII completely cover the entire region south of 60°S to the ice-edge except for Area V in 1991/92 (367,910 n.miles² not covered) and part of a circular 'bite' inside the EEZ of the South Georgia and Sandwich Islands in the 1996/97 survey that was not covered in the 1997/98 survey (14,510 n.miles²). The total area south of 60°S covered in CPIII is 3,904,967 n.miles², with an additional 46,762 n.miles² covered north of 60°S in 1996/97. Some of this longitudinal area has been covered twice: the area between 25°W and 30°W was covered in 1996/97 and 1997/98; between 60°W and 80°W in 1993/94 and 1999/2000; between 55°W to 60°W in 1997/98 and 1999/2000; and between 130°E to 150°E in 1991/92 and 2001/02.

The following steps are taken in this analysis in order to obtain CPIII abundance estimates:

- (1) The slice between 25°W and 30°W is considered to have been covered only by the 1997/98 survey; the estimates from 1996/97 are pro-rated downwards.
- (2) The estimates from the 1999/2000 survey are not included since they repeat the survey in the same region in 1993/94. The 1999/2000 survey undoubtedly provides better coverage between 60°W and 70°W than the 1993/94 survey, but raises complicated issues of how to combine estimates from two areas covered in separate years.
- (3) No results for 2001/02 are included since the data have not yet been validated and included in DESS.
- (4) Strata north of 60°S are included in obtaining these abundance estimates (but not in the 'comparable areas' analysis presented later).

These estimates are normally considered to be minimum estimates for the Southern Hemisphere as a whole, as discussed in Branch and Butterworth (2001).

The procedure outlined in Branch and Butterworth (2001) is followed here, except that the 1998/99 and 2000/01 surveys are now included. The 1999/2000 survey is not included (for reasons outlined above). A more defensible comparison is possible because there is no longer any need to make adjustments for longitudinal areas not covered in CPIII. Separate estimates are calculated for comparable areas (south of 60°S), and for comparable areas with 'like-minke' sightings included. When 'like-minke' sightings are included, a recalculated estimate of R , termed R_{like} , is needed. The re-calculated value used for R_{like} in this paper is 0.758 (CV=0.083), as detailed in table 1 of SC/54/IA26 using the same methods as in Branch and Butterworth (2001).

Results

The percentage of the ice-free area south of 60°S covered by the IDCR-SOWER surveys is recalculated, as shown in Table 1 for CPIII. The percentage coverage by the three CPs between the ice-edge and 60°S is 63.1%, 79.5% and 91.1% for CPI, CPII and CPIII respectively. Note that Branch and Butterworth (2001) inadvertently included areas north of 60°S in calculating this percentage, hence the slight differences between the percentages presented here for CPI and CPII and those in Branch and Butterworth (2001).

Table 1

Areas surveyed during CPIII, showing the area overlap, area north of 60°S, unsurveyed areas south of 60°S and the surveyed area south of 60°S. The total area south of 60°S is the area surveyed less the area overlap and area north of 60°S. All areas are in n.miles².

Year	Area surveyed	Unsurveyed S of 60°S	Area N of 60°S	Area overlap	Surveyed S of 60°S
1991/92	443,845	367,910			443,845
1992/93	445,316				445,316
1993/94	667,776				667,776
1994/95	428,564				428,564
1995/96	446,418				446,418
1996/97	445,715	14,510		73,330	445,715
1997/98	306,981		46,762		260,219
1998/99	387,581				387,581
2000/01	452,863				452,863
Total	4,025,059	382,420	46,762	73,330	3,904,967
Fraction ice-free area south of 60°S covered in CPIII surveys					0.91

Estimates of abundance from the different references cited above are presented in Table 2. The overall abundance estimate from CPIII is 312,071 (CV = 0.086). These estimates are obtained using $R = 0.826$ (CV = 0.089) for the conversion factor between Closing and pseudo-Passing mode. When the estimate from SC/54/IA4 is used: $R = 0.845$ (CV = 0.081), the abundance estimate for CPIII is hardly changed at 311,562 (CV = 0.086). Both estimates of R result in a (rounded) abundance estimate for CPIII of 312,000 (CV = 0.086).

The comparable inverse-variance weighted minke whale estimates for areas south of 60°S for CPI, CPII and CPIII are 852,000 (CV = 0.14); 931,000 (CV = 0.11); and 402,000

(CV = 0.10) respectively (Table 3). Estimates for CPI and CPII are similar, but the ratio of CPIII:CPII is 0.432 (Table 3).

When 'like-minke' sightings are included, and inverse-variance weighted estimates south of 60°S are calculated using R_{like} , the resulting comparable estimates are 928,000 (CV = 0.136); 1,031,000 (CV = 0.107); and 473,000 (CV = 0.099) for CPI, CPII and CPIII, respectively (Table 4). Again, estimates for CPI and CPII are similar but there is a low CPIII:CPII ratio of 0.459 (Table 4). Both CPIII:CPII ratios are significantly less than one at the 5% level.

Discussion

The widely quoted estimate of 760,000 (CV = 0.098) for this stock was obtained by summing the estimates from the 1982/83 to 1988/89 surveys (but not 1984/85) as designated in the 1990 Comprehensive Assessment, and may broadly be considered to apply to the middle year (1985/86) of those surveys (IWC, 1991, pp. 117, 130). Those surveys covered 80.0% of the ice-free area south of 60°S (using data from Branch and Butterworth, 2001). This Appendix provides, using standardised methodology, an estimate of abundance of 312,000 (CV = 0.086) from the 1991/92 to 2000/01 surveys, which is applicable to a middle year of 1995/96. The estimate is for a greater percentage (91.1%) of the ice-free area south of 60°S, and also comes from a more recent set of surveys, than the '1985/86' estimate. The difference in estimates between the '1995/96' estimate presented here and the previous '1985/86' estimate may be due to factors other than a real decline in abundance, as listed below.

Are the estimates here the definitive answer using standard methodology? No, since the surveys in 2001/02, 2002/03 and 2003/04 are intended to completely re-survey Area V between the ice-edge and 60°S. Once these three surveys are finished, the Southern Ocean will have been 99.6% covered by CPIII, with only a small sector within the EEZ of the South Georgia and Sandwich Islands remaining unsurveyed.

This Appendix updates the comparable estimates presented in Branch and Butterworth (2001), obtaining almost identical results: that estimates for CPIII are 43% of those from CPII for comparable areas and 46% when like-minke sightings are additionally included. In other words, the abundance estimates are still appreciably lower in

Table 2

Abundance estimates from each survey in CPIII for closing and IO mode, together with the combined, inverse-variance weighted estimate of abundance. Note that the 1999/00 survey estimates are not included in the CPIII totals since this survey was in the same region as the 1993/94 survey (admittedly with better coverage). Closing mode estimates are converted to pseudo-passing estimates by dividing by $R = 0.826$ (CV = 0.089), the estimate in Branch and Butterworth (2001).

Reference	Survey	Closing mode		IO mode		Pseudo-passing		Inverse-var. weighted	
		Total	CV	Total	CV	Total	CV	Total	CV
Branch and Butterworth (2001)	1991/92	94,855	0.28	92,684	0.22	114,837	0.29	98,682	0.18
Branch and Butterworth (2001)	1992/93	23,322	0.56	24,970	0.24	28,235	0.57	25,363	0.22
Branch and Butterworth (2001)	1993/94	30,993	0.36	37,459	0.26	37,522	0.37	37,479	0.21
Branch and Butterworth (2001)	1994/95	24,234	0.36	32,761	0.23	29,339	0.37	31,620	0.20
Branch and Butterworth (2001)	1995/96	31,950	0.27	36,988	0.30	38,680	0.29	37,839	0.21
Branch and Butterworth (2001)	1996/97	29,228	0.48	26,913	0.27	35,385	0.49	28,158	0.24
Branch and Butterworth (2001)	1997/98	21,158	0.37	12,939	0.38	25,615	0.38	15,428	0.28
Burt and Stahl (2001)+errata	1998/99	4,505	0.46	11,024	0.46	5,453	0.46	6,586	0.34
SC/54/IA3	1999/00	5,021	0.66	5,857	0.39	6,079	0.67	5,911	0.34
SC/54/IA4	2000/01	48,138	0.38	28,939	0.43	58,279	0.39	35,691	0.31
	CPIII*	304,315	0.14	297,442	0.10	368,420	0.16	312,167	0.09

*Total circumpolar estimates have been adjusted for the area of overlap between the 1996/97 and 1997/98 surveys, but still include a small area north of 60°S in 1997/98.

Table 3
Comparable abundance estimates for each circumpolar set of surveys, extrapolated to 60°S.

Survey	Closing mode		IO mode		Pseudo-passing		Inverse-var. weighted	
	Total	CV	Total	CV	Total	CV	Total	CV
1978/79	110,938	0.15			134,308	0.17	134,308	0.17
1979/80	145,967	0.24			176,716	0.26	176,716	0.26
1980/81	212,916	0.27			257,767	0.28	257,767	0.28
1981/82	55,778	0.26			67,528	0.28	67,528	0.28
1982/83	92,999	0.22			112,590	0.24	112,590	0.24
1983/84	84,956	0.23			102,853	0.25	102,853	0.25
1985/86	225,102	0.19	307,451	0.18	272,521	0.21	290,724	0.14
1986/87	142,837	0.26	159,596	0.28	172,926	0.27	166,000	0.20
1987/88	157,285	0.77	244,408	0.35	190,418	0.78	230,761	0.32
1988/89	81,223	0.33	55,549	0.21	98,333	0.34	60,180	0.18
1989/90	128,279	0.38	97,823	0.22	155,301	0.39	104,076	0.19
1990/91	57,572	0.44	57,134	0.33	69,700	0.45	60,462	0.27
1991/92	210,202	0.29	174,496	0.22	254,482	0.30	190,081	0.18
1992/93	23,322	0.56	24,970	0.24	28,235	0.57	25,363	0.22
1993/94	30,993	0.36	37,459	0.26	37,522	0.37	37,479	0.21
1994/95	24,234	0.36	32,761	0.23	29,339	0.37	31,620	0.20
1995/96	31,950	0.27	36,988	0.30	38,680	0.29	37,839	0.21
1996/97	25,616	0.51	20,457	0.30	31,012	0.52	21,828	0.26
1997/98	20,798	0.29	11,802	0.41	25,179	0.31	15,506	0.26
1998/99	4,505	0.46	11,024	0.46	5,453	0.46	6,586	0.34
2000/01	48,138	0.38	28,939	0.43	58,279	0.39	35,691	0.31
CPI	703,555	0.11			851,761	0.14	851,761	0.14
CPII	792,298	0.19	921,962	0.13	959,199	0.21	931,477	0.11
CPIII	419,758	0.16	378,897	0.12	508,181	0.19	402,474	0.10
CPII/CPI	1.126						1.094	
CPIII/CPII	0.530		0.411				0.432	

Table 4

Comparable abundance estimates for each circumpolar set of surveys, extrapolated to 60°S and with 'like-minke' sightings included. The conversion factor between closing and IO mode, R_{like} , has been re-calculated from density estimates with 'like-minke' sightings included, and is 0.758 (CV=0.083) (table 1 of SC/54/1A26).

Survey	Closing mode		IO mode		Pseudo-passing		Inverse-var. weighted	
	Total	CV	Total	CV	Total	CV	Total	CV
1978/79	110,938	0.15			146,357	0.17	146,357	0.17
1979/80	145,967	0.24			192,569	0.26	192,569	0.26
1980/81	212,916	0.27			280,892	0.28	280,892	0.28
1981/82	55,778	0.26			73,586	0.28	73,586	0.28
1982/83	92,999	0.22			122,690	0.23	122,690	0.23
1983/84	84,956	0.23			112,080	0.24	112,080	0.24
1985/86	243,284	0.19	325,389	0.18	320,955	0.21	323,474	0.13
1986/87	143,684	0.26	159,841	0.28	189,557	0.27	172,888	0.20
1987/88	156,822	0.77	281,684	0.35	206,889	0.78	261,037	0.32
1988/89	84,266	0.33	59,098	0.21	111,169	0.34	64,192	0.19
1989/90	138,793	0.38	103,495	0.22	183,104	0.39	110,664	0.19
1990/91	66,748	0.44	77,883	0.33	88,058	0.45	80,900	0.27
1991/92	225,577	0.29	199,009	0.22	297,595	0.30	217,623	0.18
1992/93	22,826	0.56	29,878	0.24	30,113	0.57	29,912	0.22
1993/94	35,161	0.36	43,418	0.26	46,387	0.37	44,307	0.21
1994/95	17,650	0.36	47,385	0.23	23,285	0.37	32,296	0.21
1995/96	36,707	0.27	42,613	0.30	48,426	0.28	45,312	0.21
1996/97	29,858	0.51	28,137	0.30	39,390	0.52	29,820	0.26
1997/98	16,412	0.29	13,556	0.41	21,652	0.31	16,863	0.25
1998/99	5,856	0.46	12,862	0.46	7,726	0.46	9,125	0.33
2000/01	48,802	0.38	31,949	0.43	64,383	0.39	39,443	0.31
CPI	703,555	0.11			928,172	0.14	928,172	0.14
CPII	833,597	0.18	1,007,390	0.13	1,099,733	0.20	1,031,229	0.11
CPIII	438,849	0.17	448,806	0.12	578,957	0.19	473,092	0.10
CPII/CPI	1.185						1.111	
CPIII/CPII	0.526		0.446				0.459	

CPIII than in CPII; and this difference remains statistically significant at the 5% level. Estimates in CPI and CPII are within 11% of each other despite the differences in survey design between the CPI and CPII surveys. The particular improvement in these estimates over those in Branch and Butterworth (2001) is that the full longitudinal range has now been covered in CPIII so that no corrections are necessary to adjust for longitudinal ranges that were not covered by all three CPs when making these comparisons.

Although the estimates are comparable in terms of consistent analysis methodology, factors other than a true decline in abundance may have caused the decrease in the estimates from CPII to CPIII. These factors are the subject of considerable debate in the ongoing in-depth review of Southern Hemisphere minke whale abundance by the IWC Scientific Committee, and include:

- (1) A decrease in sighting efficiency from CPII to CPIII as younger, less experienced observers were introduced to the surveys, which could reduce $g(0)$.
- (2) The surveys from 1994/95 to 1999/2000 were approximately three weeks later than surveys in previous years, hence possibly extending the surveys beyond the period of peak migration of minke whales in the Antarctic.
- (3) Surveys in CPIII extended further northwards than those in CPII. The more northerly regions generally have poorer weather conditions, and a greater proportion of solitary minke whales. If all schools on the trackline were sighted, i.e. $g(0) = 1$, then this would not be problem. However, if $g(0)$ is lower in these northern areas because of this poorer weather and smaller average school size, this factor may explain part of the difference in estimates between CPII and CPIII.
- (4) Possible differences in minke whale distribution, with proportionately more whales in the pack ice and/or north of the survey area for CPIII compared to CPII.
- (5) Possibly inappropriate pooling procedures used in computing standardised estimates.

- (6) Changes in the closing:IO mode ratio R calibration factor between CPII and CPIII.

When CPIII has been officially completed, a method will need to be developed to account for regions that have been surveyed in more than one year. In this analysis, for example, the 1999/2000 survey was omitted because it covered a subset of the area covered by the 1993/94 survey. A better approach would have been to combine the survey estimates using effort-weighting. However, further sub-division of the strata would be needed to ensure that this process can be implemented.

REFERENCES

- Branch, T.A. and Butterworth, D.S. 2001. Southern Hemisphere minke whales: standardised abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys. *J. Cetacean Res. Manage.* 3(2):143-74.
- Burt, M.L. and Stahl, D. 2001. Minke whale abundance estimation from the 1998/99 IWC-SOWER Antarctic Cruise in Area IV. Paper SC/53/IA3 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal – plus 10pp Errata].
- Butterworth, D.S., Borchers, D.L., Chalis, S., De Decker, J.B. and Kasamatsu, F. 1994. Estimates of abundance for Southern Hemisphere blue, fin, sei, humpback, sperm, killer and pilot whales from the 1978/79 to 1990/91 IWC/IDCR sighting survey cruises, with extrapolations to the area south of 30°S for the first five species based on Japanese scouting vessel data. Paper SC/46/SH24 presented to the IWC Scientific Committee, May 1994 (unpublished). 129pp. [Paper available from the Office of this Journal].
- International Whaling Commission. 1991. Report of the Scientific Committee. Annex E. Report of the sub-committee on Southern Hemisphere minke whales. *Rep. int. Whal. Commn* 41:113-31.
- International Whaling Commission. 2002. Chair's Report of the 53rd Annual Meeting. Annex C. Resolutions Adopted During the 53rd Annual Meeting. Resolution 2001-7. Resolution on Southern Hemisphere minke whales and special permit whaling. *Ann. Rep. Int. Whaling Comm.* 2001:57.
- Strindberg, S. and Burt, M.L. 2000. *IWC Database-Estimation System Software (DESS) User Manual*, May 2000. Research Unit for Wildlife Population Assessment, Mathematical Institute, University of St Andrews, St Andrews. 300pp. [Paper available from the Office of this Journal].

Appendix 4

INTRODUCTION OF COVARIATES IN THE HALF-NORMAL FORM OF THE DETECTION FUNCTION FOR MINKE WHALE ABUNDANCE ESTIMATION FOR THE IDCR/SOWER SURVEYS

R.A. Rademeyer, D.S. Butterworth and A. Brandão

SC/54/IA29 explored the use of the covariate estimation framework (MCDS) available in Distance 4 (Thomas *et al.*, 2001) for improving detection function estimation in the computation of minke whale abundance estimates for the IDCR/SOWER surveys. Within this framework, both design (e.g. Stratum) and environmental (e.g. Beaufort sea state) covariates may be incorporated into the scale parameter of the detection function. SC/54/IA29 used the hazard-rate form of the detection function; this paper further investigates the utility of the approach for improving IDCR/SOWER Antarctic minke whale estimates, using the half-normal detection function. This form should be more robust to

(some) correlation between covariates, and since it requires estimation of fewer parameters (one less), should also be easier to fit.

Data from the second circumpolar set of surveys (1985/86-1990/91) were used. To avoid problems with fitting to small sample sizes for some levels of covariates, some grouping of covariate levels was necessary. There were too many levels (34) of Stratum to be included in this analysis (20 being the maximum number of levels that can be handled within Distance 4). The covariates considered are shown in Table 1; in isolation, all of these except Weather improved the fit in terms of the AIC criterion. Examination

Table 1

Negative log-likelihood, AIC and change in AIC (Δ AIC) values for (i) hazard-rate detection function with no covariates; and (ii) multiple covariate half-normal detection functions, for minke whales. Data are from the second circumpolar set of surveys and include both closing and IO modes.

Detection function	Covariate used	Levels	-ln L	AIC	Δ AIC
Hazard-rate	None	-	6,801.0	13,618.0	-124.0
Half-normal	None	-	6,870.0	13,742.0	0.0
	Activity mode	IO, Closing	6,859.4	13,722.9	-19.1
	Sightability	1-3,4+	6,860.0	13,727.9	-14.0
	Beaufort	1-5,6+	6,858.9	13,731.7	-10.3
	Latitude	N,M,S	6,865.7	13,737.5	-4.5
	Vessel	K27,SM1,SM2	6,857.4	13,738.6	-3.4
	Weather	1-6	6,865.3	13,742.5	0.5
	Mode+Vessel	-		13,699.6	-42.3
	Mode+Sightability+Vessel	-		13,648.8	-57.1
	Mode+Beaufort+Vessel	-		13,701.5	-40.5

Table 2

Correlation matrix for possible covariates to be included in the detection function. For the 'vessel' covariate, only the vessels 'SM1' and 'SM2' were included in the analysis. The **bold** values are greater than 20%.

	Year	Vessel	Latitude	Mode	Weather	Windspeed	Sightability	Beaufort	vis	SeenByA	Cluster size	Confirmed	Perp Dist
Year	1.000												
Vessel	0.101	1.000											
Latitude	0.035	0.131	1.000										
Mode	-0.038	0.031	-0.61	1.000									
Weather	0.070	0.084	0.110	0.119	1.000								
Windspeed	-0.156	0.041	-0.053	0.101	0.152	1.000							
Sightability	0.109	0.148	-0.025	-0.120	-0.564	-0.477	1.000						
Beaufort	-0.070	0.057	-0.075	0.092	0.159	0.896	-0.465	1.000					
vis	0.023	-0.042	-0.095	-0.024	0.214	-0.012	-0.075	0.004	1.000				
SeenByA	0.032	0.076	-0.068	0.134	0.038	0.027	-0.035	0.041	0.016	1.000			
Cluster size	-0.027	-0.074	0.030	0.120	-0.035	-0.055	0.069	-0.059	-0.014	-0.046	1.000		
Confirmed	-0.008	-0.028	-0.128	0.642	0.050	0.074	0.099	0.068	-0.026	0.112	0.102	1.000	
Perp Dist	-0.008	-0.113	0.066	-0.102	-0.059	-0.111	0.112	-0.113	-0.005	-0.096	0.143	-0.173	1.000

of the categories of Weather reveals that this is not surprising since this code is a very general descriptor, and would not be expected to have a marked difference on the detectability of whales (at least in Weather conditions suitable for surveying). It is interesting to note that AIC would choose the perpendicular distance only hazard-rate detection function in preference to the covariate models presented here.

The correlation matrix of the covariates used above is provided in Table 2. The bold values are correlation coefficients that are greater than 20%. The data are from the

second circumpolar set only, from both IO and closing modes (a sample size of 2,981). For the 'vessel' covariate, K27 (with the corresponding sightings) was omitted (reducing the sample size to 2,435).

REFERENCE

Thomas, L., Strindberg, S., Marques, F.F.C., Borchers, D.L., Buckland, S.T., Anderson, D.R., Burnham, K.P., Hedley, S.L. and Pollard, J.H. 2001. Distance 4.0. Beta 4. Research Unit for Wildlife Population Assessment, University of St Andrews, UK. [At: <http://www.ruwpa.st-and.ac.uk/distance/>]

Appendix 5

REPORT OF THE WORKING GROUP TO EVALUATE THE PERFORMANCE OF METHODS USED TO ESTIMATE SOUTHERN HEMISPHERE (SH) MINKE WHALE ABUNDANCE

Members: Palka (Chair), Burt, Bravington, Cooke, Hakamada, Hatanaka, Hedley, Matsuda, Matsuoka, Mori, Okamura, Polachek.

Five methods have been proposed that could be used to estimate the abundance of SH minke whales. These are the 'standardised method' (Branch and Butterworth, 2001), the generalised regression method combined with spatial modelling, as proposed in SC/54/IA23, CT spatial-density estimator (SC/54/IA21), a new hazard probability model (SC/54/IA10), and the Cooke estimator (SC/54/IA1). The

latter four methods propose ways to account for potential biases that are not accounted for in the standard method presently used to analyze the IDCR/SOWER data. These potential biases may be, at least partially, responsible for the apparent decline in abundance of SH minke whales. However, uncertainty exists about the performance of these methods, particularly about their robustness, efficiency and potential biases when multiple sources of heterogeneity exist under the data collection procedures used by the IDCR/SOWER procedures. To evaluate the performance of

Table 1

Modifications to the existing IDCR/SOWER survey program.

(1) Underlying density of animals	(a) Clustered groups of whales, modelled by a Neyman-Scott process, conditioned on SH minke data. (b) A skewed distribution of group sizes like that from SH minke (e.g. group sizes ranging from 1-300, where most are less than 5). (c) A density gradient such that the density of groups is correlated with group size.
(2) Whale movement	(a) Assume there is no responsive movement (at this time). (b) Assume whales move randomly at speeds much less than the ship's speed.
(3) Whale surfacing pattern options	(a) Cue rate of individuals are dependent of school size. (b) Cues of individuals within a group are independent of the other individuals in the group. (c) Cues of individuals are the same for entire group. (d) Cues are distributed Poisson, over-dispersed Poisson, uniform, or patterns such as 3 short dives then 1 long dive.
(4) Platforms	(e) Cues generated from actual dive data recorded from North Atlantic minke whales. (a) Three platforms. (b) Separate detection functions for each platform. (c) Partial independence between platforms (i.e. the bridge team stops searching after a group is detected).
(5) Detection function	(a) Accounts for observers using binoculars. (b) Accounts for differential detectability for body and blow sighting cues. (c) $g(0)$ ranges from 0.3 to 1, depending on conditions. (d) Could be dependent on group size, sighting cue, weather, dive time. (e) Could include heterogeneity within a platform and between platforms. (f) Could incorporate the effect of closing mode.
(6) Covariates	(a) Weather (e.g. Beaufort). (b) Group size. (c) Sighting cue (could interact with weather or interact with distance from ice-edge). (d) Hidden variables (i.e. not available to analyser) ... could be aspect (direction of body).
(7) Measurement error	(a) Errors exist in the angle, radial distance, time (already in program). (b) Errors exist in some recorded school sizes and sightability conditions (not in program).
(8) Output	(a) Effort dataset: positions of ship when there are changes in weather, team changes, etc. (b) Sightings dataset: time, position of group, group size, aspect (angle of body).
(9) Closing mode	(a) Will not be included in simulation model explicitly, however, the effect of closing mode could be incorporated into the shape of the detection function and other places above. (b) Later may include clustering/density effects.

these methods, estimates of density and effective strip half-width could be compared after applying each method to simulated data. The true density of the simulated dataset is known and the heterogeneities and survey procedures of interest are included in the simulation. A similar type of evaluation was conducted on the Schweder *et al.* (1999) method used to estimate abundance of North Atlantic minke whales and to evaluate four estimators that do not require the assumption of $g(0)$ equals one (Polacheck *et al.*, 2000).

To successfully achieve the objectives of estimating the abundance and determining the trends of the Southern Hemisphere minke whale population, in addition to addressing Resolution 2001-7 (IWC, 2002), it is necessary to apply an appropriate analysis method to the IDCR/SOWER data. The following work plan is a way forward to identify such an appropriate analysis method (or methods). To complete this work plan in a time frame that would be of most use to the Scientific Committee sufficient resources are necessary, including both money and time.

For the purposes of this evaluation, the range of simulated scenarios will not be exhaustive but will include a variety of scenarios thought to be the most relevant, influential and practical. The basic simulation model consists of a

'universe' of surfacing/diving whales in a two-dimensional plane that spans the viewing region on either side of a long, straight, continuous track line that an observation ship travels on. The ship has multiple platforms which teams of observers survey from. Observers scan the area in front of the ship and each whale surfacing is tested for whether it is detected or not. The detection process can be a function of a large number of variables including the relative position and heading of the whale, weather conditions, school size, sighting cue, etc. The data from the detected whales can then be modified to simulate errors in the measuring/recording process. Because the two-dimensional plane of whales surrounds a long, straight, continuous track line, these simulations do not incorporate the true spatial relationship that exists between a series of zig-zag lines or edges of a study area, this evaluation will not inspect the performance of estimators that attempt to incorporate this spatial relationship between track lines.

To more accurately simulate the sighting procedure used in the IDCR/SOWER surveys and the characteristics of the minke whale population, the existing program used to create simulated datasets (Polacheck *et al.*, 2000) could be modified to include the following.

The timetable for this work plan is:

Time	Event
June 2002	Provide existing simulated datasets to analysers so they can set up their programs to read this type of data.
June to October 2002	Communicate via e-mail to finalise parameterisation of the simulation models and define scenarios.
October 2002	Send first set of simulated data to analysers to determine if datasets appear correct.
November 2002 to May 2003	Iterate production of simulated datasets and getting results from analysers.
May 2003	Present results to SC meeting.

REFERENCES

- Branch, T.A. and Butterworth, D.S. 2001. Southern Hemisphere minke whales: standardised abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys. *J. Cetacean Res. Manage.* 3(2):143-74.
- International Whaling Commission. 2002. Chair's Report of the 53rd Annual Meeting. Annex C. Resolutions Adopted During the 53rd Annual Meeting. Resolution 2001-7. Resolution on Southern Hemisphere minke whales and special permit whaling. *Ann. Rep. Int. Whaling Comm.* 2001:57.
- Polacheck, T., Palka, D., Borchers, D., Cooke, J.G., Skaug, H.J. and Dixon, C. 2000. Simulation comparison of different methods for estimating whale density from double-team line transect data. Paper SC/52/RMP18 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- Schweder, T., Skaug, H.J., Langaas, M. and Dimakos, X.K. 1999. Simulated likelihood methods for complex double-platform line transect surveys. *Biometrics* 55: 678-687.

Appendix 6

RELATIONSHIP BETWEEN ICE CONDITION AND NUMBER OF SIGHTINGS OF ANTARCTIC MINKE WHALES—COMPARISON BETWEEN 1997/98 AND 2001/2002 JARPA SURVEYS IN AREA III E AND IV

Hajime Ishikawa

On the 2001/2002 JARPA cruise, a substantial number of minke whales were sighted, especially near the ice-edge in the East-south stratum and Prydz Bay (Figs. 1a, 1b; SC/54/O18). The number of sightings of minke whales made in Area IV during the 2001/2002 JARPA cruise was the second highest record after the 1999/2000 JARPA cruise conducted in the same area (Ishikawa *et al.*, 2000); the distribution pattern of minke whales in both surveys were very similar. In contrast to these two surveys, there were few sightings of minke whales in the East-south stratum during the 1997/1998 JARPA cruise. According to National Ice Center (NIC) information, there were many ice-free areas south of the ice-edge where research vessels could enter in the 1997/1998 austral summer season (Figs 2a, 2b; Ishikawa *et al.*, 1998). Sexual maturity rate of female minke whales taken by random sampling showed a big difference between

the 1997/1998 and 2001/2002 JARPA surveys. It is well known that pregnant minke whales in the Antarctic summer season tend to gather near the ice-edge, however, sexual maturity rate of females sampled in the East-south stratum on the 1997/1998 JARPA cruise was only 5.3%, while that on the 2001/2002 JARPA cruise was 74.0% (Table 1). This difference strongly supports the hypothesis that mature female minke whales on the 1997/1998 JARPA cruise distributed in the ice-free areas formed south of the ice-edge in the East-south stratum. Therefore, for the purpose of precise estimation of minke whale abundance, the definition of timing of survey should consider the time of retreat of the ice-edge late in the season.

REFERENCES

Table 1
Comparison of density index (DI), maturity rate and abundance of Antarctic minke whales between 1997/1998 and 2001/2002 JARPA surveys in the East-south stratum in Area IV. DI is represented by schools sighted/100 n.miles searching distance. Maturity rate of sampled whales is from Ishikawa *et al.* (1998) and SC/54/O18; estimated abundance is from Hakamada *et al.* (2001).

Survey season	Period (East-south)	DI (Sighting Vessel)	Maturity rate (male / female)	Estimated abundance (Sighting Vessel)
1997/1998	1/15 - 1/30	3.15	68.6% / 5.3%	1,347 (CV=0.33)
2001/2002	1/27 - 2/11	23.03	68.6% / 74.0%	*

*Although the estimated abundance of minke whales in 2001/2002 has not been calculated yet, estimated abundance in 1999/2000 that presented a similar distribution pattern as in 2001/2002 was estimated at 14,036 (CV=0.29).

- Hakamada, T., Matsuoka, K., Nishiwaki, S., Murase, H. and Tanaka, S. 2001. Abundance trend of Southern Hemisphere minke whales in Areas IV and V using JARPA sighting data. Paper SC/53/IA12 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Ishikawa, H., Matsuoka, K., Tohyama, D., Yzu, S., Shimokawa, T., Ohshima, K., Mizuwhima, Y., Nibe, T., Kido, T., Asada, M., Nakamura, M., Ichinomiya, D. and Kinoshita, T. 1998. Cruise report of the Japanese Whale Research Programme under Special Permit in the Antarctic (JARPEN) Area IV and eastern part of Area II in 1997/98. Paper SC/50/CAWS8 presented to the IWC Scientific Committee, April 1998 (unpublished). 26pp. [Paper available from the Office of this Journal].
- Ishikawa, H., Murase, H., Tohyama, D., Yuzu, S., Otani, S., Mogoe, T., Masaki, T., Kimura, N., Ohshima, T., Konagai, T., Asada, M., Takeuchi, J. and Kinoshita, T. 2000. Cruise report of the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA) Area IV and eastern part of Area III in 1999/2000. Paper SC/52/O20 presented to the IWC Scientific Committee, June 2000, Australia (unpublished). [Paper available from the Office of this Journal].

[Figures 1 and 2 follow]

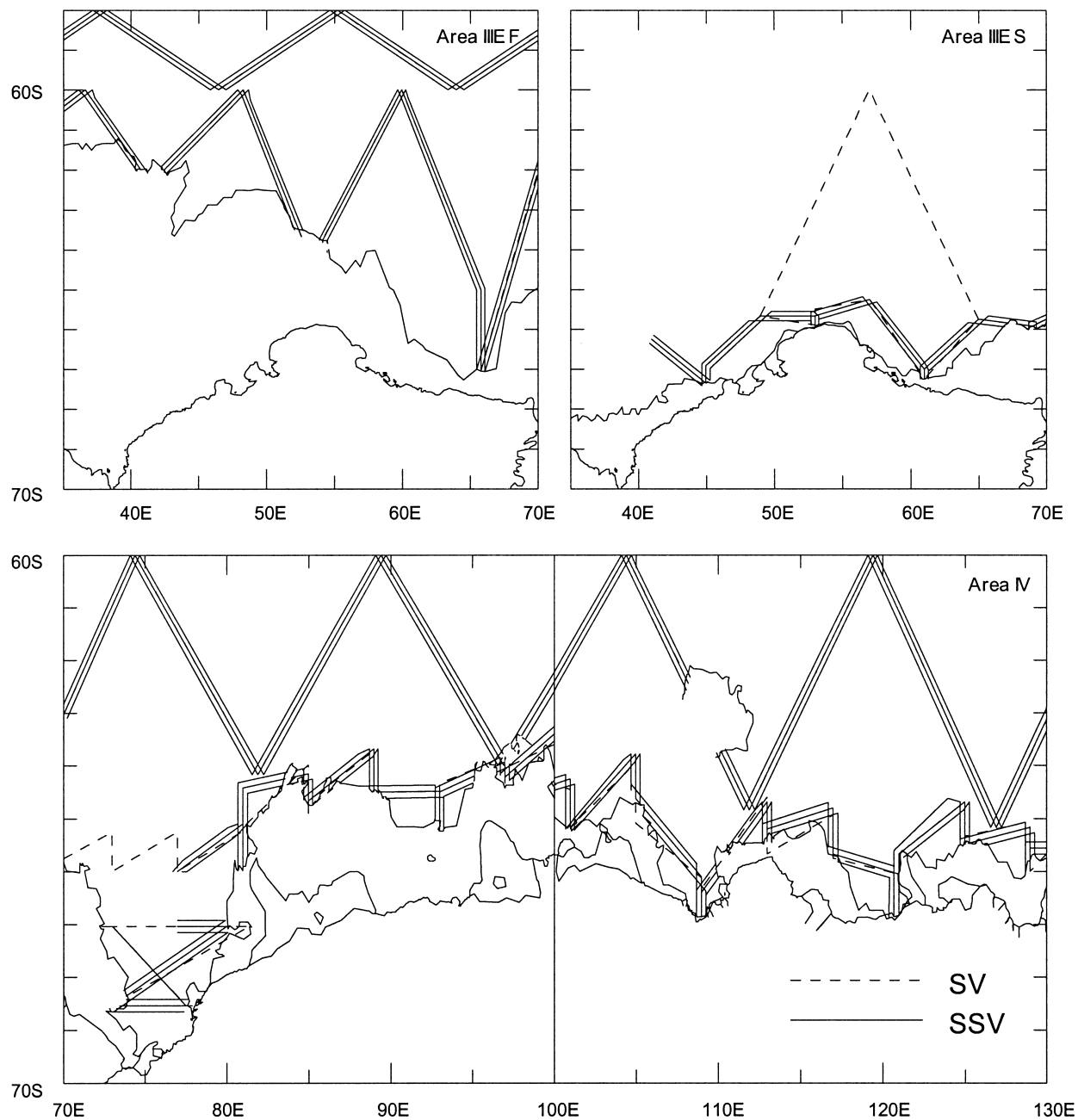


Fig. 1a. Cruise track line of sighting vessel (SV, broken line) and three sighting and sampling vessels (SSVs, solid line) from 2001/2002 JARPA (SC/54/O18). Ice-edge line (solid line) was estimated by observation of research vessels and the information from the National Ice Center (NIC). Upper: eastern part of Area III (the first and the second period); lower: Area IV.

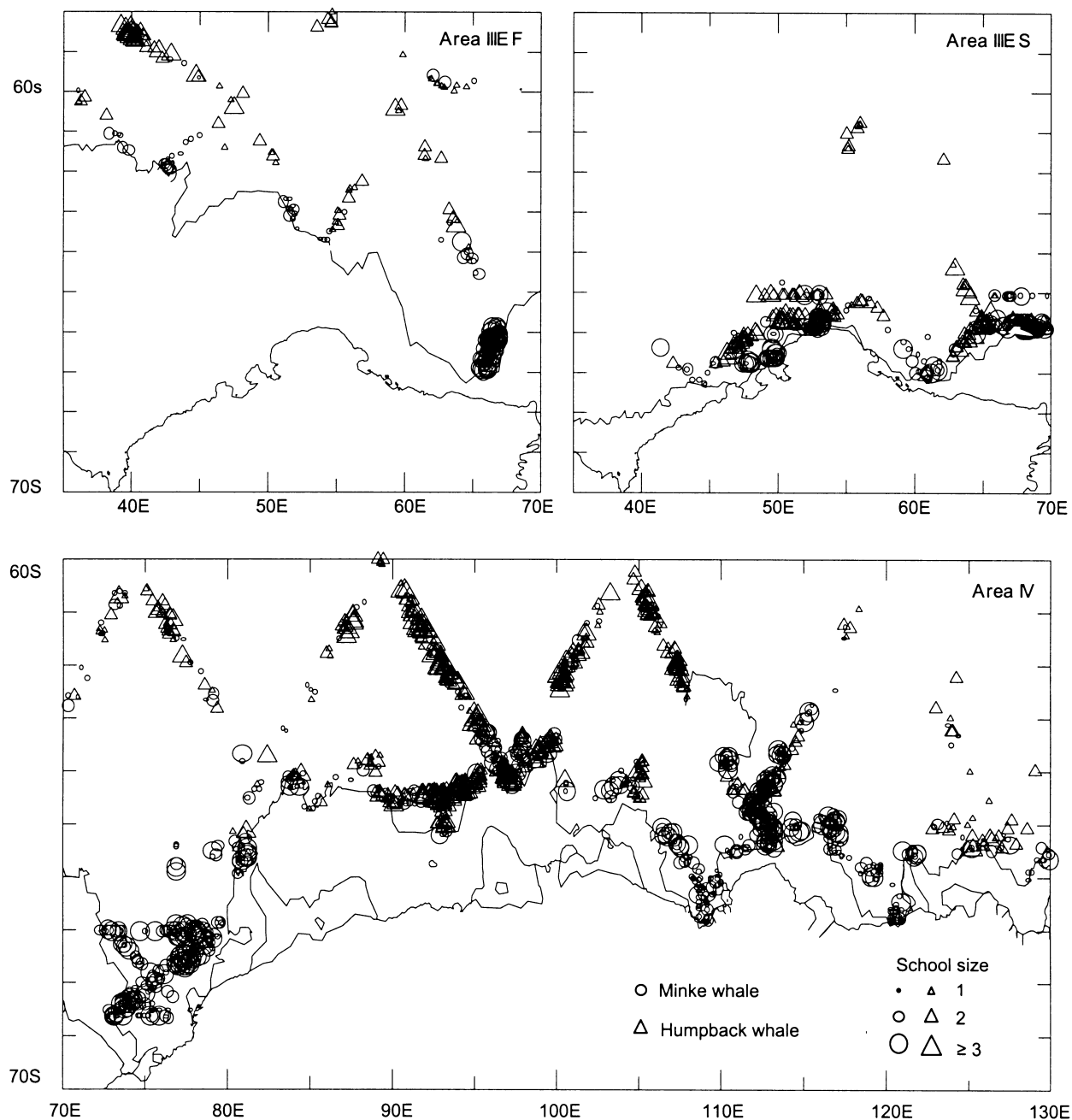


Fig. 1b. Segregative distribution of Antarctic minke whale (circle) and humpback whale (triangle) from the 2001/2002 JARPA cruise (SC/54/O18). Upper: eastern part of Area III (the first and the second period); lower: Area IV.

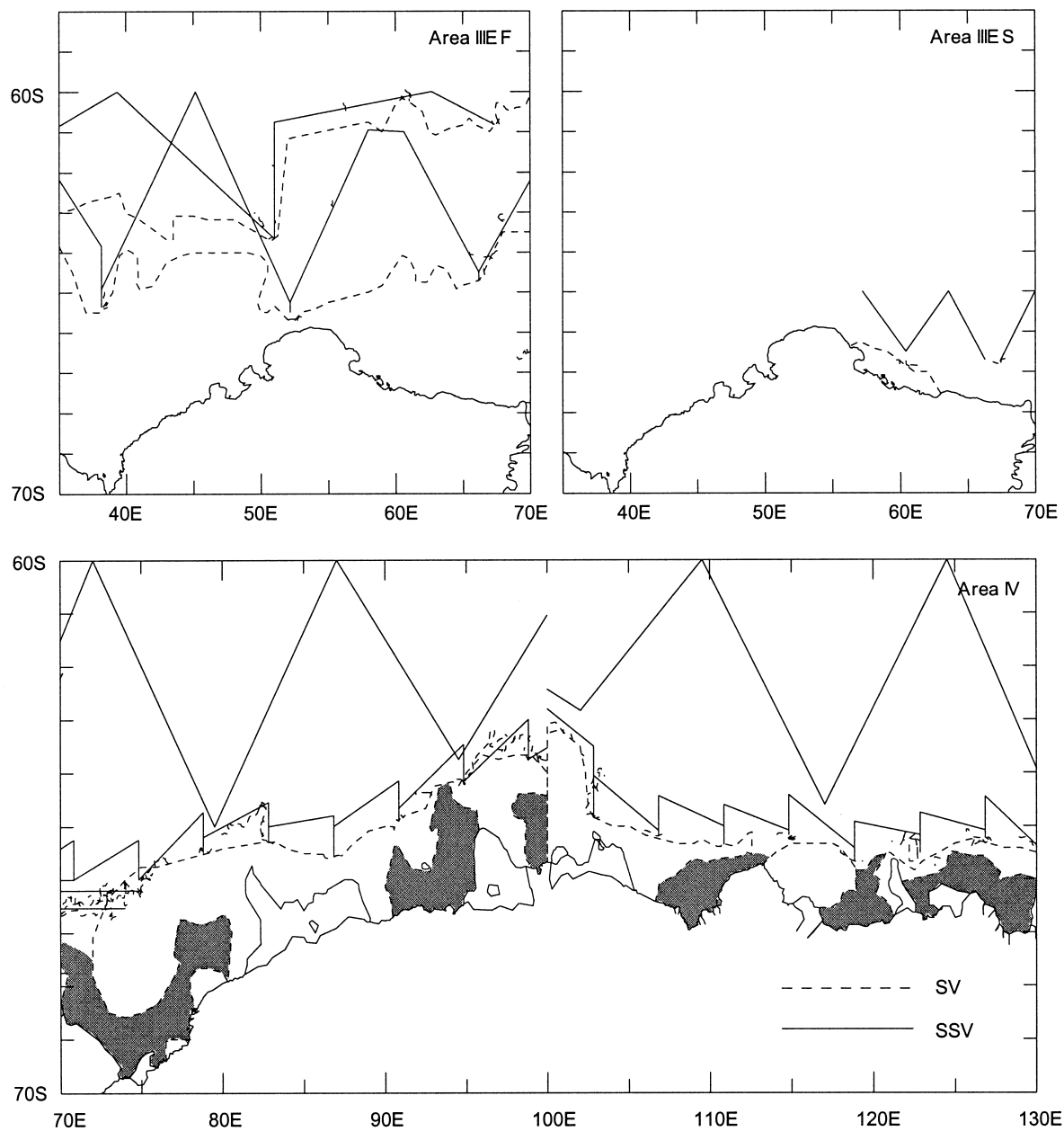


Fig. 2a. Cruise track line of sighting and sampling vessel (SSV, main course) from the 1997/1998 JARPA cruise (Ishikawa *et al.*, 1998). Ice-edge line (broken line) was estimated by observation of research vessels and the information from the National Ice Center (NIC). Shaded area represents estimated ice-free areas south of the ice-edge. Upper: eastern part of Area III (the first and the second period); lower: Area IV.

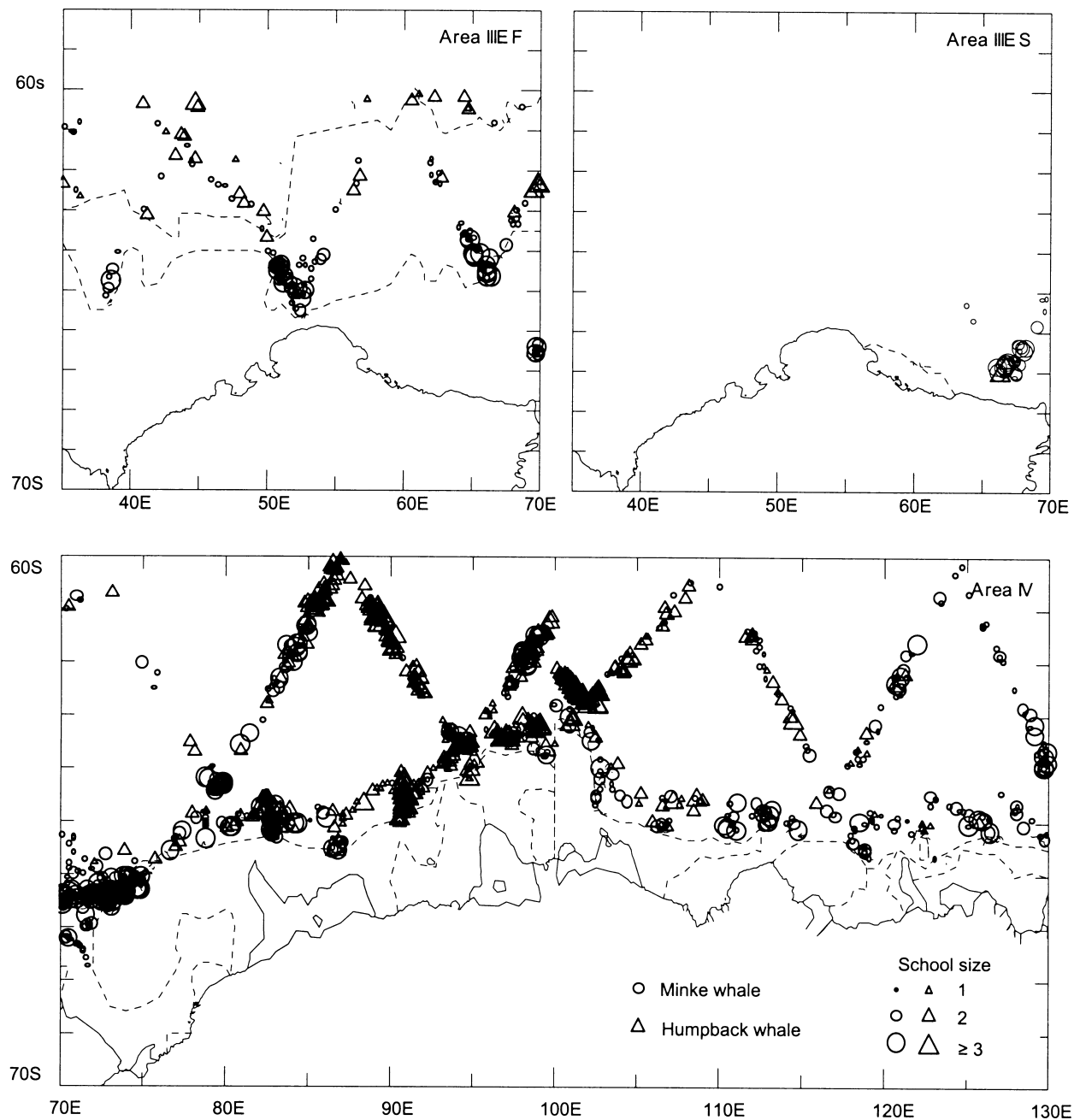


Fig. 2b. Segregative distribution of Antarctic minke whale (circle) and humpback whale (triangle) from the 1997/1998 JARPA cruise (Ishikawa *et al.*, 1998). Upper: eastern part of Area III (the first and the second period); lower: Area IV.

Appendix 7

EXTRAPOLATION OF ANTARCTIC MINKE WHALE ABUNDANCE TO SOUTH OF ICE-EDGE USING SEXUAL STATUS DATA FROM JARPA

T. Hakamada, Y. Fujise, D.S. Butterworth, R. Zenitani and H. Ishikawa

During the 1997/98 JARPA survey of Area IV, a high proportion of pack-ice precluded survey coverage at the higher latitudes. Therefore, fewer mature females (which tend to distribute near the ice-edge) could be sampled than is usual in this Area. As a result, the ratio of mature to immature females sampled in the southern strata was lower in 1997/98 than in other years (Table 1). According to National Ice Center Information, there were many ice-free areas south of the southern boundary of the survey area (the 'ice-edge') during the 1997/98 austral summer. It was suggested that there were mature females that were not detected in 1997/98 but would be usually be detected when the vessels had access to the higher latitudes as in other years.

The composition of sexual status is different between the northern and southern strata due to the segregation by sex and maturity (Fig. 1; Fujise *et al.*, 1999). Therefore, samples were used from the only southern strata. In the northern strata of Area IV, the composition of sexual status is approximately consistent in the northern strata in all years. In the southern strata however, the composition in 1997/98 is markedly different from the other years. In Area V, the composition of sexual status was quite variable between years, in both the northern and southern strata. This may be due to fluctuations in the pack-ice coverage in the Ross Sea.

One hypothesis for the difference in the southern strata in Area IV in 1997/98 is that a large proportion of mature females were distributed in the pack-ice. The number of

mature females that may have been in the pack-ice south of Area IV in 1997/98 was estimated as:

$$\frac{x_{ave} - x_{97/98}}{1 - (x_{ave} - x_{97/98})} P_{97/98, South}$$

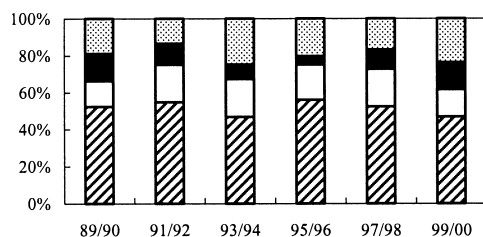
Table 1

Reproductive status and maturity rate in male minke whales sampled by the 1989/90-1999/00 JARPA surveys, in the southern strata of Area IV. (Note that sexual maturity for males was determined by seminiferous tubules over 100µ diameter or spermatid in the tubules and for females was determined by the presence of at least one corpus luteum or albicans in both ovaries).

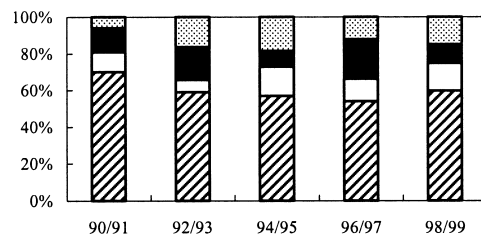
Research Area	Male		Female		MF/(IM+MM+IF)=x
	%	%	%	%	
	Immature (IM)	Mature (MM)	Immature (IF)	Mature (MF)	
Area IV					
89/90	4.4	47.6	16.9	31.1	0.452
91/92	4.9	42.4	13.6	39.1	0.643
93/94	8.8	48.4	15.2	27.6	0.382
95/96	7.3	50.0	13.4	29.3	0.414
97/98*	15.8	39.8	37.2	7.1	0.077
99/00*	4.8	39.0	13.4	42.8	0.748
89/90-99/00**	6.1	45.9	14.5	33.4	0.502
Area V					
90/91	1.5	31.5	10.3	56.7	1.307
92/93	3.0	44.7	10.2	42.1	0.727
94/95	4.9	48.3	9.8	37.1	0.589
96/97*	4.2	16.8	7.9	71.2	2.473
98/99*	6.1	53.8	12.2	27.9	0.386
90/91-98/99	4.0	40.4	10.2	45.4	0.833

*Zenitani (unpublished data). **Excluding 97/98 data.

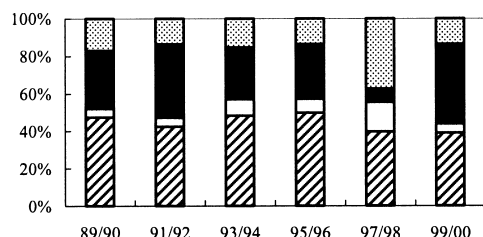
Area IV - North



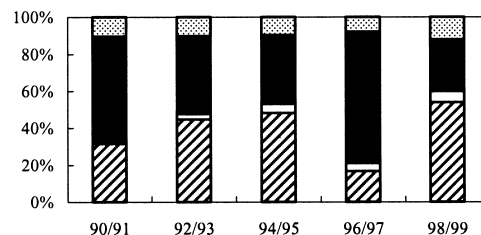
Area V - North



Area IV - South



Area V - South



■ MM □ IM ■ MF ▨ IF

Fig. 1. Composition of sexual and maturity status in the northern and southern strata in Areas IV and V, from JARPA data. MM: mature male. IM: immature male. MF: mature female. IF: immature female

where x_{ave} is the average of x in Area IV excluding 1997/98 and where $P_{1997/98, south}$ is the abundance estimate of 3,888 in south strata from 1997/98 JARPA. Applying this formula, the number of mature females in the pack-ice in 1997/98 was estimated to be 2,876. This is 14.9% of the abundance estimate of 19,342 calculated for the whole of Area IV that year.

To estimate density within the pack-ice, minke whales were assumed to be distributed throughout the pack-ice, including areas where the ice concentration was close to 100%. Some support for this assumption is provided in SC/54/IA19 and SC/54/IA6. Thus, the area of the pack-ice was defined as the area between the ice-edge and the

boundary of the Antarctic continent in Area IV (a total area of 163,925 n.miles² in 1997/98. In this region, the estimate of minke whale density within pack-ice was 0.18 whale/n.miles².

REFERENCE

Fujise, Y., Tamura, T., Ichihashi, H. and Kishino, H. 1999. Further examinations of the segregation pattern of minke whales in the Antarctic Area IV using a logistic regression model, with considerations on the pack-ice distribution. Paper SC/51/CAWS18 presented to the IWC Scientific Committee, May 1999, Grenada, WI (unpublished). 18pp. [Paper available from the Office of this Journal].

Appendix 8

COMPARISON OF SEX RATIOS IN AREA IV AND V IN JARPA SAMPLES

Tom Polacheck and Paul Ensor

This Appendix compares the sex ratio in JARPA samples based on the information presented in Zenitani *et al.* (2001).

Fig. 1 displays the sex ratio overtime in Areas IV and V for mature animals and Fig. 2 displays the same information for immature animals. For mature animals, the proportion of animals which are males in Area IV always exceeds that observed in Area V and is greater than ~0.60 in all years compared to ~0.50 in Area V. One possible hypothesis for the consistently greater proportion of males among the mature animals in Area IV compared to Area V is that mature females preferentially prefer penetrating into the marginal ice-edge relative to males. Such an hypothesis is consistent with the differences in ice conditions in the two areas (i.e. the ice-edge in Area V tends to form a dense, solid boundary while in Area IV it is associated with numerous pockets and leads). Another, but possibly less plausible, hypothesis is that the mature females relative to mature males prefer other regions then Area IV (e.g. to penetrate further south into the Ross Sea).

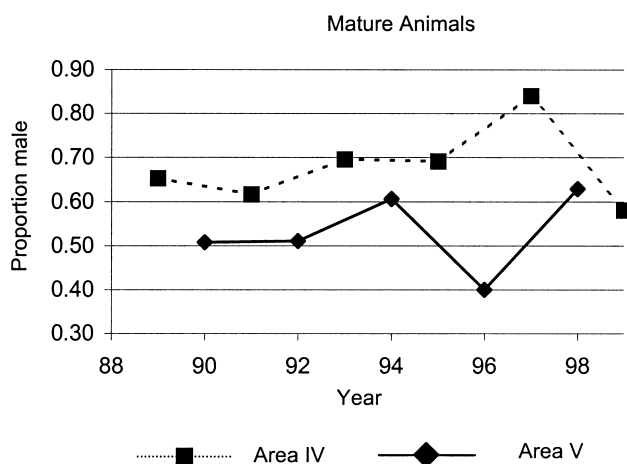


Fig. 1. Proportion of mature whales that were male in the JARPA samples by area and year.

Also evident, in Fig. 1 is the substantial variability in the proportion of males among years (i.e. difference in about 0.25 between the maximum and minimum proportions). In

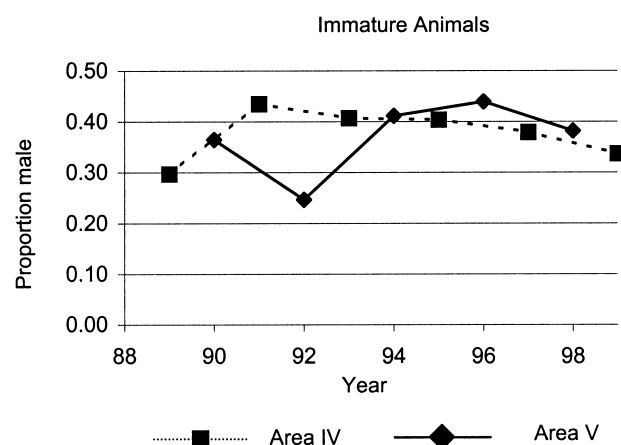


Fig. 2. Proportion of immature whales that were male in the JARPA samples by area and year.

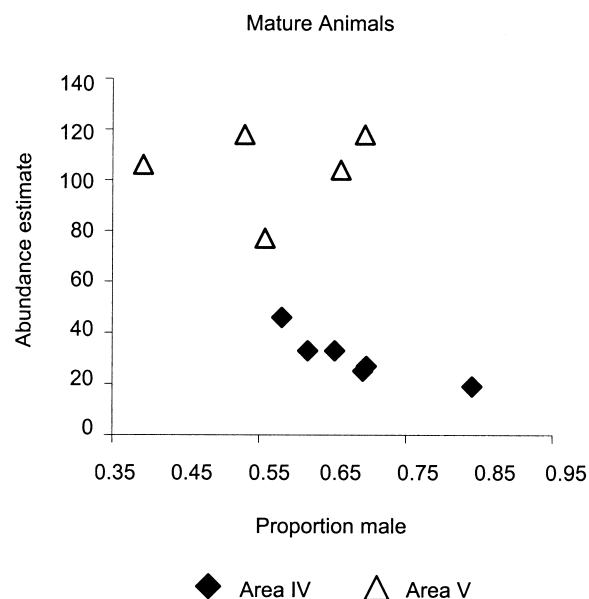


Fig. 3. The relationship between the proportion of mature whales that were male versus the abundance estimates (in thousands) from the JARPA samples and sighting data.

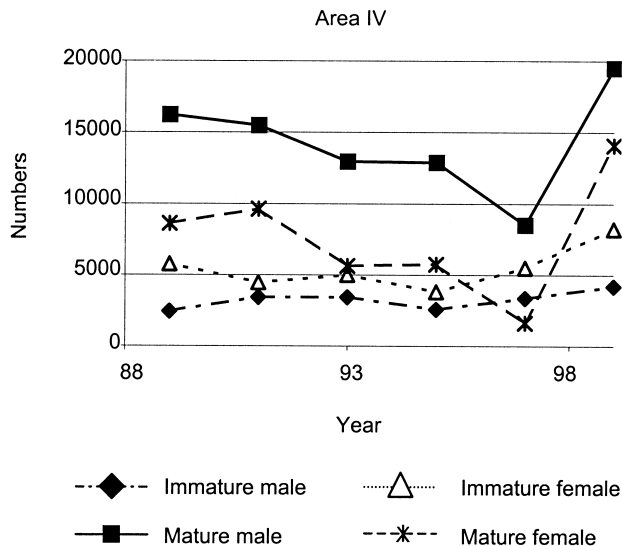


Fig. 4. Estimates of the number of immature and mature whales by sex and year for Area IV from the JARPA survey and abundance estimates. Estimates of numbers were obtained by estimating the total abundance estimates from sighting data by the relative proportion of immature and mature whales by sex in JARPA samples.

Area IV, the variation appears to be inversely proportional to the JARPA abundance estimates, while in Area V there appears to be not any or little relationship (Fig. 3). For Area IV, the inverse relationship appears to be consistent with the hypothesis that in low abundance years a greater proportion of the females are within the ice and is also consistent with observations about ice conditions in 1997. However, the absence of any relationship in Area V with similar levels of variation in the sex ratios suggests that either this may not be the explanation for the observed data in Area IV or that different factors are the source of the variation in this Area.

Figs 4 and 5 provide estimates of the number of mature and immature animals in Areas IV and V by sex and year. These were obtained by multiplying the observed proportions from the JARPA samples by the abundance estimates from JARPA. This figure suggests that the

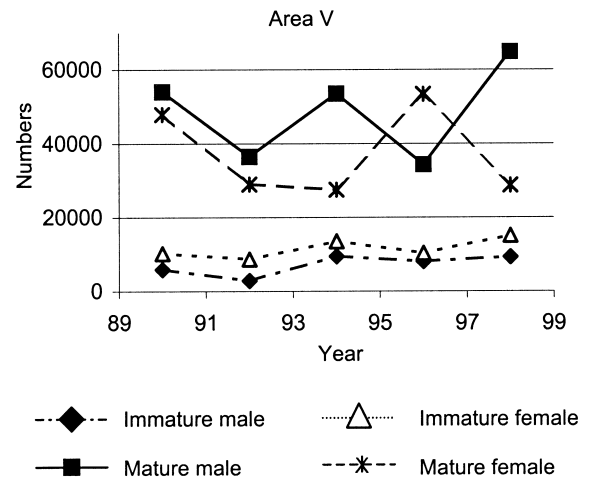


Fig. 5. Estimates of the number of immature and mature whales by sex and year for Area V from the JARPA survey and abundance estimates. Estimates of numbers were obtained by estimating the total abundance estimates from sighting data by the relative proportion of immature and mature whales by sex in JARPA samples.

declines in the abundance estimates in Area IV through 1997/1998 with the very low value in 1997/98 can not be explained simply by increasing proportions of females within the ice and that if increase in ice is the explanation for the declines then both males and females must be entering into the ice zone.

Finally, Fig. 2 suggests that there is no consistent differences in the sex ratio for immature animals between Areas IV and V. However, in all years and Areas, the proportion of immature females exceeds that for males.

REFERENCE

- Zenitani, R., Kato, H. and Fujise, Y. 2001. Year to year trend of some biological parameters of the Antarctic minke whales from the view point of population monitoring. Paper SC/53/IA13 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].

Appendix 9

TASKS TO FURTHER THE ANTARCTIC MINKE REVIEW

The list below is not exhaustive. Where relevant, item numbers have been given referring to points in Annex G that the task addresses, or partly addresses. Letters in bold indicate priority for completion by the 2003 meeting: **H** for High; **M** for Medium; and **L** for Low. Priorities will be reviewed in 2003 in the light of progress made intersessionally.

Methodological issues

- (1) **H**: Validate the most recent year of IDCR/SOWER data (2001/02), put the data into DESS and analyse it using the standard method.
- (2) **H**: Develop new methods to estimate $g(0)$, esw and average school size, and evaluate the performance of these new methods and the standard method using simulations.

- (3) **H**: Apply new methods discussed during the meeting to the IDCR/SOWER data.
- (4) **H**: Develop methods to estimate spatial patterns, specifically the issues discussed in item 6.2.3.
- (5) **M**: For 2003, evaluate performance of analysis methods to estimate the spatial patterns. It is expected this will have to be a high priority task for 2004.
- (6) **M**: Develop methods to estimate variance and additional variance ('process error') when using the new methods.
- (7) **L**: Improve standard methods.

Integration with/use other datasets

- (1) **H**: Coordinate with other projects working in the pack-ice and request access to any cetacean data within and outside of the pack-ice.

- (2) **H:** Investigate data from the American portion of APIS and the BROKE surveys to determine usefulness of data to address estimating densities of minke whales both inside and outside of the pack-ice.
- (3) **H:** Determine if there is any correlation between ice characteristics and cetacean abundance estimates obtained in the IDCR/SOWER and JARPA data.
- (4) **H:** Centralise data required for population dynamics modelling and make them available to the appropriate individuals/organisations.
- (5) **M:** Refine and continue the analyses on the proportion of mature females that could be within the pack-ice.
- (6) **M:** Continue development of appropriate population dynamic models for interpreting changes in abundance estimates.
- (7) **M:** Compare the biological parameters and condition indices of animals in CPII and CPIII. Determine if there are any trends.
- (8) **M:** Continue collating information on relative density of minke whales in the pack ice from previously published reports.

Stock structure

- (1) **H:** Extend the mtDNA work to all Areas around the Antarctic and use microsatellite techniques to investigate the stock structure of the minke whales.
- (2) **H:** Put satellite tags on minke whales seen at the end of the summer in higher latitudes to try to find the breeding grounds.
- (3) **M:** Collect samples of minke whales in the lower latitudes and analyse them to determine the relationship between animals in lower latitudes with those in higher latitudes.
- (4) **M:** Conduct power analyses to determine where more samples are needed to have confidence about the spatial and temporal patterns of the stock structure.

Appendix 10

HYPOTHESES THAT MAY EXPLAIN WHY THE ESTIMATES OF ABUNDANCE FOR THE THIRD CIRCUMPOLAR SET OF SURVEYS (CP) USING THE 'STANDARD METHODS' ARE APPRECIABLY LOWER THAN ESTIMATES FOR THE SECOND CP

Estimates of abundance using the 'standard methods' of Branch and Butterworth (2001b) for the third circumpolar set of surveys (CP) are appreciably lower than estimates for the second CP. The set of hypotheses given in Table 1 may explain (or exacerbate) this difference. These hypotheses relate to: (A) factors related to the population surveyed; (B) factors related to survey process; and (C) factors that could cause a real decline in abundance. The size of the effect of the hypothesis on the ratio of the abundance from CPIII to CPII has been qualitatively indicated as 'small', 'medium' or 'large', where medium is of the order of 10%, and large is of the order of some 10s of a percent. Sources of information describing each hypothesis and its effect on the ratio of abundance from CPIII to CPII have been specified. In addition, methods have been proposed to either account for the effect of the hypothesis or investigate the hypothesis more thoroughly.

These hypotheses might interact to produce effects greater or less than the effect of a single hypothesis when considered on its own.

REFERENCES

- Branch, T.A. and Butterworth, D.S. 2001a. Estimates of abundance south of 60°S for cetacean species sighted frequently on the 1978/79 to 1997/98 IWC/IDCR-SOWER sighting surveys. *J. Cetacean Res. Manage.* 3(3):251-70.
- Branch, T.A. and Butterworth, D.S. 2001b. Southern Hemisphere minke whales: standardised abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys. *J. Cetacean Res. Manage.* 3(2):143-74.
- Brierley, A.S., Fernandes, P.G., Brandon, M.A., Armstrong, F., Millard, N.W., McPhail, S.D., Stevenson, P., Pebody, M., Perret, J., Squires, M., Bone, D.G. and Griffiths, G. 2002. Antarctic krill under sea ice: elevated abundance in narrow band just south of ice edge. *Science* 295:1890-2.
- Fujise, Y. 1997. A brief review of studies related to research on effects of environmental changes on cetaceans in the JARPA survey. Paper SC/M97/5 presented to the IWC Scientific Committee Intersessional Working Group to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic (unpublished). 19pp. [Paper available from the Office of this Journal].
- Fujise, Y., Honda, K., Yamamoto, Y., Kato, H., Zenitani, R. and Tatsukawa, R. 1997. Changes of hepatic mercury accumulation of southern hemisphere minke whales in the past fifteen years. Paper SC/M97/20 presented to the IWC Scientific Committee Intersessional Working Group to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic (unpublished). 16pp. [Paper available from the Office of this Journal].
- Ichii, T., Tamura, T., Fujise, Y., Nishiwaki, S. and Matsuoka, K. 1997. Interannual changes in body fat, stomach-content mass and distribution of minke whales in Areas IV and V. Paper SC/M97/16 presented to the IWC Scientific Committee Intersessional Working Group to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic (unpublished). 19pp. [Paper available from the Office of this Journal].
- International Whaling Commission. 1998. Report of the Intersessional Working Group to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic, Tokyo, 12-16 May 1997. *Rep. int. Whal. Commn* 48:377-412.
- Loeb, V., Siegal, V., Holm-Hansen, O., Hewitt, R., Fraser, W., Trivelpiece, W. and Trivelpiece, S. 1997. Effects of sea ice extent and krill or salpa dominance on the Antarctic food web. *Nature, Lond.* 387:897-900.
- Mitchell, E.D. 1974. Present status of northwest Atlantic fin and other whale stocks. pp. 108-69. In: W.E. Schevill (ed.) *The Whale Problem: a status report*. Harvard University Press, Cambridge, Massachusetts. i-viii+419pp.
- Murase, H., Matsuoka, K., Ichii, T. and Nishiwaki, S. 2002. Relationship between the distribution of euphausiids and baleen whales in the Antarctic (35°E-145°W). *Polar Biol.* 25:135-45.
- Ohsumi, S., Fujise, Y., Ishikawa, H., Hakamada, T., Zenitani, R. and Matsuoka, K. 1997. The fattiness of the Antarctic minke whale and its yearly change. Paper SC/M97/18 presented to the IWC Scientific Committee Intersessional Working Group to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic (unpublished). 21pp. [Paper available from the Office of this Journal].
- Zenitani, R., Kato, H. and Fujise, Y. 2001. Year to year trend of some biological parameters of the Antarctic minke whales from the view point of population monitoring. Paper SC/53/IA13 presented to the IWC Scientific Committee, July 2001, London. [Paper available from the Office of this Journal].

Hypothesis	Likely size of effect on the ratio	Sources of information describing the hypothesis and the size of its effect on the ratio between the abundance estimates from CPIII to CPII	Proposed methods to account for effect or to further investigate effect
A. Factors related to the population surveyed			
A.1. Changes in coverage of Management Areas over years It is difficult to compare the results from the three CP surveys because in the CPI and CPII the full coverage to 60°S was not completed, and in CPIII the full latitudinal coverage in Area V has not yet been completed.	Small	Appendix 3 indicates that abundance estimates for comparable regions that include the 1998/99 to 2000/01 data did not change the CPIII to CPII ratio compared to the ratio when less data from the CPIII survey were available.	Spatial modelling has been proposed to extrapolate over unsurveyed regions.
A.2. Changes in the location of the ice-edge and the proportion of animals south of the ice-edge Minke whale school density and school size drops off with distance from the ice-edge. The location of the ice-edge affects the proportion of the population within the survey region. Thus, an unknown, but conceivably large proportion of the SH minke whale population may be south of the ice edge, where vessels cannot go. This proportion is likely to change from year to year. The ice-edge extent and ice coverage are greatly affected by Antarctic and extra-polar climatological connections such as the Semiannual Oscillation (SAO), the Southern Oscillation Index (SOI) and the El Niño-Southern Oscillation (ENSO).	Uncertain, potentially large	SC/54/IA7 provides summary information and reference on inter-annual and longer-term trends in the Antarctic sea ice on regional scales. Climatological indices and available sources of satellite-derived sea-ice data are summarised under item 6.3.3.1. SC/54/IA6 indicates there were minke whales in the pack-ice between 150E and 77E a month earlier than the IDCR/SOWER survey; however, no abundance estimates were possible. SC/54/IA18 indicates that the low abundance estimate from Area IV in the 1998/99 IDCR/SOWER data (CPIII) as compared to that in 1989/90 (CPII) was correlated with more ice coverage during 1998/99. Appendix 6 indicates that in 1997/98 the abundance from Area IV using JARPA data was low and ice coverage was high, in contrast to the next two times when this Area was surveyed, in 1999/2000 and 2001/02, when the abundance was high and ice coverage low. Murase <i>et al.</i> (2002) indicates that an important feeding ground is the continental slope-shelf zone that is covered by ice during summer and not able to be surveyed by the survey vessels in some years. SC/54/IA19 indicates that the predicted number of minke whales in the pack-ice could vary from 18% to 159% of the open water abundance estimate, depending on the data used to estimate the relative density of minke whales in the ice to that in open water. None of the data currently available to estimate the relative density were collected during the full time period of the IDCR/SOWER surveys. Appendices 7 and 8 indicate that mature females were sampled less than usual due to higher coverage of pack-ice in 1997/98 JARPA. This is possibly because these animals are in the pack-ice.	To account for the potential effects of sea-ice location, several methods have been proposed. For example, use covariates in the analysis (i.e. distance for ice-edge, school size, descriptors of sea-ice (i.e. sea-ice coverage or concentration)), or stratify data by the North and South strata (instead of stratifying by vessel). To investigate the percentage of the population in the ice-pack, a work plan has been proposed that includes fully understanding existing published data, gathering all available recent data, and collecting additional data in the future, in collaboration with other national projects when possible (see item 6.3.3 for more details).
A.3. Changes in the timing of the survey Compared to earlier IDCR/SOWER surveys, the timing of the surveys from 1994/95 to 2000/01 was later in the summer. This may have resulted in a smaller fraction of the population being present in the survey area during the 1994/95 to 2000/01 surveys.	Small	SC/54/IA7 summarises information on satellite-imagery available to examine the change in ice extent/ice coverage between survey years, as well as the rate of retreat of the pack ice during the December-January period of most rapid ice retreat. SC/54/IA12 indicates that when using the JSV and IDCR/SOWER data, the peak migration in Areas III, IV and V in waters south of 60°S was in January during the 1970s and later during the 1990s. However, due to combining the datasets collected during CPI and CPIII and small samples, it is difficult to fully interpret these data. SC/54/IA28 indicates that when using the IDCR/SOWER data from 1978/79 to 1997/98, densities appear reasonably stable over the January to mid-February period, following which there was a decrease of about 20% in late February. The implications of this for abundance estimates given the later timing of some CPIII surveys were not investigated.	

Hypothesis	Likely size of effect on the ratio	Sources of information describing the hypothesis and the size of its effect on the ratio between the abundance estimates from CPIII to CPII	Proposed methods to account for effect or to further investigate effect
A.4. Changes in the school size distribution The estimated mean school size appears to have decreased in CPIII. This may be due to the following: true mean school size tends to increase with latitude, observed school size tends to decrease with increased Beaufort conditions, and more inexperienced observers were used in CPIII compared to CPII.	Small to medium	SC/54/IA13 indicates there is a significant difference in the school size distribution in the North and South strata. SC/54/IA17 indicates that the school size distribution changed between the CP surveys. This is related to the changes of areas covered and sighting cues.	Incorporate the school size as a potential covariate in fitting the detection function.
A.5. Animals north of 60°S	Uncertain, likely small	SC/54/IA12 indicates that using JSV data has shown that there are minke whales north of 60°S. However, the relative magnitude of possible changes of abundance in this area is uncertain.	Further investigate use of the JSV data to extrapolate to areas north of 60°S.
B. Factors related to survey process			
B.1. Changes in the proportion of schools classified as 'like-minke'	Small	Appendix 3 indicates that the ratio of abundance from comparable regions for CPIII to CPII increased by 6% when like-minke whale sightings were included.	Estimate abundance excluding and including sightings that are like-minke to investigate the effects of this factor when using any of the proposed analytical methods.
B.2. Changes in the probability of observing animals on the track line $g(0)$ $g(0)$ for small school sizes is less than one. Factors that affect the estimated mean school size include: sightability conditions, observer experience, sighting cue, and survey mode. Some of these changes may be due to surveying more northerly waters where the weather is usually worst, and the true group size is smaller than that from near the ice-edge. More inexperienced observers have been used in CPIII compared to previous CP surveys.	Medium to large	SC/54/IA10 indicates that when using the 1989/90 (from CPII) and 1993/94 (from CPIII) IDCR/SOWER data from Area I with the new variant of the hazard probability analysis method, $g(0)$ is about 0.6 for school sizes of one, and about 0.9 for school sizes greater than two. Within a school size, $g(0)$ from the one year analysed from CPII was 2-9% greater than that from the one year analyzed from CPIII. The effect of including an estimate of $g(0)$ using this method on these data was an increase in the abundance by about 29%. SC/54/IA16 indicates that the duplicate sighting probability was lower for small schools, schools detected in bad weather, and those schools that were made by inexperienced observers. For school sizes of two, the duplicate sighting probability was 1.56 times larger than for schools of size one, and the probability for school sizes >2 was 1.84 times larger. The duplicate sighting probability tended to be smaller for CPIII than for CPII by about 20%, where the effect was largest in the North stratum. SC/54/IA30 indicated that when using $g(0)$ values from SC/54/IA10, the density estimates derived from the standard methods are negatively biased by 18% to 39%, depending on the survey mode (IO versus Closing mode) and circumpolar survey series.	Incorporate the following covariates into the analysis, if deemed necessary: school size, sightability (or Beaufort sea state), sighting cue, survey mode, or environmental indicators. The analytical methods will not assume $g(0)=1$. The performance of the analysis methods will be evaluated using simulated data that account for effects from above and incorporate a variety of heterogeneities.
B.3. Changes in the bias of Closing mode estimates compared to IO mode estimates	Small	SC/54/IA26 indicates that the bias of Closing mode estimates relative to IO mode estimates from CPIII are different than that from CPII, though the estimates from CPIII appear to be less stable due to small sample sizes.	
B.4. Changes in the analysis options Alternative options of stratification, data truncation, school size estimation methods, and model for the detection function could lead to different school size and esw estimates and hence different abundance estimates.	Uncertain, probably small	SC/54/IA5 indicates that when using the 1998/1999 IDCR/SOWER data, the abundance estimate from the closing mode could increase by up to 23%, and that from the IO mode could change by -3% to +18%, depending on the combination of alternative options used. Effects on the CP level were not investigated. SC/54/IA10 indicates that when using the 1989/90 and 1993/94 IDCR/SOWER data, the school size estimate can decrease to up to approximately 50%, depending on how the data were stratified, and school size estimated. SC/54/IA13 and SC/54/IA15 indicate that when using IDCR/SOWER data from 1985/86 to 1998/99, the annual abundance estimates changed by -6% to +47% of the previous estimates when the data were stratified by North and South instead of by vessel, where the 1995/96 to 1998/99 have the largest positive differences.	Incorporate the following covariates into the analysis, if deemed necessary: school size, sightability (or Beaufort sea state), sighting cue, survey mode, or environmental indicators. The analytical methods will not assume $g(0)=1$. The performance of the analysis methods will be evaluated using simulated data that account for effects from above and incorporate a variety of heterogeneities.

Hypothesis	Likely size of effect on the ratio	Sources of information describing the hypothesis and the size of its effect on the ratio between the abundance estimates from CPIII to CPII	Proposed methods to account for effect or to further investigate effect
B.4. Changes in the analysis options cont.		SC/54/IA32 indicated that using 1985/86 to 2000/01 IDCR/SOWER data to estimate abundance where data were stratified by North and South (from Appendix 3), instead of by vessel (from SC/54/LAWP6), the abundance estimate from CPII increased by 4% and that from CPIII increased by 8%. Thus, the ratio of abundance from CPII to CPIII increased by about 4% when the data were stratified by North and South.	
C. Factors that could cause a real decline in abundance			
C.1 Natural mortality Natural mortality may have increased due to increases in killer whale populations and/or killer whale prey preference.	Unknown, no evidence	Estimates of natural mortality presented in SC/54/IA25 were 0.046 to 0.070 yr ⁻¹ but there is no estimation of changes over time. Some reports of killer whales feeding on minke whales but no indication of trends, and the power of detecting a change based on observations is minimal. Abundance estimates of killer whales (predators) are higher in CPI, but similar in CPII and CPIII for comparable areas (Branch and Butterworth 2001b); differences between CPI and the other two sets may be caused by a change in the survey design.	Analysing changes in age structure. Models estimating natural mortality (e.g. extending the analyses in SC/54/IA25). Refinement of killer whale abundance estimates, including stratification by population type (fish versus mammal consumer). Analysis of killer whale scars in JARPA data.
C.2 Mortality due to whaling Effect in the opposite direction since commercial whaling (which ended in 1987) caught many more minke whales than JARPA (1988 onwards).	Small	Branch and Butterworth (2001a) note that mortality from JARPA would need to be more than an order of magnitude higher to explain the observed decline. Catches have declined from CPII to CPIII so effect is in the opposite direction.	None planned. Models could address this issue.
C.3 Incidental mortality from ship strikes, bycatch There may be increased mortality from ship strikes, and bycatch in CPIII.	Very small	No scars from ship contacts or net entanglement in JARPA samples. No ship strikes recorded during JARPA or IDCR/SOWER surveys. Very few minke deaths in passive shark nets off South Africa affect the Southern Hemisphere stock; the impact on the stock was considered not significant. Drift netting in the waters east of New Zealand in the 1980s has now ceased, so this minor source of mortality may be even lower in CPIII.	
C.4. Mortality due to pollution Increasing levels of marine pollution could cause greater mortality.	None to small	Air and sea water samples from IDCR-SOWER showed very low pollution in Antarctic. Ingested plastic from JARPA cruises showed no evidence of an increase. Pollution residues (PCBs, DDT and mercury) were examined in Fujise (1997) and Fujise <i>et al.</i> (1997). Although there was an increasing trend in PCBs from 1984 to 1993, concentrations were much lower than in the Northern Hemisphere and are unlikely to result in increased mortality. Mercury concentration in younger animals decreased in the last decade (IWC, 1998, p388).	JARPA collection of pollution data continuing.
C.5. Increasing mortality due to disease	Unknown, no evidence	Very rarely reported from JARPA samples.	
C.6. Decrease in recruitment rate¹	Unknown, little information	Zenitani <i>et al.</i> 2001 showed that apparent pregnancy rate did not change. Neonatal survival is likely a function of the condition of the mother. Blubber thickness data from JARPA showed that body fat was correlated to sea ice: when the ice extent was great, body condition was poor because krill was less available. Reported briefly in IWC (1998 p387), check in paper Ichii <i>et al.</i> (1997). Trends in blubber thickness are reported in Ohsumi <i>et al.</i> (1997).	Update and reanalyse the JARPA samples to develop a condition factor series by area and year.

Hypothesis	Likely size of effect on the ratio	Sources of information describing the hypothesis and the size of its effect on the ratio between the abundance estimates from CPIII to CPII	Proposed methods to account for effect or to further investigate effect
C.7. Phenomenon of overshooting	Medium	This could occur because minke whales may be capable of relatively rapid increase and may be expected to overshoot the carrying capacity levels and subsequently decline. Given indications in SC/54/IA25 that minke whales had been increasing towards the carrying capacity, some more recent decline might be expected.	Age structure, newborn to mature ratios, and modelling efforts could address the extent of implied density-dependent recruitment rate and include age-structure of the krill resources.
C.8. Decreases in carrying capacity due to lower krill populations (also related to natural mortality)	Unknown, possibly large either direction	Brierley <i>et al.</i> (2002) show that the ice-edge length which is favoured by krill has decreased by perhaps 9% since the 1960s. Loeb <i>et al.</i> (1997) showed that krill abundance went through major changes in opposite directions to salp abundance in the Antarctic. CCAMLR reports indicate circumpolar krill abundance has increased from 1981 to 2000 (SC-CCAMLR 2000)	Review krill abundance estimates to decide whether there has been a change.
C.9. Decrease in carrying capacity due to increase in competition from other predators (e.g. baleen whales) Some baleen whales may have increased in numbers since commercial whaling stopped. Increases might reduce the krill available to minke whales.	Unknown, possibly medium	Abundance of humpbacks in some areas has increased at near to the maximal possible rate.	Multispecies models could address this issue.
C.10. Krill fishing reducing available prey	None to small	The krill fishery is very small compared to the estimated productivity of the krill population (see references in C.8.).	
C.11. Indirect effects of changes in other non-cetacean species that may feed on krill	Unknown, no evidence		
C.12. Climate oscillation and global warming	Unknown, positive or negative	Effects on sea-ice are complex. Changes could be directional or cyclic (see references in A.2). Episodic ice-induced mortality by closure of leads trapping animals (Mitchell, 1974). A directional climate effect seems unlikely since other species (humpback and right whales in some areas) are increasing at near to their maximal rates.	

¹ Recruitment rate is the product of the pregnancy rate and juvenile survival rate.

Appendix 11

BLUE WHALE ESTIMATES FROM THE IDCR-SOWER SURVEYS: UPDATED COMPARISONS INCLUDING RESULTS FROM THE 1998/99 TO 2000/01 SURVEYS

T.A. Branch and R.A. Rademeyer

An updated estimate is presented for blue whales in the Antarctic for the third circumpolar set of surveys (CPIII) from the IDCR-SOWER surveys. The following surveys are included: 1991/92-1998/99 and 2000/01; the survey in 1999/2000 is not included since it resurveyed the same area as the 1993/94 survey. Standard line transect methodology is applied. The estimate for CPIII is 1,700 (CV = 0.42), and applies to the full longitudinal range around the Antarctic and to 91.1% of the ice-free area south of 60°. Updated comparable estimates for CPI, CPII and CPIII are presented for equal areas and for when 'like-blue' sightings are additionally included. The CPIII:CPII ratio is 2.8 and 3.3 for 'comparable' and 'comparable + like' abundances respectively, but this increase in comparable abundance is not significant at the 5% level.

Introduction

Standardised methods were used in Branch and Butterworth (2001) to provide blue whale abundance estimates from the IWC's IDCR and SOWER programmes. Subsequently, a further three surveys (1998/99 to 2000/01) have been validated and included in the IWC's Database Estimation System Software (DESS 3.2 Revised, Strindberg and Burt, 2000). This paper updates the estimate from the third circumpolar set of surveys (1991/92 to 2000/01) by including results from the recent surveys. The new surveys also make it possible to use fewer assumptions when producing comparable estimates among circumpolar sets, and so the 'comparable areas' estimates in Branch and Butterworth (2001) are also updated in this paper. The methods are similar to those used in Appendix 3 and only the differences are outlined here.

Methods

Estimates were obtained using DESS 3.2. Maps of the additional surveys and the third circumpolar set of surveys in entirety are presented in Appendix 3. The 1999/2000 survey was not included since it covered a subset of the region of the 1993/94 survey. Admittedly, the later survey obtained better coverage of the area, but including it would have required restratification of both the 1993/94 and the 1999/2000 surveys in addition to further averaging of the results of the two surveys. The 5° overlap between the 1996/97 and 1997/98 surveys was dealt with in the same manner as Branch and Butterworth (2001). All estimates are for the

same species codes as in Branch and Butterworth (2001), i.e. codes 1, 96, 98 and 99 were used for the blue whale estimates; for 'like blue' estimates, code 94 was also included.

Results

Estimated school size and effective search half-width were very similar between CPII and CPIII (Table 1), but both were smaller than those in CPI. Estimates of abundance are summarised in Table 2, together with estimates from comparable areas and estimates including like-blue sightings from comparable areas.

Given the high associated CVs, the differences between CPII and CPIII estimates are not significant at the 5% level in any of the scenarios above, but the power to detect this difference is also low.

Table 1

Estimated mean school size, $E[s]$, and effective search half-width, w , for the three circumpolar sets of surveys for blue whales.

Circumpolar set	$E[s]$	CV	w	CV
I	1.75	0.16	1.97	0.11
II	1.43	0.21	1.57	0.30
III	1.39	0.10	1.65	0.35

Discussion

These estimates are normally considered to be minimum estimates for true blue whales in the Southern Hemisphere. A number of factors need to be considered before extrapolating from these surveys in the Southern Ocean to the Southern Hemisphere:

- (1) The possibility that $g(0) < 1$, i.e. some schools on the trackline are missed.
- (2) Some blue whales may not migrate into the survey areas south of 60°S.
- (3) There may be a small proportion of pygmy blue whales in these estimates.

Table 2

Estimates of abundance (with CVs and 95% confidence intervals) for each circumpolar set of surveys for blue whales. 'Baseline' refers to estimates of abundance for blue whales in the Antarctic. 'Comparable areas' adjust the baseline estimates so that they are for comparable areas between 60°S and the ice-edge. 'Comparable + like sp.' additionally include 'like-blue' sightings in the estimates for comparable areas. Confidence intervals are calculated according to the method of Buckland (1992).

Circumpolar set	Baseline			Comparable areas			Comparable + like sp.		
	Abundance	CV	95% CI	Abundance	CV	95% CI	Abundance	CV	95% CI
I	437	0.41	(200; 940)	546	0.41	(250; 1,200)	546	0.41	(250; 1,200)
II	549	0.48	(230; 1,300)	680	0.51	(270; 1,700)	675	0.51	(260; 1,700)
III	1,671	0.42	(760; 3,700)	1,891	0.42	(860; 4,200)	2,257	0.38	(1,100; 4,600)

A possible concern was that the northward extension of the surveys in CPIII to 60°S may have resulted in increased numbers of pygmy blue whales being sighted, instead of the true blue whales to which these results refer. However, most of the blue whale sightings occurred in the southern strata. If greater numbers of pygmy blue whales were being sighted, they would likely be in the northern strata, so it is unlikely that the (apparent) increase in abundance is caused by a greater percentage of pygmy blue whales in the sightings. An updated analysis in SC/54/IA8 indicated that a small proportion (perhaps up to 7%) of pygmy blue whales may be present south of 55°S. The increase (admittedly not significant) in the abundance estimates for blue whales contrasts markedly with the significant decrease in estimates of abundance for minke whales from the same surveys. It is possible that $g(0)$ for minke whales is much less than one in the northern strata in CPIII, where solitary minke are more common and weather conditions more severe; however, the increasing trend for blue whales would seem to indicate that changes in $g(0)$ are not a problem for the more easily detected blue whales. SC/54/IA16 found no indication of a

decrease in $g(0)$ for blue whales with smaller school sizes or between northern and southern strata; this may be taken as further evidence that $g(0)$ for blue whales is greater than for minke whales.

The 2001/02 to 2003/04 surveys will completely re-cover Area V, replacing the 1991/92 survey. Once completed, the Southern Ocean will have been 99.6% covered by CPIII, and abundance estimates for blue whales can be finalised.

REFERENCES

- Branch, T.A. and Butterworth, D.S. 2001. Estimates of abundance south of 60°S for cetacean species sighted frequently on the 1978/79 to 1997/98 IWC/IDCR-SOWER sighting surveys. *J. Cetacean Res. Manage.* 3(3):251-70.
- Buckland, S.T. 1992. Report of the Scientific Committee, Annex H. Proposal for standard presentation of abundance estimates. *Rep. int. Whal. Commn* 42:235.
- Strindberg, S. and Burt, M.L. 2000. *IWC Database-Estimation System Software (DESS) User Manual, May 2000*. Research Unit for Wildlife Population Assessment, Mathematical Institute, University of St Andrews, St Andrews. 300pp. [Paper available from the Office of this Journal].
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Annex H

Report of the Sub-Committee on the Comprehensive Assessment of Humpback Whales

Members: Hammond (Chair), Baker, Baldwin, Bando, Bannister, Berggren, Best, Brandão, Brownell, Butterworth, Carlson, Childerhouse, Clapham, Clark, C., Clark, E., Collins, Dalebout, Diake, Donahue, Donovan, Ensor, Friday, Fujise, Fulford-Gardiner, Gales, Garrigue, George, Goodman, Goto, Grønvik, Gunnlaugsson, Hakamada, Hatanaka, Haug, Hedley, Hester, Iniguez, Ishikawa, Johnston, Kasuya, Kell, Kim, Kingsley, Kock, Larsen, Matsuoka, Mattila, Melnikov, Mikhalev, Minton, Miyashita, Morishita, Murase, Nagahata, Nagatomo, Nishiwaki, Northridge, Ohsumi, Øien, Okamura, Oosthuizen, Palsbøll, Pastene, Peddemors, Perrin, Pike, Punt, Rademeyer, Rambally, Reeves, Ridoux, Robbins, Rogan, Rosenbaum, Rowles, Sadler, Sakamoto, Schweder, Shimada, Simmonds, Smith, Swartz, Tamura, Taylor, Thiele, Urban-Ramirez, Van Waerebeek, Vikingsson, Wade, Wakako, Walløe, Weinrich, Williams, Witting, Yamamura, Yasunaga, Yoshida, Zeh, Zenitani, Zerbini.

1. CONVENOR'S OPENING REMARKS

Hammond welcomed the participants. He noted that the sub-committee would continue work on the Comprehensive Assessment of North Atlantic humpback whales, begun last year. The sub-committee would also be responsible for reviewing continuing work on the Comprehensive Assessment of Southern Hemisphere humpback whales.

2. ELECTION OF CHAIR AND APPOINTMENT OF RAPPORTEURS

Hammond was elected Chair. Clapham undertook the duties of rapporteur, with assistance from Robbins.

3. ADOPTION OF AGENDA

The adopted agenda is given as Appendix 1. The Chair appointed Childerhouse to convene a Working Group to deal with Item 6.

4. REVIEW OF DOCUMENTS

Documents identified as containing information relevant to the sub-committee included: SC/54/H1-23; SC/54/IA16; SC/54/O10, 12, 14.

5. NORTH ATLANTIC HUMPBACK WHALES

5.1 New information

5.1.1 Population structure and stock identity

Incidental observations of humpback whales given in the logbooks of 19th century American whalers (those primarily targeting other species, particularly sperm whales) were summarised in SC/54/H22. Although these data are difficult to interpret without knowledge of effort, they are of interest in that they show humpback whales in locations where little or no survey effort has occurred in recent times. In particular, a surprising number of whales were reported on, or to the west of, the Mid-Atlantic Ridge. Although some of these undoubtedly represent whales migrating north to feeding grounds, sightings in summer (June and July) are difficult to explain in this way, and may represent animals in previously unknown mid-ocean feeding habitats. Clark noted that singing is common on the Mid-Atlantic Ridge from November through March; no acoustic sampling had occurred there during June, July and August. Acoustic sampling in this region in summer would be useful in the future.

A query was raised regarding the distribution of the sperm whaling effort on which these incidental observations were based. Examination of Townsend's (1935) charts of sperm whale catches suggested that the logbooks examined in SC/54/H22 were reasonably representative of sperm whaling activity. The relatively larger number of sightings on the Western Ground suggested that humpbacks were more abundant in the central North Atlantic than on the sperm whaling grounds to the west (notably in May and June). The lack of sightings between the Western Ground and the Cape Verde Islands could be due to a lack of whales or an absence of effort.

Palsbøll noted that he had recently analysed three biopsy samples taken on a US research cruise in the eastern Caribbean; one of these matched (by microsatellite genotyping) an individual sampled in the Barents Sea. This represents the first match (either photographic or genetic) between the eastern Caribbean and the northeastern North Atlantic.

The sub-committee repeated its request from previous years that samples and photographs from the St Vincent hunt be submitted to the appropriate central archives for comparison to existing material (specifically the North Atlantic Humpback Whale Catalogue at the College of the Atlantic in Maine, and the YoNAH genetic database at the University of California at Berkeley). Lawrence informed the sub-committee that photographs had been taken and that

tissue samples would be analysed in collaboration with Japanese colleagues. Hester reported that a collaborative project among eastern Caribbean countries had been initiated to collect photo-identification data. The sub-committee encouraged further collaboration and looked forward to results next year. This is discussed further under Item 5.4.

5.1.2 Catches and incidental takes

Intersessional work attempting to improve estimates of historical removals of humpback whales was presented. Searches of historical archives in Maine and in Provincetown, Massachusetts yielded a modest amount of new information (SC/54/H16). To refine estimates of catches from the West Indies and the Cape Verde Islands, whaling logbooks from an additional stratified sample were read. From this, the proportions of voyages attempting to take humpback whales, and the average number of whales landed per voyage were estimated. These figures were then multiplied by the total number of voyages that were known or thought to have gone to the West Indies or Cape Verdes to provide an overall estimate of humpback whales landed in these areas. The resulting figures generally corroborate previous work, but improve the accuracy of removal estimates and provide measures of precision that were lacking in these earlier studies.

A struck and lost rate of 1.85 was applied to West Indies and Cape Verde non-mechanised shore fisheries up to 1957; this was derived from information given in Mitchell and Reeves (1983). A rate of 1.23 was used for catches after 1957; this was derived from data given in Price (1985), and reflects the fact that use of power boats to tow dead whales resulted in a decrease in the struck and lost rate.

Vikingsson reported the bycatch of a single humpback in Icelandic waters in 1998.

The new data were added to existing records of removals; these are listed by year in Appendix 2. It was stressed that these figures were provided for use in the assessment model and while they represent plausible estimates they should not be taken as absolute values. However, they are best rather than minimum estimates, with the possible exception of a shore-based fishery in the Cape Verde Islands (searches for information on which have not been conducted). Current knowledge suggests that there are no substantial gaps in the catch history as presented. Rambally pointed out that some historical data on shore whaling at St Lucia were available but have yet to be incorporated into the catch history. Reeves responded that if any of the oil initially landed at St Lucia had been exported via St Vincent, it probably would have been taken into account, but that direct examination of the St Lucia Blue Books was nevertheless desirable.

Hester reported the catch of a 55ft non-lactating female and a 28ft male (no milk present in stomach) at Bequia on 27 March 2002. He stated that photos and skin samples had been taken. However, he noted that the animal's ventral side may not have been photographed due to problems turning it over. More specific information on these catches is given in SC/54/ProgRep St Vincent and the Grenadines. Hester confirmed that a straight line measurement was used to determine length. However, the whale was measured in water, which would have been logistically more difficult and may have introduced a measurement error. Brownell and Clapham noted that a length of 55ft for a North Atlantic humpback whale was highly improbable (Clapham and Mead, 1999) and suggested that this reflected a measurement error.

5.1.3 Abundance and trends

Information on humpback whales was presented for the Icelandic component of the NASS-95 survey, with an estimate of abundance that was revised from that presented to the sub-committee last year (SC/54/H10). The revised estimate was 13,900, with a wide confidence interval (95% CI = 3,900-29,000). SC/54/H10 also presented estimates for each of the two vessels separately. One of these, 7,900 (CV = 0.22) for the vessel AFR was considered by the sub-committee to be the most appropriate estimate for inclusion as input into the assessment model (see Item 5.2). An estimate of abundance for Icelandic nearshore waters from the NASS-2001 aerial survey (SC/54/H2) was given as 3,057 (95% CI = 1,727-5,410). However, this survey did not sample the entire area and the analysis did not account for availability bias; these are both sources of negative bias.

A trend of 11.4% (SE = 2.1%) annual increase was estimated from an analysis of sighting rates of humpback whales in four aerial surveys conducted in Icelandic coastal waters in the period 1986-2001 (SC/54/H6). The reported rate was similar to one of 11.6% reported from sightings of humpback whales recorded by whalers for the period 1970-1988. In discussion, it was noted that these figures should not necessarily be taken as population growth rates; they are close to the maximum plausible rates for humpback whales calculated from demographic parameters (Clapham *et al.*, 2001). Some members believed that this may reflect a combination of population growth and immigration into the survey area from other regions.

5.1.4 Biological parameters

An update on previously published data on reproductive parameters of Gulf of Maine humpback whales was presented in SC/54/H23. Apparent birth rates were calculated for the period 1979-2001; the average for all years ranged from 0.27-0.47 calves per mature female per year, depending on assumptions about the maturational state of the sample of females. The wide range in those values was due, in part, to heterogeneity in the data from geographic shifts in animal distribution over time. Mature females observed in five consecutive years produced an average of 0.43 calves during that time period. Older females produced more calves than younger animals, and all mature females observed for at least five consecutive years ultimately reproduced. There was no evidence for reproductive senescence among individually identified whales tracked for more than 20 years. There is evidence that mothers and calves are much more likely to occur in the south-western Gulf of Maine (rather than the northern area) and recent data weighted towards that region continues to support findings that the average age at first parturition in this population is six years. The single female observed to first parturition in the northern Gulf of Maine produced her first calf at age 13. This suggests that studies of humpback whale reproductive rates in other populations may be subject to bias (notably negative bias) if sampling is not undertaken in all parts of the feeding range; this may have important implications for assessments of humpback whales in other feeding populations.

5.1.5 Environmental concerns

There was no new information on environmental concerns in relation to North Atlantic humpback whales.

5.2 Assessment

5.2.1 Framework for assessment

Last year, the sub-committee had recommended further development of the assessment model (IWC, 2002a, p.239). The Commission had supported this work and an improved framework for the assessment of North Atlantic humpback whales was outlined in SC/54/H1. The population dynamics model underlying the assessment is density-dependent, age- and sex-structured, and allows for multiple feeding and breeding grounds, 'stock'- or feeding ground-specific values for the resilience parameter and survival rates, as well as depensation. The model is fitted to data on absolute abundance, trends in relative abundance, estimated rates of increase, and information about the proportion of animals from each breeding ground on the feeding grounds. In runs of the model on a preliminary dataset, the model formulations that can adequately mimic the bulk of the data all involve invoking depensatory dynamics at low stock size.

5.2.2 Results

A Working Group consisting of Friday, Hammond, Kingsley, Mattila, Punt and Reeves met to discuss which were the appropriate options for running the assessment model described in SC/54/H1, and how the new information provided at this meeting should be incorporated. A series of model runs were agreed upon. After it became clear that none of the cases considered resulted in a good fit of the assessment model to the data, an additional case was specified that allowed the resilience parameter to vary among feeding areas, rather than being a single value for all feeding areas. However, this run also provided a poor fit to the data.

Results from the model runs are given in Appendix 3. The main general features of all the results are: (1) a poor fit; (2) populations in all areas have recovered to carrying capacity. This is not consistent with observed continuing increases in a number of areas. In addition, the observed fecundity rate (0.43 in SC/54/H23) is not consistent with the model's prediction of a lower rate.

Punt commented that the data for North Atlantic humpback whales were very similar in their pattern to those observed for eastern North Pacific gray whales. To explore the problems with the data, Punt employed a simple exponential model, which assumed that catches and abundance data for each feeding ground were independent, and approximated the trend in each feeding ground. The simple model requires only two parameters (initial abundance and rate of increase). For areas (such as Eastern Canada) for which there was inadequate or no information, data were approximated using information on trends from the West Indies. The results of this simple model suggested that population sizes for the Gulf of Maine and Iceland were still very low during the period 1940 to the 1960s. This is not consistent with known catch data in at least Iceland, which were believed to be fairly accurate and therefore any additional (unrecorded) catches would have to have occurred elsewhere. Gunnlaugsson noted that sightings by whalers of humpback whales off the western coast of Iceland were very rare in the 1950s. In response to a query, Punt responded that it might be possible to calculate the number of catches that would be required to provide a better fit to the data, but the increase in current known catches would likely be substantial.

It was agreed that possible explanations for the failure of the assessment model to fit the data included:

- (1) The model structure is wrong. It is possible that other structures, such as an inertia model (Witting, 2001), might provide a better approach to the assessment.
- (2) The catch data contain major gaps. This is unlikely to be the case for the 20th century, for which the catch record is reasonably well documented, but it is possible that removals from earlier periods have been significantly underestimated. Best wondered whether 20th century humpback catches off equatorial West Africa (not included in the assessment) might include some Northern Hemisphere animals. Reeves believed that this was implausible.
- (3) The recent estimates of abundance are wrong. These would have to be overestimates to explain the problems with model fitting; this was not considered likely.
- (4) Carrying capacity may have fluctuated and increased in recent years, thus affecting the abundance of whales. It was acknowledged that the marine ecosystem has changed in many respects over the last century as a result of human exploitation and climatic variations.
- (5) The existence of a largely unexploited population of humpback whales in some unknown area of the North Atlantic, which has expanded and is now recolonising other habitats.

With regard to the last possibility, the sub-committee noted the incidental historical sightings around the Mid-Atlantic Ridge (SC/54/H22) as well as recent acoustic observations of humpback whales in the Norwegian Sea in winter (reported by Clark last year). It was also noted that satellite tagging (in the North Pacific) has shown that humpback whales sometimes feed in remote offshore areas. Overall, the impression of the humpback whale as largely a coastal and shelf animal may well be erroneous.

5.3 Management advice

As discussed in Item 5.2.2, the assessment model developed over the last two years did not provide good fits to the available data, nor were the results consistent with the observed data. In particular, all the best fits of the model under the range of options discussed above (Item 5.2.1) predicted that the populations in all areas have recovered to carrying capacity. As a result of this inconsistency, the sub-committee is unable to provide advice on the population level of North Atlantic humpback whales in relation to carrying capacity. This statement applies to past carrying capacity and to present carrying capacity.

In conclusion, the sub-committee agreed that it had greatly increased its knowledge of North Atlantic humpbacks as a result of its Comprehensive Assessment. In particular, populations are increasing in a number of areas in the North Atlantic (Gulf of Maine, Iceland, West Indies) and the rate of increase of the West Indies breeding population is estimated at 3% per annum between 1979 and 1992 (IWC, 2002a, p.236). This breeding population had an estimated population size of 10,752 in 1992 (IWC, 2002b, p.258).

The sub-committee reiterated its view of last year that the population identity of humpback whales in the eastern Caribbean remains unresolved.

In response to a specific request to the Chair of the Scientific Committee from the Commissioner for St Vincent and the Grenadines, the sub-committee considered the likely impact on the stock of an annual take of four whales. Assuming that the humpback whales found in the eastern Caribbean are part of the West Indies breeding population, the sub-committee **agreed** that a catch of up to four whales taken annually would be unlikely to harm this stock.

5.4 Future work

At last year's meeting, the sub-committee had an extensive discussion of future work that would lead to a better understanding of North Atlantic humpback whales (IWC, 2002a, pp.239-41). This year, catch data had been updated (Item 5.1.2), new information on abundance around Iceland had been received (Item 5.1.1), analysis of data on calves per mature female in the Gulf of Maine had been completed (Item 5.1.4) and work recommended on development of the assessment model had been completed (Item 5.2.1).

However, most of the identified areas of future work had not yet been progressed. In addition, the sub-committee identified a number of additional areas of future work arising from discussions this year. The following areas of future work were identified by the sub-committee.

Catches

- (1) Review of historical data sources for land station catches in the Cape Verde Islands.
- (2) Examination of eastern North Atlantic catch data by season.
- (3) Review of additional historical data to allocate unidentified catches to species in the Faroe Islands and Iceland for the period approximately 1880-1930.
- (4) Further examination of Bermuda Blue Books and other colonial records on the Bermuda shore fishery.
- (5) Review of the Blue Books for Grenada, St Lucia and other West Indies Islands not previously covered.
- (6) Examination of whaling station diaries from West Greenland.

Analysis and data collection

- (1) Obtaining photographic and genetic samples from the Cape Verde Islands. The Commission has provided partial support for sample collection being undertaken in the Cape Verde Islands this year by Jann and colleagues. The sub-committee looked forward to the results of this work being presented at a future meeting and noted that further recommendations for additional work may be warranted in light of those results.
- (2) Estimation of survival rates in areas other than the Gulf of Maine.
- (3) Examination of the effect of heterogeneity of capture probabilities on abundance estimates.
- (4) Further examination of patterns of migration and distribution using photo-identification data and historical records.
- (5) Matching the YoNAH dataset to the North Atlantic Humpback Whale Catalogue. This work would greatly facilitate recommendations 3 and 4, above.
- (6) Further elucidation of the relationship between animals in the Lesser Antilles (eastern Caribbean) and the rest of the West Indies; additional photographic and genetic samples are required (see Item 5.1.1).
- (7) Calculation of abundance estimates from NASS and NILS data that have not yet been analysed.
- (8) Investigation of oceanic distribution through satellite tagging, offshore surveys or other means. In particular, the collection of acoustic data at the mid-Atlantic ridge during the summer months would be valuable.
- (9) Additional photo-identification and biopsy-based surveys off the eastern coast of Iceland.
- (10) Genetic approaches to determine the number and identity of animals using a 'missing' breeding and/or feeding ground, based on an analysis of microsatellites and/or haplotype frequencies.

- (11) Continuation of assessment model development, including incorporation of the ability for carrying capacity to change, and exploring other types of models.

The sub-committee agreed that all of these areas of future work were valuable and **recommended** that they should be pursued as possible.

6. SOUTHERN HEMISPHERE HUMPBACK WHALES

6.1 New information on distribution, stock structure, abundance and trends

Information on surveys for humpback whales off the coast of Oman during the period 2000-2002 was presented (SC/54/H3). This population appears to be resident in the Arabian Sea year-round, and was subject to illegal catches by the Soviet Union in the 1960s (Mikhalev, 1997). There were relatively low encounter rates (range 0.0 to 0.545 whales per hour), with more whales seen inshore than in offshore areas. A total of 36 individuals was photo-identified; two of these were resighted in different years. Skin biopsies were taken for genetic analysis; these revealed sex ratios at parity in October, but strongly biased towards males in February. Feeding was observed in both spring and autumn, but observations of song and of mother/calf pairs in February supported the suggestion by Mikhalev (1997) that this population is on a Northern Hemisphere breeding cycle. There is evidence that many whales in the region are involved in fisheries entanglements.

Genetic analysis was conducted on samples from 27 humpback whales from Oman (SC/54/H4). Six mtDNA haplotypes were found, and haplotype diversity was somewhat lower than that reported from the southern Indian Ocean. Two of the six haplotypes had not been reported in other studied populations. Analysis of molecular variance showed statistically significant variance between the Omani samples and those collected from sites in the southwestern Indian Ocean. The two lineages shared between Oman and the southwestern Indian Ocean does not necessarily imply a recent migratory connection between the two areas. However, given the observations of year-round feeding off Oman in SC/54/H3, it is possible that animals that breed in the southwestern Indian Ocean cross the equator to feed in the Arabian Sea in the austral summer (boreal winter).

Humpback whale occurrence and distribution around Mayotte in the Mozambique Channel was investigated from boat-based surveys on 136 survey days during the austral winters of 1995-2001 (SC/54/H18). There were sightings of 152 groups of humpback whales involving 197 animals. Eighty-eight individuals were identified by fluke pattern. Of the 152 humpback groups, 64% were mother/calf pairs; this is a much higher percentage than has been reported for other studied breeding areas such as Hawaii and Samana Bay (Dominican Republic), and suggests that Mayotte may represent an important nursing/calving area or resting point along the migration route. Singletons were also observed frequently, but there were very few sightings of competitive groups. Photographic comparisons revealed two matches between Mayotte and Antongil Bay, Madagascar.

SC/54/H20 summarised research on humpback whales in the coastal waters of eastern Madagascar and off Gabon. To date, 1,875 hours of boat-based surveys have been completed in Antongil Bay (Madagascar) where 951 groups of whales were encountered, 809 skin samples collected for genetic analysis, 4,388 photographs catalogued for

identification of individual whales and 3,715 records of positional data recorded for spatial analysis. In Gabon, 300 hours of boat-based surveys have been conducted during the initial two years, where 242 groups of whales were encountered, 261 skin samples collected, 1,167 identification photographs catalogued and 735 positions recorded. Based on historical catch data and the assumption that Antongil Bay and Gabon represent wintering grounds that are at the northernmost extent of the migration, it would be expected that relative seasonal abundance would be characterised by a unimodal peak in distribution. Data from Antongil Bay indicate a relatively stable rate in the number of identified individuals per hour throughout the season, with a gradual decline following a peak in late July and early August. Because only one full season of prolonged systematic surveys has been completed in Gabon, it is not possible at this time to make any conclusive statement regarding the seasonal abundance. Abundance of humpback whales in Antongil Bay between the years 1996 and 1999 was estimated using the Chapman-modified Petersen estimator, resulting in an estimated population size between 1,128 (for 1996 and 1999) and 2,004 (for 1997 and 1998) individuals in Antongil Bay, with CVs ranging from 0.30-0.43. The weighted mean of six pair-wise estimates was 1,746 (CV = 0.19). This estimate is conservative, since 47.0% of the identified individuals exist from dorsal fin photographs and were excluded from the analysis. Occurrence data from Antongil Bay and Gabon do not contradict the previous assumption that most individuals are relatively transient throughout their breeding range. Revised population size estimates and analyses of population structure are anticipated at the next meeting.

Rosenbaum described the formation and activities of the Indo-South Atlantic Humpback Whale Network. The Network exists to promote collaboration and to coordinate research among scientists working in the Indian and South Atlantic Oceans (primarily around Africa). A regionally distributed database consisting of data from systematic surveys from each group in the network will be implemented. This is a critical first step for large-scale data comparisons to investigate migration links, population structure, trends in abundance, and identification of critical habitats for humpback whales over a large proportion of their range around Africa and in the northern Indian Ocean. The Government of South Africa has contributed ship time for a whale research and training cruise, which will be conducted in collaboration with dedicated shore-based surveys off Cape Vidal. The sub-committee expressed its appreciation to the Network and to the Government of South Africa for this important collaborative effort, and looked forward to seeing the results next year.

A shore-based survey for humpback whales on the west coast of South Africa was conducted from July to December 2001, using a lookout position on North Head, Saldanha Bay (SC/54/H21). This is only a few kilometres from two land stations that operated in Saldanha Bay from 1909 until the last one (Donkergat) closed in 1967. Because of the scarcity of previous surveys in this area, the commercial catch and effort data from these two stations (and one at Hangklip, 180km to the southeast) between 1920 and 1930 were first examined for clues to the migratory pattern. These years were chosen because they were as close to the start of exploitation as possible, and because there were no legal restrictions on size or the taking of lactating females in operation at the time, so the catches may have been more representative of the population. Data sources were principally the Harmer records from the Natural History

Museum, London, and the Cape Provincial archives, Cape Town. Catch per unit effort data from the Donkergat and Salamander whaling stations showed two peaks in humpback whale availability, one in July and the other in November/December (when the whaling season closed for presumed logistical reasons). The size composition of the catch (after adjusting for the fact that the whales were not measured in the standard way) indicated that these peaks coincided with an influx of mature animals, suggesting that they represented peaks of migration. Females with near-term foetuses occurred prior to 25 August (mean date 25 July), i.e. in the first peak of migration, whereas females in early pregnancy occurred after 10 October (mean date 1 November), or in the second migration peak. The incidence of females in late pregnancy between April and August (when they should all have been discovered) was 38.6%, which, although imprecise, is similar to other estimates of pregnancy rate from whaling data, and calves-per-mature-female estimated from photo-identification data. There was no sign of a male-biased sex ratio in the catch of either immature or mature whales. Incidental records indicated that some females on the autumn and subsequent spring migrations were still accompanied by the previous winter's calf. Shore-based observations at North Head in 2001 were carried out on 102 days for 681 hours between 24 July and 20 December, and 95 sightings of 233 humpback whales, and 217 sightings of 354 right whales were made. Observations probably started too late to include much of the first expected migration peak, but clearly detected a rise in humpback availability from late October, presumably representing the onset of the southern migration. The results of theodolite tracking of 71 groups, however, showed that whereas most groups were moving southwards from July to September, from October onwards there were as many groups moving northwards or in an indeterminate direction. Adopting a linearity index of >0.9 as indicative of active migration, the proportion of actively migrating animals declined from 100% in July and August to less than 50% in December. These results seem to confirm the presence of a suspended migration in spring, as proposed in earlier work on the West Coast of South Africa (Best *et al.*, 1995). This suspension may be associated with bouts of feeding. When weather permitted, groups were approached from the shore in a 6m inflatable, and 41 biopsies and 23 fluke photographs were obtained from 40 groups of 101 humpback whales. Shore-based observations will resume on 5 May 2002, and are planned to run through to April 2003. Apart from describing the characteristics of the migration as closely as possible, the project aims to investigate the possible correlation between local environmental conditions (upwelling) and the patterns of migratory behaviour shown by both humpback and right whales in the area.

In discussion, it was noted that the Saldanha Bay data and the recent observations from Gabon suggest the occurrence of a somewhat unusual and interesting situation off this coast, with what may be a suspended migration.

Carlson noted that surveys for humpback whales and other marine mammals off Kenya were being conducted (Weru, 2001), and would be coordinated with other members of the Indo-South Atlantic Humpback Whale Network. The sub-committee welcomed this work, and strongly supported research in this important and previously unstudied area.

Data from field notebooks kept by the late Dr William Dawbin include information on land-based sighting surveys for humpback whales in Fiji during the austral winters of 1956, 1957 and 1958. A preliminary analysis of these data

(SC/54/H7) indicated that humpbacks were quite abundant in the area during this period. Surveys ran from May to October. Sightings peaked during August, with as many as 43 whales per day recorded. Anecdotal reports indicate that humpbacks are much rarer in Fijian waters today than they were in the late 1950s, suggesting that this population has yet to recover from intensive commercial whaling. Clapham noted that, if details of Dawbin's field effort could be obtained from his notebooks, there would be an attempt to conduct replicate surveys in the area to better assess the present status of this population, which is presumably part of the depleted Area VI stock.

Activities of another regional collaborative organisation, the South Pacific Whale Research Consortium (SPWRC) were summarised in SC/54/O14. This group includes researchers from areas of Oceania and the South Pacific (including French Polynesia, the Cook Islands, Tonga, Samoa, New Caledonia, New Zealand and Eastern Australia) as well as from adjacent regions of South America and the Antarctic. Matching within the regional catalogue of fluke photographs (representing 949 individuals from Oceania alone) has revealed some degree of migratory interchange between adjacent areas of Oceania, South Pacific, but there was no interchange with South America or the Antarctic Peninsula. Non-systematic surveys and published capture-recapture estimates based on photo-identification indicate that the density of whales remains low throughout the wintering grounds of Oceania and the New Zealand migratory corridor. Genetic analyses of skin samples collected throughout the Oceania region are underway.

Ishikawa commented that the South Pacific Whale Research Consortium (SPWRC) stated in SC/54/O14 that they would not use data from JARPA for ethical reasons. JARPA has collected sighting data, photographs and biopsy samples of humpback whales using non-lethal methods and therefore Ishikawa believed that the position of the SPWRC was based on political rather than ethical reasons. He noted that from a scientific perspective, this lack of collaboration is unfortunate. Baker replied that members of the SPWRC were not convinced that the JARPA programme meets the requirements of animal experiment guidelines or regulations in effect in most countries, including Japan, or those of many international scientific journals. For this reason, the Consortium has chosen not to approach JARPA for collaboration on comparison of individual identification photographs from the Antarctic. In response, Ishikawa pointed out that Baker was incorrect and that there had been many scientific papers from JARPA data published in international journals including those with experimental guidelines (e.g. *Journal of Veterinary Medical Sciences*, *Theriogenology*).

The abundance of humpback whales in New Caledonia was estimated from a catalogue of 214 individuals identified by microsatellite genotyping, 217 individuals identified by fluke photographs and combined records of both, collected from 1995-2001. Estimates from the weighted mean of Petersen capture-recapture estimates ranged from 319-520 individuals. Two estimates from the combined genotypes and photo-identification records provided the greatest precision but were likely to be biased downwards as only resightings were included in dataset extensions. The estimate obtained from the genotype data ($n = 520$, 95% CI = 366-674) was larger and less precise than the photo-identification estimate ($n = 355$, 95% CI = 279-432). The genotype estimates of males and females (278 and 248, respectively) were similar although the female estimate was

less precise. The genotyping was used to detect a small number of errors in the photo-identification records; this work does not support the suggestion that the predominance of white flukes is an obstacle to photo-identification. Overall, it is apparent that the population of humpback whales in New Caledonia is small.

The relatively equal sex-specific estimates from New Caledonia differ from those of the West Indies, which showed a larger proportion of males. This could be explained by the longer sampling period (both in terms of years and within seasons), and lower density in New Caledonia, resulting in a more complete or more representative sampling. Although there were unresolved methodological issues with combined photo-identification and genotyping estimates of abundance, the sub-committee noted that this was a promising approach and encouraged further investigation into this issue. In this context, a collaborative discussion between the Indo-South Atlantic Humpback Whale Network, the South Pacific Whale Research Consortium, and researchers in the North Atlantic was **recommended**.

SC/54/H14 summarised the occurrence of humpback whales in French Polynesia over the period 1988-2001. From 1988-2001, more than a thousand observations of humpback whales were made near 25 islands in four of French Polynesia's five archipelagos; no humpbacks have been confirmed in the Marqueses. In the Society Islands, whales have been observed from mid-June to early December. The area is used as both a calving and mating ground. Dedicated surveys for photo-identification and genetic sampling have been conducted at Mo'orea, with lower effort in the Austral Islands at Rurutu and Tubuai. A total of 185 individual humpbacks was photographically identified between 1991 and 2001; there was a relatively low resighting rate, although some whales were present for more than six weeks at Rurutu. Analysis of 15 sloughed skin samples showed a male-biased sex ratio, as well as few mtDNA haplotypes shared with other areas of the South Pacific. Given the high haplotype diversity within this region, this latter finding is not surprising. A local hunt, introduced by westerners to the Rurutu islanders in the early 1900s, took small numbers of humpbacks (nine from 1930 to 1959, including two mother/calf pairs). The hunt ceased in 1959.

SC/54/H5 reported on aerial surveys carried out off the coast of Brazil, between 12 and 20°S. This area corresponds to a portion of the distribution area of the breeding stock 'A'. Surveys were carried out as far offshore as the 500m isobath with the objective of investigating distribution and abundance of humpback whales. Standard line transect sampling was conducted from a high-wing two-engine aircraft. Estimates were corrected for availability bias by calculating the time whales spend at the surface and the time window during which whales are within the visual range of the observers. Whales were observed along the whole latitudinal range of the area sampled, but a substantially higher density was recorded in the southern portion. Higher densities were found on Abrolhos Bank, a large coral reef area off the eastern coast of South America. Corrected abundance was estimated as 2,291 individuals (CV = 0.45). The authors noted that this was the first of a series of three surveys to be carried out in the coming years.

Population estimates for humpback whales from Abrolhos Bank, Brazil over the period 1996 and 2000 ranged from 1,389 to 3,977 with an average CV of 0.27 (SC/54/H11). A maximum-likelihood estimate for the year 2000 was 3,871 (95% CI = 2,795-5,542), and this analysis estimated growth

rate at 31%. In discussion, it was noted that this growth rate was clearly unreasonable (see Clapham *et al.*, 2001), and suggested the existence of some unknown methodological problems in sampling or in the estimation process. As a result, the estimate of abundance should be treated with considerable caution.

SC/54/H12 described research conducted off the western side of the Antarctic Peninsula, in particular the Gerlache Strait. This study was part of the cetacean component of the Brazilian Antarctic Survey (PROANTAR) and had the objectives of conducting photo-identification and biopsy sampling of humpback whales as well as investigating distribution and density of cetaceans in the Antarctic Peninsula area. SC/54/H12 provided encounter rates of humpback whales in the Gerlache Strait from summer, 1997/98 to 2001/02. Encounter rates were not statistically different among years and therefore the authors pooled data across years to investigate monthly variation in encounter rates in the area. Results showed that whales were more abundant in the Gerlache Strait from January to early March. The authors concluded that the area is appropriate for ecological cetacean studies as well as to conduct photo-identification and biopsy sampling of humpback whales. They encouraged the development of multidisciplinary habitat studies in the region to improve the understanding of humpback whale ecology in the Antarctic.

The sub-committee regretted that a lack of funding had prevented the authors of the papers SC/54/H5, H11 and H12 from attending the meeting, and highlighted the need for the IWC to support the attendance of researchers from developing countries.

It was noted that there were plans to continue work in the Gerlache Strait within the next year. In addition, Bannister noted an observation of humpback whales in the Strait of Magellan in mid-February 2002, and that Chilean scientists were conducting research in this area.

A comparison of duplicate sighting rate for Southern Hemisphere humpback whales between the second and third circumpolar surveys of IWC/IDCR-SOWER was presented in SC/54/IA16. A factor that strongly affects duplicate sightings is school size. The duplicate sighting probability for school sizes greater than 2 was 1.6 times larger than for a single school. This confirms that duplicate sighting probability (and hence $g(0)$) is dependent on school size. The probability of duplicate sighting did not differ significantly between the second and third set of circumpolar surveys. However, the mean duplicate sighting probability is low for the northern area of the third circumpolar compared to the southern area of the second circumpolar, and this may be because of the bad weather conditions in the former region.

Sightings of humpback whales from the 2001/2002 JARPA survey were summarised in SC/54/O18. More humpback whales were observed during this survey than in previous JARPA surveys in 1999 and 2000. Total primary sightings of humpback whales were 1,219 schools/2,387 animals, and this was the highest record for any JARPA survey; this was particularly true in the north and west-south strata of Area IV. Biopsy samples were obtained. Humpback whales and minke whales showed clear separation in most areas, except for some areas near the ice edge where both species were concentrated. The authors suggested that the increase in abundance of humpback whales may have resulted in interspecific competition with minke whales.

In response, Clapham noted that simple overlaps in distribution were not sufficient to support claims of interspecific competition, which was a complex issue

(Clapham and Brownell, 1996). Weinrich also noted that experience in the Gulf of Maine over 25 years has shown that patterns of prey abundance and distribution can cause medium-scale annual shifts in humpback distribution. Hence, dramatic local increases cannot be interpreted without similar effort throughout the stock's feeding range. In response, Ishikawa noted that JARPA surveys covered a large part of the Antarctic and had been conducted repeatedly over the last 15 years, and that therefore the results were reliable and showed that there had been an increase in humpback whales.

Bannister and Hedley (2001) outlined results of aerial surveys to provide relative abundance estimates of humpback whales migrating northward along the coast of Western Australia between 1976 and 1994. These demonstrated a high rate of increase, at least between 1982 and 1991, of approximately 10% per year. The 1994 survey confirmed the rate of increase and provided an abundance estimate of 4-5,000. The most recent survey in 1999, planned to provide an estimate of absolute abundance, was considerably affected by poor weather. Nevertheless, applying a correction factor for animals missed while submerged to the estimated number sighted gives a 1999 population estimate of 8,207-13,640. This result is dependent on 'deep diving' time and would be proportionally lower should this dive time be less than the range used (10-15 minutes). Reported rates of increase and population estimates for this stock in the Antarctic (Area IV) were reviewed, as well as preliminary Southern Hemisphere population estimates that take account of much larger than officially reported catches in the 1950s-60s. Plans for future surveys were discussed.

Carlson reported on the status of IWC Research Contract 16, the Antarctic Humpback Whale Catalogue (SC/54/H13). The catalogue has received 448 images from 17 contributors during the contract period, bringing the total number of catalogued individuals to 1,405. Of particular note were thirteen matches, including between Southern Ocean Area V and Eastern Australia (one match) and between the Antarctic Peninsula and Costa Rica (three matches). There was considerable discussion about the protocols for accessing these data. A Working Group was set up to discuss this issue; its report is given as Appendix 4. The sub-committee was pleased to receive this information and **recommended** that this work continues to be supported with the new conditions laid out in Appendix 4.

Overall, in reviewing current studies in the Southern Hemisphere, the sub-committee commended all of the researchers working on humpback whales in Oman, Kenya, Madagascar, the Comoros, Mayotte, Brazil, South Africa, Australia, Oceania and the Antarctic. The sub-committee was particularly pleased to see multi-area collaborations such as the Indo-South Atlantic Humpback Whale Network and the South Pacific Whale Research Consortium, and strongly encouraged the development of additional collaborative work of this nature.

6.2 Population dynamics modelling

An assessment of the West and East Australian stocks of humpback whales was conducted using an age-aggregated production model that allows for mixing in the feeding grounds of Areas IV and V (SC/54/H17). The approach is similar to that presented for the North Atlantic (SC/54/H1). Analysis of the available data provided a self-consistent picture of populations recovering well from their minima of the 1960s; the models were fitted to CPUE and relative abundance data from the breeding grounds, as well as to

JARPA abundance estimates from feeding grounds in Areas IV and V. These populations were projected to reach pristine levels (assuming zero catches) in 10-15 years for the western stock and 15-20 years for the more depleted eastern breeding stock. It was suggested that further modelling of males and females separately would be useful. The authors noted that their results were dependent upon absolute abundance estimates available for the two breeding stocks; the current estimate for the western stock is the less firmly founded of the two and would merit further study. A subsequent reanalysis of the data was conducted using new estimates of abundance provided by Bannister and Hedley (2001); use of the upper limit of that estimate (13,640 in 1999) suggested that current abundance was about 65% of the pristine level.

Baker commented that the total known catch was greater than the number of animals assumed by the model over certain periods. Butterworth responded that the numbers reflected a combination of mixing and reproduction. It was suggested that this merited further examination. Baker commented that genetic analysis in progress may allow the assignment of animals from the feeding grounds to the breeding grounds, and that this would assist future modelling efforts.

In response to a question, the authors responded that the growth rate in the model began with an initially high rate of approximately 12.6% when abundance was at its lowest, and that this rate declined as the population grew in size. Clapham noted that 12.6% was the maximum plausible rate of increase derived from knowledge of humpback whale biological parameters.

6.3 Work required to complete assessment

It was noted that substantial progress had been made in recent years in improving the understanding of humpback whales in certain areas of the Southern Hemisphere. However, many major gaps in data remain. Because of the time constraints facing the sub-committee, a comprehensive review of the current state of knowledge about Southern Hemisphere humpbacks was impossible to achieve during the meeting. To address this, an intersessional group under Bannister was established (see Annex S). The terms of reference of this group were: (1) to summarise current knowledge regarding Southern Hemisphere humpback whales, by population or management area; (2) to identify major gaps in knowledge; and (3) to establish priorities for research to fill these gaps. Current information under (1) would include abundance and trends, catches and incidental takes, population structure and stock identity, biological parameters, environmental concerns, and assessment models. The intersessional group would use the North Atlantic humpback whale Comprehensive Assessment as a model in summarising information. After reviewing the group's report at next year's meeting, further consideration will be given to whether it is feasible to set a deadline for the completion of the Comprehensive Assessment.

The sub-committee **agreed** that the results of the most recent East Australia humpback whale survey (in 2000) were important to the assessment, and **strongly recommended** that they be made available soon.

6.3.1 Work plan

The sub-committee **agreed** that considerable progress had been made in some areas of the work plan from last year; however many items still required further work. The sub-committee proposed the following work plan for the coming year.

- (1) An intersessional working group (see above) will summarise current knowledge regarding Southern Hemisphere humpback whales, by population or management area; identify major gaps in knowledge; and establish priorities for research to fill these gaps.
- (2) To the extent possible, run the humpback population dynamics model for breeding stock E with three sub-populations, for which individual population estimates are available.
- (3) Conduct a sensitivity analysis for breeding ground C using the combined Mozambique and low-latitude Madagascar abundance estimates, as reported in Rosenbaum *et al.* (2000).
- (4) Investigate use of a population dynamics model disaggregated by sex for stocks D and E.
- (5) Investigate use of a model with depensation.
- (6) Investigate the data from whaling operations from a time shortly after blue/humpback whales were protected that are held by the IWC Secretariat (see IWC, 2001, p.185), with a view to using them to provide relative abundance estimates.
- (7) Investigate the feasibility of using a model that incorporates information on biological parameters, similar to that being developed for the North Atlantic.
- (8) Further investigate the use of the abundance estimates from IDCR/SOWER and JARPA survey data in the population dynamics model.
- (9) Update the Antarctic humpback whale photo-identification catalogue.
- (10) Investigate the issue of correlation between minke and humpback whale distribution on IDCR/SOWER and JARPA surveys.

The only item that has funding implications is the Antarctic humpback whale catalogue with a budget of £5,100 (as laid out in SC/54/H13).

7. ADOPTION OF REPORT

The report was adopted at 18:37 on 5 May 2002. On behalf of the sub-committee the Chair expressed thanks to Childerhouse for his chairing of the Working Group dealing with Item 6, and to the rapporteurs. The sub-committee reiterated its appreciation of the efforts of Friday and Punt for their work during the year and at the meeting. The sub-committee expressed its appreciation to Hammond for chairing the meeting.

REFERENCES

- Bannister, J.L. and Hedley, S.L. 2001. Southern Hemisphere group IV humpback whales: their status from recent aerial survey. *Mem. Queensl. Mus.* 47(2):587-98.
- Best, P.B., Sekiguchi, K. and Findlay, K.P. 1995. A suspended migration of humpback whales *Megaptera novaeangliae* on the west coast of South Africa. *Mar. Ecol. Prog. Ser.* 118(1-3):1-12.
- Clapham, P.J. and Brownell, R.L. 1996. The potential for interspecific competition in baleen whales. *Rep. int. Whal. Commn* 46:361-7.
- Clapham, P.J. and Mead, J.G. 1999. *Megaptera novaeangliae*. *Mamm. Species* 604:1-9.
- Clapham, P., Robbins, J., Brown, M., Wade, P. and Findlay, K. 2001. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on the Comprehensive Assessment of Whale Stocks – In-depth Assessments. Appendix 5. A note on plausible rates of population growth in humpback whales. *J. Cetacean Res. Manage. (Suppl.)* 3:196-7.
- International Whaling Commission. 2001. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on the Comprehensive Assessment of Whale Stocks – In-depth Assessments. *J. Cetacean Res. Manage. (Suppl.)* 3:177-208.

- International Whaling Commission. 2002a. Report of the Scientific Committee. Annex H. Report of the Sub-Committee on the Comprehensive Assessment of North Atlantic Humpback Whales. *J. Cetacean Res. Manage. (Suppl.)* 4:230-60.
- International Whaling Commission. 2002b. Report of the Scientific Committee. Annex H. Report of the Sub-Committee on the Comprehensive Assessment of North Atlantic Humpback Whales. Appendix 5. Specification of stock structure hypotheses and input data for the assessment model. *J. Cetacean Res. Manage. (Suppl.)* 4:258-9.
- Mikhalev, Y.A. 1997. Humpback whales, *Megaptera novaeangliae* in the Arabian Sea. *Mar. Ecol. Prog. Ser.* 149:13-21.
- Mitchell, E. and Reeves, R.R. 1983. Catch history, abundance, and present status of northwest Atlantic humpback whales. *Rep. int. Whal. Commn* (special issue) 5:153-212.
- Price, W.S. 1985. Whaling in the Caribbean: historical perspective and update. *Rep. int. Whal. Commn* 35:413-20.
- Rosenbaum, H.C., Razafindrakoto, Y., Ersts, P. and Ventresca, G. 2000. A preliminary population estimate for humpback whales from the Antongil Bay, Madagascar wintering ground in the southwestern Indian Ocean. Paper SC/52/1A10 presented to the IWC Scientific Committee, June 2000, Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whalships. *Zoologica (NY)* 19(1-2):1-50+6 maps.
- Weru, S. 2001. Rapid baseline survey of large marine animals, with special emphasis on humpback whales, in Kenya. *KWS Technical Series*. [Available from: werus@africaonline.co.ke].
- Witting, L. 2001. On inertial dynamics in whale populations. The case of the eastern North Pacific gray whale. Paper SC/53/AWMP6 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].

Appendix 1

AGENDA

1. Convenor's opening remarks
 2. Election of Chair and appointment of rapporteurs
 3. Adoption of agenda
 4. Review of documents
 5. North Atlantic humpback whales
 - 5.1 New information
 - 5.1.1 Population structure and stock identity
 - 5.1.2 Catches and incidental takes
 - 5.1.3 Abundance and trends
 - 5.1.4 Biological parameters
 - 5.1.5 Environmental concerns
 - 5.2 Assessment
 - 5.2.1 Framework for assessment
 - 5.2.2 Results
 - 5.3 Management advice
 - 5.4 Future work
 6. Southern Hemisphere humpback whales
 - 6.1 New information on distribution, stock structure, abundance and trends
 - 6.2 Population dynamics modelling
 - 6.3 Work required to complete assessment
 - 6.3.1 Work plan
 7. Adoption of report
-

Appendix 2

ESTIMATING HISTORIC HUMPBACK WHALE REMOVALS FROM THE NORTH ATLANTIC: AN UPDATE

Tim D. Smith and Randall R. Reeves

Abstract

Updated estimates of historical landings and total removals of humpback whales in the North Atlantic are presented for three fisheries, along with a table of estimates of removals for all breeding and feeding grounds.

Introduction

Last year removals of humpback whales were estimated for some 30 fisheries in the North Atlantic (Smith and Reeves, 2002). No estimates were provided for the American non-mechanised coastal fishery and only minimal estimates were provided for the American mechanised coastal fishery, both of which fisheries were assumed to target the Gulf of Maine feeding stock. Estimates for the American non-mechanised pelagic fishery in the two breeding grounds (West Indies and Cape Verdes) were based on numbers of voyages with certain characteristics (Starbuck, 1878;

Hegarty, 1959), using landings per voyage estimated from a sample of logbooks that was not randomly selected (IWC, 2002, p.239). Results of additional investigations into historical data sources for these three fisheries have been reported to this meeting (SC/54/H16, SC/54/H15). Also, in addition to contemporary bycatches of humpbacks in Canadian waters previously included, there was a report from Iceland (Vikingsson, pers. comm.) of one humpback taken in 1998. Here, these new results are used to generate revised time series of total removals that update the estimates given in Smith and Reeves (2002).

Methods

Landings were estimated for the three fisheries (as defined by Reeves and Smith, 2002) using essentially the same assumptions and procedures as in Smith and Reeves (2002). Corresponding total removals were estimated by adjusting

Table 1

The struck-and-lost factors (S&L Factors) used to convert estimated landings of humpback whales into total removals, and the catch composition in terms of percent calves and percent non-calves that were female, for each of the North Atlantic fisheries for which catches were estimated.

Fisheries	Sub-Fisheries	S&L Factor	% Calves	Non-calf % Female
Norwegian	N. Norway	1.02	0.047	0.38
	W. Norway	1.02	0.047	0.38
	Svalbard	1.02	0.047	0.38
	Iceland	1.02	0.047	0.38
	Faroes	1.02	0.047	0.38
	British Isles	1.02	0.047	0.38
	Newfoundland	1.02	0.047	0.38
	Gulf of St Lawrence	1.02	0.047	0.38
	Nova Scotia	1.02	0.047	0.38
	Grenada	1.02	0.020	0.19
Shore	Spain	1.02	0	0.50
Norwegian Mechanised Pelagic		1.02	0.047	0.38
Greenland Non-mechanised Shore		1.5	0.04	0.52
Greenland Mechanised Shore		1.02	0	0.5
Canada Non-mechanised Shore		1.5	0	0.5
Canada Non-mechanised Pelagic (Gaspé)		1.5	0	0.5
American Non-mechanised coastal		1.5	0	0.5
American Mechanised Coastal		1.5	0	0.5
Bermuda Non-mechanised Shore		1.85	0.41	0.78
West Indies	Barbados	1.85	0.41	0.78
	St. Vincent & the Grenadines:			
	Before 1958	1.85	0.41	0.78
	1958-present	1.23	0.41	0.78
Non-mechanised	Grenada	1.85	0.41	0.78
	Trinidad			
Shore		1.85	0.41	0.78
American Non-mechanised Pelagic	West Indies	1.85	0.10	0.43
	Cape Verde Islands	1.85	0.10	0.43
Cape Verde Islands Non-mechanised Shore		1.85	0.41	0.78

Table 2

Nominal annual landings of humpback whales by the American non-mechanised and mechanised coastal fisheries in the Gulf of Maine, derived for input to the model described in SC/54/H1 and based on data in Reeves and Smith (2002) and SC/54/H16. Constant landings were assumed from the beginning to ending year of each period, inclusive, for whaling operations in the states of Massachusetts and Maine. Notes indicate the rationale used in formulating the entries.

State	Period (Years)		Number landed/year	Notes
	Beginning	Ending		
Massachusetts	1730	1776	5	Decline of right whales resulted in some redirection of effort towards humpbacks.
Massachusetts	1777	1812	10	Between wars with Britain, some effort of Nantucket distant-water whalers was redirected to local waters; 4 Wellfleet vessels humpbacking in Gulf of Maine during early 1800s.
Maine	1810	1834	4	1 shore station.
Massachusetts	1813	1849	5	After War of 1812, Massachusetts effort shifted towards distant-water voyages.
Maine	1835	1840	5	Peak of activity for the 1 shore station; reported average catch 6-7, maximum 10, probably not all humpbacks.
Maine	1841	1860	7	Second shore station opened taking at least 3/yr; earlier station continued at nominal 4/yr.
Massachusetts	1850	1878	10	Several Provincetown schooners operating; up to 6 whales taken by 1 vessel in a year; 349bbls humpback oil taken in one year.
Maine	1861	1879	1	Minimal activity reported.
Massachusetts	1879	1883	20	Schooner activity increased, along with expanded use of bomb-lances; 20 reported in 1 year at Provincetown.
Maine	1880	1880	10	Menhaden fishery collapsed; 1 steamer converted to whaling, with bomb-lances.
Maine	1881	1882	10	1 steamer
Maine	1883	1883	20	2 steamers
Maine/Mass	1884	1884	40	4 steamers
Maine/Mass	1885	1885	50	5 steamers
Maine/Mass	1886	1886	30	3 steamers
Maine/Mass	1887	1887	25	At least 2-3 steamers
Massachusetts	1888	1896	10	1 steamer
Maine	1914	1914	5	1 shore station

the landings estimates to account for struck and lost animals, using loss rates appropriate to each fishery. Total removals were allocated to males, females and calves as appropriate to each fishery.

For the American non-mechanised and mechanised coastal fisheries in the Gulf of Maine, the limited data in Reeves and Smith (2002) and SC/54/H16 were used to interpolate and extrapolate to total landings. Best judgment was applied in deriving estimates from fragmentary data on, e.g. the number of vessels and shore stations or oil factories operating, published descriptions of the fisheries, and anecdotal observations in newspapers and other sources. It was necessary to make educated guesses not only on the scale of whaling effort and levels of catch, but also on the species composition of catches. This applied particularly to the mechanised fishery from 1880-96 that involved a high proportion of fin whales. For the American non-mechanised pelagic fishery, annual landings of humpbacks for two breeding grounds were estimated from the total landings for 1865-86 given in SC/54/H15, by assuming that each year's catch was proportional to the number of voyages sailing that year.

The struck-and-lost factors ('correction factors') used by Smith and Reeves (2002) to estimate total removals from estimated landings for the various fisheries are shown in Table 1. Where necessary, the correction factors for fisheries with sufficient struck/lost data were applied to similar fisheries with insufficient data.

The proportion of calves and sex ratio of non-calves for the Norwegian mechanised fisheries were estimated from individual-animal catch data. For sub-fisheries on feeding grounds, the data were pooled to produce a single set of rates. The proportion of calves and sex ratio for non-calves for the American non-mechanised pelagic fishery were estimated from data from a sample of logbooks and data from the YoNAH project, in which West Indies animals were sexed by molecular genetic techniques (Robbins *et al.*, 2001). Although the rationale was summarised in last year's sub-committee report (IWC, 2002, p.234), the calculations were not completely reported by Smith and Reeves (2002). These are described here. The sample of logbooks described in IWC (2002, p.234) included 142 whales reported landed. Fourteen of those were calves, so the calf proportion was estimated as $14/142 = 0.10$. Of the remaining whales, 26 were female and 102 were not specified. The female proportion of the 102 whales was estimated using the observed proportion females in the YoNAH sample after excluding mothers and calves, 0.285 ($n = 284$). Thus, the proportion of females in the fishery landings was estimated to be $(26 + 0.285 \cdot 102) / (26 + 102) = 0.43$.

Results

American non-mechanised and mechanised coastal fisheries

Estimated annual landings by the American non-mechanised and subsequent mechanised coastal fisheries in the Gulf of Maine from 1730-1914 are given in Table 2. The total of landings for the non-mechanised fishery from 1730-1850 was 990. The total of landings for the mechanised fishery from 1851-1914 was 759, with a slow increase from 1851-1879 followed by a pronounced increase after the switch from menhaden fishing to whaling in 1880 (Fig. 1)¹.

¹Preliminary estimates of landings used in SC/54/H1 totalled 1,227 for American non-mechanised coastal whaling and 1,697 for American mechanised coastal whaling.

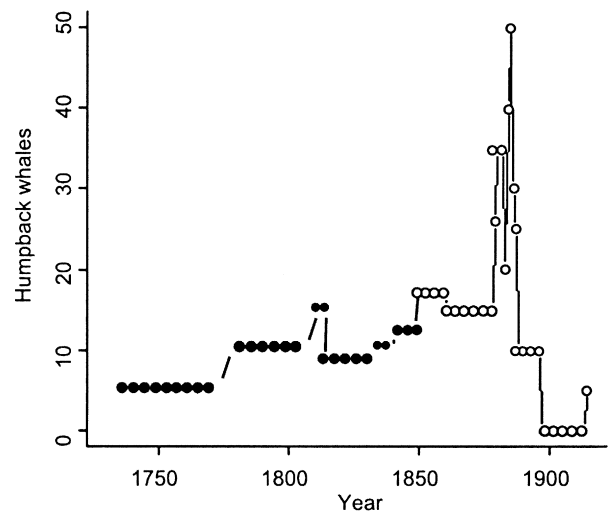


Fig. 1. Nominal landings of humpback whales in the Gulf of Maine from 1730 to 1914 by the American non-mechanised (1730-1850, solid circles) and mechanised (1851-1914, open circles) coastal fisheries (Table 2).

These were the only two fisheries known to have operated in the Gulf of Maine, and the estimated total removals are shown in Table 3.

American non-mechanised pelagic fishery (West Indies and Cape Verde Islands sub-fisheries)

The estimated total landings for the American non-mechanised pelagic fishery from 1865-86 were 1,617 and 441 for the West Indies and Cape Verde Islands, respectively (SC/54/H15). Estimated landings for other periods are unchanged from those in Smith and Reeves (2002). The estimated landings were allocated to year by multiplying the total landings for the period 1865-86 by the proportion of voyages for that period that sailed in each year. The new estimated landings for 1865-86 and for the earlier period of this fishery are shown in Fig. 2. The estimated total removals are shown in Table 3.

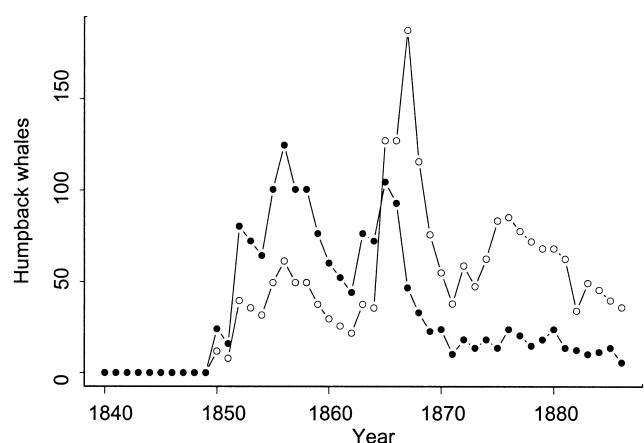


Fig. 2. Estimated landings of humpback whales by American pelagic whalers in the West Indies (open circles) and Cape Verde Islands (solid circles) breeding areas from 1840 to 1886. The values for 1840-64 are identical to those in Smith and Reeves (2002), while those for 1865-86 are derived from SC/54/H15 (see text).

Estimated numbers of North Atlantic humpback whales removed from 1664 to 1999 from two breeding grounds (West Indies and Cape Verde Islands) and five feeding grounds (Gulf of Maine, Canada, Greenland, Iceland, Norway), for males (M), females (F), and calves (C). Includes incidental catches in Canada from 1869 to 1992.

[illegible]

Table 3 (continued)

Year	West Indies			Cape Verde			Gulf of Maine			Canada			Greenland			Iceland			Norway		
	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
1706	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1707	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1708	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1709	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1710	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1711	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1712	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1713	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1714	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1715	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1716	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1717	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1718	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1719	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1720	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1721	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1722	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1723	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1724	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1725	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1726	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1727	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1728	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1729	3	12	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1730	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1731	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1732	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1733	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1734	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1735	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1736	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1737	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1738	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1739	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1740	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1741	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1742	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1743	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1744	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1745	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1746	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1747	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1748	5	17	15	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1749	3	12	11	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
1750	3	12	11	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1751	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1752	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0

Table 3 (continued)

Year	West Indies			Cape Verde			Gulf of Maine			Canada			Greenland			Iceland			Norway		
	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
1753	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1754	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1755	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1756	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1757	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1758	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1759	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1760	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1761	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1762	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1763	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1764	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1765	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1766	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1767	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1768	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1769	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1770	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1771	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1772	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1773	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1774	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1775	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1776	1	2	2	0	0	0	4	4	0	0	0	0	4	4	0	0	0	0	0	0	0
1777	1	2	2	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1778	1	2	2	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1779	1	2	2	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1780	0	1	1	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1781	0	1	1	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1782	0	1	1	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1783	0	1	1	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1784	0	1	1	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1785	0	1	1	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1786	1	2	2	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1787	1	2	2	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1788	1	2	2	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1789	1	2	2	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1790	1	2	2	1	4	4	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1791	1	2	2	1	4	4	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1792	1	2	2	1	4	4	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1793	1	2	2	1	4	4	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1794	1	2	2	1	4	4	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1795	1	2	2	1	4	4	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1796	1	2	2	1	4	4	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1797	0	0	0	1	4	4	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1798	1	2	2	1	4	4	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1799	1	2	2	1	4	4	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0

Table 3 (continued)

Year	West Indies			Cape Verde			Gulf of Maine			Canada			Greenland			Iceland			Norway		
	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
1800	1	2	2	1	4	4	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1801	1	2	2	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1802	1	2	2	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1803	1	2	2	0	0	0	8	8	0	0	0	0	4	4	0	0	0	0	0	0	0
1804	1	2	2	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1805	1	2	2	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1806	1	2	2	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1807	1	2	2	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1808	1	2	2	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1809	1	2	2	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1810	1	2	2	0	0	0	10	10	0	14	14	0	4	4	0	0	0	0	0	0	0
1811	1	2	2	0	0	0	10	10	0	14	14	0	4	4	0	0	0	0	0	0	0
1812	1	2	2	0	0	0	10	10	0	14	14	0	4	4	0	0	0	0	0	0	0
1813	1	2	2	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1814	1	2	2	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1815	1	2	2	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1816	1	2	2	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1817	1	2	2	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1818	1	2	2	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1819	1	2	2	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1820	1	2	2	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1821	1	2	2	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1822	1	2	2	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1823	1	2	2	0	0	0	7	7	0	0	0	0	4	4	0	0	0	0	0	0	0
1824	1	2	2	0	0	0	7	7	0	0	0	0	4	4	0	0	0	0	0	0	0
1825	1	2	2	0	0	0	7	7	0	0	0	0	4	4	0	0	0	0	0	0	0
1826	3	12	10	0	0	0	7	7	0	0	0	0	4	4	0	0	0	0	0	0	0
1827	3	9	8	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1828	1	3	3	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1829	1	4	4	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1830	4	14	13	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1831	4	13	12	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1832	7	24	21	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1833	5	17	15	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1834	9	32	29	0	0	0	7	7	0	14	14	0	4	4	0	0	0	0	0	0	0
1835	8	28	25	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1836	7	25	22	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1837	7	25	22	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1838	9	31	28	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1839	6	21	19	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1840	8	27	24	0	0	0	8	8	0	14	14	0	4	4	0	0	0	0	0	0	0
1841	7	26	23	0	0	0	9	9	0	14	14	0	16	16	0	0	0	0	0	0	0
1842	7	25	22	0	0	0	9	9	0	14	14	0	13	13	0	0	0	0	0	0	0
1843	7	25	22	0	0	0	9	9	0	14	14	0	13	13	0	0	0	0	0	0	0
1844	5	19	17	0	0	0	9	9	0	14	14	0	10	10	0	0	0	0	0	0	0
1845	6	23	20	0	0	0	9	9	0	14	14	0	13	13	0	0	0	0	0	0	0
1846	6	21	19	0	0	0	9	9	0	14	14	0	13	13	0	0	0	0	0	0	0
1847	2	7	6	0	0	0	9	9	0	14	14	0	13	13	0	0	0	0	0	0	0

Table 3 (continued)

Year	West Indies			Cape Verde			Gulf of Maine			Canada			Greenland			Iceland			Norway		
	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
1848	9	32	29	0	0	0	9	9	0	14	14	0	13	13	0	0	0	0	0	0	0
1849	7	24	21	0	0	0	9	9	0	14	14	0	13	13	0	0	0	0	0	0	0
1850	16	26	18	23	17	4	13	13	0	14	14	0	11	11	0	0	0	0	0	0	0
1851	12	23	17	15	12	3	13	13	0	14	14	0	13	13	0	0	0	0	0	0	0
1852	41	42	19	76	58	15	13	13	0	14	14	0	13	13	0	0	0	0	0	0	0
1853	40	46	25	69	52	13	13	13	0	14	14	0	13	13	0	0	0	0	0	0	0
1854	34	38	20	61	46	12	13	13	0	14	14	0	13	13	0	0	0	0	0	0	0
1855	51	51	23	95	72	19	13	13	0	14	14	0	13	13	0	0	0	0	0	0	0
1856	63	61	27	118	89	23	13	13	0	28	28	0	13	13	0	0	0	0	0	0	0
1857	51	51	23	95	72	19	13	13	0	28	28	0	13	13	0	0	0	0	0	0	0
1858	51	50	22	95	72	19	13	13	0	40	40	0	13	13	0	0	0	0	0	0	0
1859	39	38	17	72	55	14	13	13	0	34	34	0	13	13	0	0	0	0	0	0	0
1860	32	36	18	57	43	11	13	13	0	34	34	0	13	13	0	0	0	0	0	0	0
1861	28	32	17	50	37	10	8	8	0	27	27	0	13	13	0	0	0	0	0	0	0
1862	23	23	11	42	32	8	8	8	0	21	21	0	13	13	0	0	0	0	0	0	0
1863	37	33	12	72	55	14	8	8	0	12	12	0	13	13	0	0	0	0	0	0	0
1864	35	31	11	69	52	13	8	8	0	20	20	0	13	13	0	0	0	0	0	0	0
1865	122	95	27	33	25	6	8	8	0	12	12	0	13	13	0	0	0	0	0	0	0
1866	122	98	30	33	25	6	8	8	0	10	10	0	2	2	0	0	0	0	0	0	0
1867	180	143	42	49	37	9	8	8	0	21	21	0	2	2	0	0	0	0	0	0	0
1868	112	89	27	30	23	6	8	8	0	14	14	0	2	2	0	0	0	0	0	0	0
1869	74	60	19	20	15	4	8	8	0	14	14	0	2	2	0	0	0	0	0	0	0
1870	53	43	14	14	11	3	8	8	0	17	17	0	2	2	0	0	0	0	0	0	0
1871	42	50	27	10	7	2	8	8	0	14	14	0	2	2	0	0	0	0	0	0	0
1872	61	60	27	15	11	3	8	8	0	7	7	0	2	2	0	0	0	0	0	0	0
1873	50	52	25	12	9	2	8	8	0	9	9	0	2	2	0	0	0	0	0	0	0
1874	66	67	31	17	16	7	8	8	0	10	10	0	2	2	0	0	0	0	0	0	0
1875	85	81	34	23	21	8	8	8	0	14	14	0	2	2	0	0	0	0	0	0	0
1876	86	81	33	23	21	8	8	8	0	8	8	0	2	2	0	0	0	0	0	0	0
1877	80	77	33	21	19	8	8	8	0	8	8	0	2	2	0	0	0	0	0	0	0
1878	78	87	45	20	18	7	8	8	0	4	4	0	2	2	0	0	0	0	0	0	0
1879	70	67	29	19	18	7	16	16	0	7	7	0	2	2	0	0	0	0	0	0	0
1880	72	74	35	19	18	7	22	22	0	7	7	0	2	2	0	0	0	0	0	0	0
1881	66	68	32	17	16	7	22	22	0	8	8	0	2	2	0	0	0	0	5	3	0
1882	41	54	33	10	11	6	22	22	0	4	4	0	2	2	0	0	0	0	0	0	0
1883	53	58	30	15	18	10	30	30	0	4	4	0	2	2	0	0	0	0	19	12	2
1884	60	91	61	14	17	10	30	30	0	2	2	0	2	2	0	0	0	0	16	10	1
1885	49	70	44	13	16	10	38	38	0	4	4	0	2	2	0	0	0	0	58	35	5
1886	60	118	88	12	16	9	22	22	0	4	4	0	4	4	0	0	0	0	61	37	5
1887	13	48	42	2	9	8	19	19	0	4	4	0	4	4	0	0	0	0	18	11	1
1888	5	18	16	2	9	8	8	8	0	2	2	0	4	4	0	0	0	0	42	25	3
1889	7	25	23	2	9	8	8	8	0	0	0	0	2	2	0	8	5	1	13	8	1
1890	9	31	28	2	9	8	8	8	0	0	0	0	4	4	0	7	4	1	14	9	1
1891	7	25	22	2	9	8	8	8	0	0	0	0	4	4	0	11	7	1	34	21	3
1892	6	21	19	2	9	8	8	8	0	0	0	0	2	2	0	17	11	1	49	30	4
1893	11	39	35	2	9	8	8	8	0	0	0	0	6	6	0	33	20	3	53	33	4
1894	7	25	22	1	4	4	8	8	0	0	0	0	7	7	0	38	23	3	52	32	4
1895	8	29	26	1	4	4	8	8	0	0	0	0	6	6	0	47	29	4	39	24	3

Table 3 (continued)

Year	West Indies			Cape Verde			Gulf of Maine			Canada			Greenland			Iceland			Norway		
	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
1896	8	29	26	1	4	4	8	8	0	0	0	0	2	2	0	59	36	5	112	69	9
1897	21	74	66	1	4	4	0	0	0	0	0	0	5	5	0	61	37	5	43	26	3
1898	4	13	11	1	4	4	0	0	0	19	11	1	2	2	0	106	65	8	46	28	4
1899	9	33	29	1	4	4	0	0	0	22	13	2	5	5	0	99	61	8	50	31	4
1900	12	44	39	1	4	4	0	0	0	22	14	2	8	8	0	94	57	7	65	40	5
1901	17	61	54	1	4	4	0	0	0	52	32	4	8	8	0	166	102	13	103	63	8
1902	14	49	43	2	9	8	0	0	0	95	58	8	8	8	0	191	117	15	134	82	11
1903	13	47	42	2	9	8	0	0	0	173	106	14	8	8	0	149	91	12	41	25	3
1904	4	15	13	2	9	8	0	0	0	169	104	13	8	8	0	117	71	9	33	20	3
1905	3	10	9	2	9	8	0	0	0	97	59	8	4	4	0	127	78	10	6	4	0
1906	5	17	15	2	9	8	0	0	0	49	30	4	4	4	0	80	49	6	5	3	0
1907	4	16	14	2	9	8	0	0	0	48	29	4	4	4	0	105	64	8	7	4	1
1908	6	20	18	2	9	8	0	0	0	14	9	1	4	4	0	94	58	8	6	4	0
1909	3	10	8	2	9	8	0	0	0	20	12	2	4	4	0	120	74	10	10	6	1
1910	2	7	6	2	9	8	0	0	0	14	9	1	2	2	0	83	51	7	8	5	1
1911	2	7	6	2	9	8	0	0	0	14	9	1	6	5	0	29	18	2	4	2	0
1912	2	8	8	2	9	8	0	0	0	13	8	1	6	5	0	22	13	2	2	1	0
1913	1	5	5	0	0	0	0	0	0	5	3	0	2	2	0	6	4	0	2	1	0
1914	1	4	3	0	0	0	4	4	0	8	5	1	2	2	0	2	1	0	2	1	0
1915	2	7	6	0	0	0	0	0	0	3	2	0	2	2	0	2	1	0	2	1	0
1916	3	10	8	0	0	0	0	0	0	0	0	0	2	2	0	2	1	0	2	1	0
1917	1	5	5	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0
1918	1	5	5	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	1	0	0
1919	4	13	12	0	0	0	0	0	0	0	0	0	8	5	1	0	0	0	2	1	0
1920	4	13	12	0	0	0	0	0	0	0	0	0	1	1	0	10	6	1	10	6	1
1921	1	2	2	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
1922	3	12	11	0	0	0	0	0	0	0	0	0	85	53	7	0	0	0	0	0	0
1923	2	8	7	0	0	0	0	0	0	2	1	0	91	56	7	1	0	0	1	0	0
1924	3	11	10	0	0	0	0	0	0	10	6	1	27	19	2	1	0	0	1	0	0
1925	84	21	4	0	0	0	0	0	0	21	13	2	4	4	0	1	1	0	1	1	0
1926	58	17	5	0	0	0	0	0	0	11	7	1	6	6	0	1	1	0	2	1	0
1927	1	2	2	0	0	0	0	0	0	48	29	4	5	6	0	0	0	0	0	0	0
1928	1	5	5	0	0	0	0	0	0	13	8	1	4	5	0	1	1	0	2	1	0
1929	1	4	3	1	1	0	0	0	0	7	4	1	5	5	0	0	0	0	1	1	0
1930	1	2	2	0	0	0	0	0	0	4	3	0	18	12	1	5	3	0	17	11	1
1931	1	4	3	0	0	0	0	0	0	0	0	0	13	9	1	3	2	0	11	7	1
1932	1	3	2	0	0	0	0	0	0	0	0	0	5	4	0	1	1	0	4	3	0
1933	1	2	2	0	0	0	0	0	0	0	0	0	3	2	0	1	1	0	3	2	0
1934	1	2	2	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	1	1	0
1935	1	4	3	0	0	0	0	0	0	6	4	0	3	3	0	1	0	0	1	0	0
1936	1	2	2	0	0	0	0	0	0	6	4	0	2	3	0	0	0	0	0	0	0
1937	1	2	2	0	0	0	0	0	0	5	3	0	7	5	1	2	1	0	1	1	0
1938	1	2	2	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0
1939	1	4	3	0	0	0	0	0	0	2	1	0	1	1	0	1	1	0	1	1	0
1940	0	1	1	0	0	0	0	0	0	4	3	0	0	0	0	0	0	0	0	0	0
1941	1	2	2	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0
1942	0	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0
1943	0	0	0	0	0	0	0	0	0	4	2	0	0	0	0	0	0	0	1	1	0

Table 3 (continued)

Year	West Indies			Cape Verde			Gulf of Maine			Canada			Greenland			Iceland			Norway		
	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
1944	0	0	0	0	0	0	0	0	0	6	4	0	0	0	0	0	0	0	0	0	0
1945	0	0	0	0	0	0	0	0	0	5	3	0	0	0	0	0	0	0	0	0	0
1946	0	0	0	0	0	0	0	0	0	3	2	0	2	2	0	0	0	0	1	1	0
1947	0	1	1	0	0	0	0	0	0	4	2	0	2	3	0	0	0	0	0	0	0
1948	1	3	2	0	0	0	0	0	0	9	6	1	0	1	0	0	0	0	0	0	0
1949	0	0	0	0	0	0	0	0	0	7	4	1	1	1	0	2	1	0	1	1	0
1950	0	0	0	0	0	0	0	0	0	10	6	1	1	2	0	0	0	0	5	3	0
1951	0	0	0	0	0	0	0	0	0	17	11	1	2	3	0	1	0	0	3	2	0
1952	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0
1953	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	1	0	3	2	0
1954	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	4	2	0
1955	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
1956	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0
1957	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1958	1	4	4	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0
1959	1	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1960	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1961	0	0	0	2	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
1962	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
1963	1	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1964	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1965	0	1	1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
1966	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0
1967	1	3	2	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0
1968	1	3	2	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0
1969	1	3	2	0	0	0	1	1	0	4	3	0	1	2	0	0	0	0	0	0	0
1970	2	7	6	0	0	0	1	0	0	9	6	1	0	0	0	0	0	0	0	0	0
1971	1	3	2	0	0	0	2	1	0	11	7	1	2	2	0	0	0	0	0	0	0
1972	1	5	5	0	0	0	0	0	0	1	1	0	1	2	0	0	0	0	0	0	0
1973	0	1	1	0	0	0	0	0	0	1	1	0	5	6	0	0	0	0	0	0	0
1974	0	1	1	1	1	0	0	0	0	1	1	0	4	5	0	0	0	0	0	0	0
1975	0	0	0	0	0	0	0	0	0	1	1	0	4	5	0	0	0	0	0	0	0
1976	0	1	1	1	1	0	0	0	0	1	1	0	4	5	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	1	1	0	8	8	1	0	0	0	0	0	0
1978	0	1	1	1	1	0	0	0	0	4	4	0	11	12	1	0	0	0	0	0	0
1979	1	3	3	0	0	0	0	0	0	6	6	0	7	7	1	0	0	0	0	0	0
1980	0	2	2	0	0	0	0	0	0	8	8	0	7	8	1	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	4	4	0	6	6	0	0	0	0	0	0	0
1982	1	2	2	0	0	0	0	0	0	2	2	0	6	6	0	0	0	0	0	0	0
1983	0	1	1	0	0	0	0	0	0	2	2	0	7	8	1	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	3	3	0	7	8	1	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	4	4	0	4	4	0	0	0	0	0	0	0
1986	0	1	1	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
1987	0	1	1	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
1988	0	1	1	0	0	0	0	0	0	6	6	0	0	1	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	2	2	0	1	1	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	5	5	0	0	1	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	4	4	0	0	1	0	0	0	0	0	0	0

Table 3 (continued)

Year	West Indies			Cape Verde			Gulf of Maine			Canada			Greenland			Iceland			Norway		
	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C
1992	0	1	1	0	0	0	0		0	4	4	0	0	1	0	0	0	0	0	0	0
1993	0	1	1	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	0	0	1	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1999	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Discussion

The present estimates are substantial improvements over those of Smith and Reeves (2002) for these three fisheries. The lack of removal estimates for the American non-mechanised coastal fishery in the previous time series (Smith and Reeves, 2002) reflected the fact that little information was available at last year's meeting. Following a directed search for additional data (SC/54/H16), the fragmentary information that exists for this fishery has been examined and considered more closely and plausible, albeit extremely crude, estimates have been generated (Table 1). These estimates represent the time periods of operation and catch patterns of the fishery. It is emphasised, however, that the absolute values of the landings given in Table 2 are only educated guesses produced for modelling purposes. The total of removals for this fishery is now estimated at 1,556 humpbacks (Table 3).

The previous estimates of total removals for the American mechanised coastal fishery totalled 183 (Smith and Reeves, 2002, pp.253-4), which is substantially less than the new total of 1,142 (Table 3). This increase is largely the result of new data from Webb (2001) and an intensive, focused search of various materials not previously examined in detail (SC/54/H16).

The present estimates of total removals for the American non-mechanised pelagic fishery between 1865-86 are somewhat lower than those in Smith and Reeves (2002): 2,990 vs 3,180 for the West Indies and 816 vs 1,084 for the Cape Verdes. Estimates by Smith and Reeves (2002) were based on simple extrapolations of voyage catch rates to relatively coarsely selected voyages made by the American whaling fleet. The new estimates in SC/54/H15 were based on the reading of a stratified random sample of logbooks for the period 1865-1886. It is encouraging that the new estimates, while lower, are similar to those obtained by Smith and Reeves (2002). This suggests that estimates of removals before 1865, while probably biased upwards, may in fact not be greatly biased.

REFERENCES

- Hegarty, R.B. 1959. *Returns of Whaling Vessels Sailing from American Ports. A Continuation of Alexander Starbuck's 'History of the American Whale Fishery', 1876-1928.* The Old Dartmouth Historical Society and Whaling Museum, New Bedford, MA. 58pp.
- International Whaling Commission. 2002. Report of the Scientific Committee. Annex H. Report of the Sub-Committee on the Comprehensive Assessment of North Atlantic Humpback Whales. *J. Cetacean Res. Manage. (Suppl.)* 4:230-60.
- Reeves, R.R. and Smith, T.D. 2002. Historical catches of humpback whales in the North Atlantic Ocean: an overview of sources. *J. Cetacean Res. Manage.* 4(3): 219-234.
- Robbins, J., Bérubé, M., Clapham, P., Palsboll, P., Stevick, P. and Mattila, D.K. 2001. Group composition and social dynamics of North Atlantic humpback whales (*Megaptera novaeangliae*) on the West Indies breeding ground. Paper SC/53/NAH4 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal.]
- Smith, T.D. and Reeves, R.R. 2002. Report of the Scientific Committee. Annex H. Report of the Sub-Committee on the Comprehensive Assessment of North Atlantic Humpback Whales. Appendix 2. Estimating historical humpback whale removals from the North Atlantic. *J. Cetacean Res. Manage. (Suppl.)* 4:242-55.
- Starbuck, A. 1878. History of the American whale fishery from its earliest inception to the year 1876. Appendix A. pp. 1-768+6pls. *In: Report of the US Commissioner of Fish and Fisheries, Part 4, 1875-76.* Government Printing Office, Washington, D.C. [Reprinted in 1964 in two volumes by Argosy Antiquarian Ltd, New York].
- Webb, R.L. 2001. Menhaden whalemens: nineteenth-century origins of American steam whaling. *Am. Neptune* 60:277-88.

Appendix 3**RESULTS OF NORTH ATLANTIC HUMPBACK WHALE ASSESSMENT RUNS****Case A**

Catch data: New data series as agreed under Item 5.2.2
 MSY level: 60% of *K* (IWC convention)
 Depensation: No
 Resilience: Single parameter

Case B

Catch data: New data series as agreed under Item 5.2.2
 MSY level: 60% of *K*
 Depensation: Yes
 Resilience: Single parameter

Case C

Catch data: New catch series as agreed under Item 5.2.2 but with Gulf of Maine catches multiplied by 2
 MSY level: 60% of *K*
 Depensation: No
 Resilience: Single parameter

Case D

Catch data: New data series as agreed under Item 5.2.2
 MSY level: 75% of *K*

Depensation: No

Resilience: Single parameter

Case E

Catch data: New data series as agreed under Item 5.2.2
 MSY level: 60% of *K*
 Depensation: No
 Resilience: Variable among feeding areas

Abundance estimates were the same for all Cases. These were the same as used last year (IWC, 2002), but the estimate for the Iceland feeding area was replaced with the shipboard estimate for 1995 from the single vessel AFR from SC/54/H10 (see Item 5.1.3). All other data and options were as described in IWC (2002).

REFERENCE

International Whaling Commission. 2002. Report of the Scientific Committee. Annex H. Report of the Sub-Committee on the Comprehensive Assessment of North Atlantic Humpback Whales. Appendix 5. Specification of stock structure hypotheses and input data for the assessment model. *J. Cetacean Res. Manage. (Suppl.)* 4:258-9.

Cases A–E on following pages

Case A

Number of parameters = 8. Objective function value = 18.1704.

Single value for resilience parameter, A , estimated as 4.32709.

Depensation not allowed.

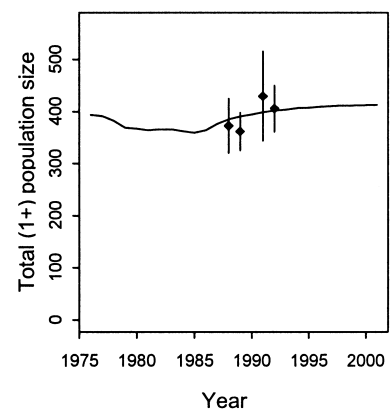
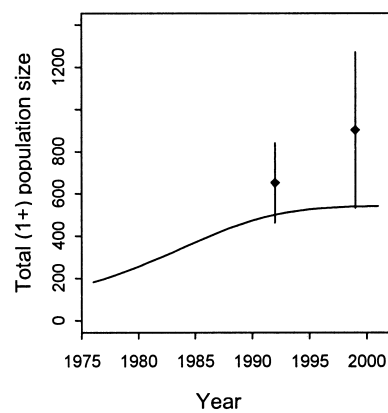
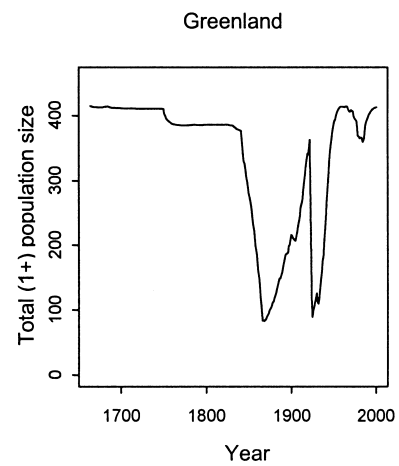
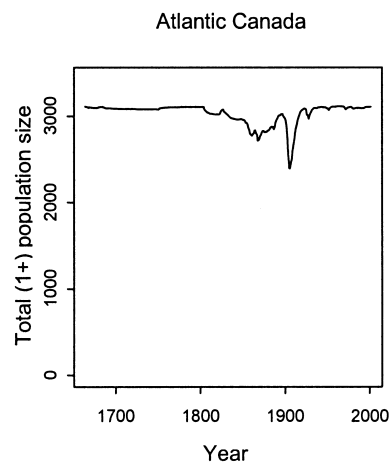
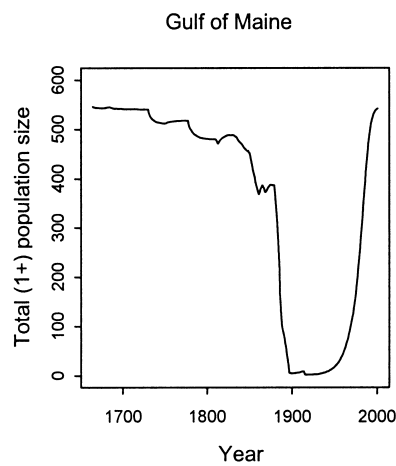
Gulf of Maine	Years	Predicted	Observed	SD
Rate of Increase	1979-1991	0.0614808	0.063	0.011
Average Fecundity	1995-2001	0.13171429	0.43	0.141

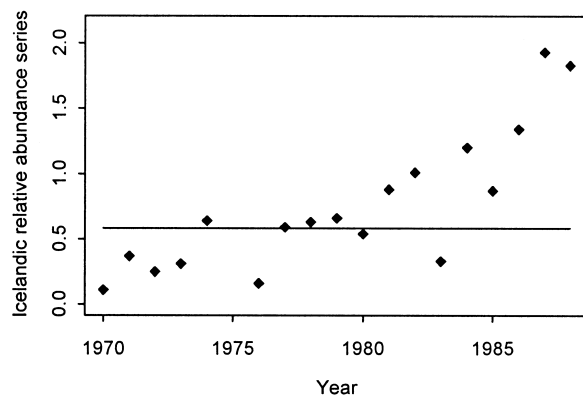
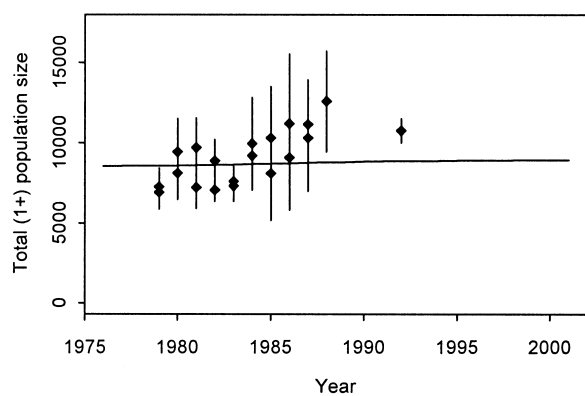
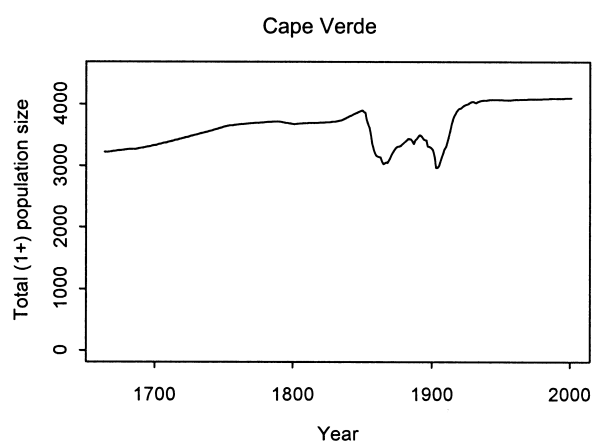
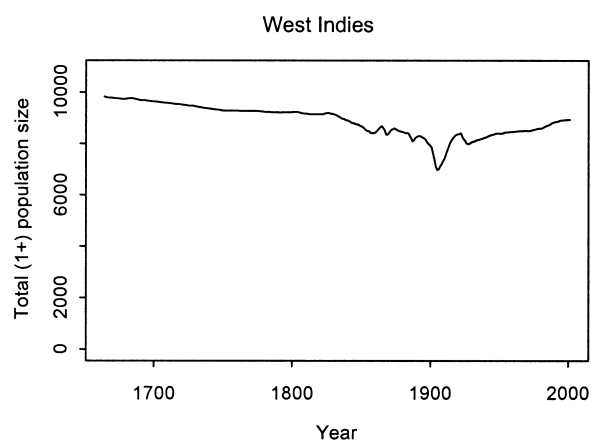
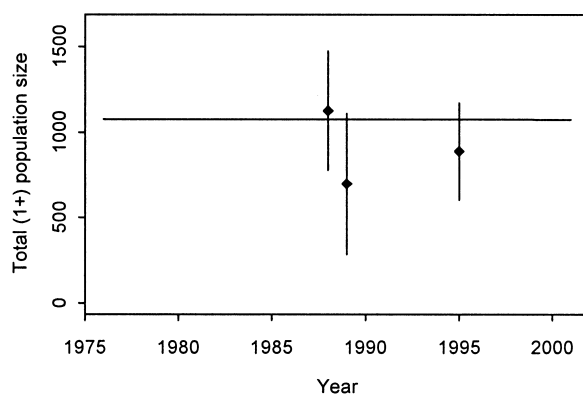
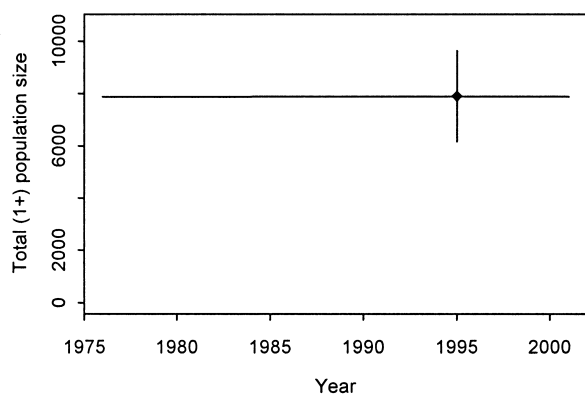
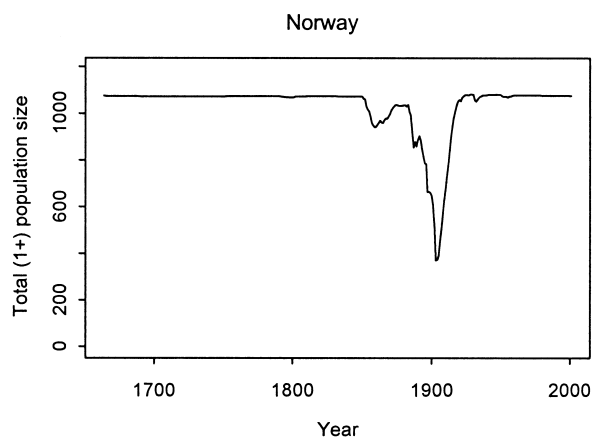
Ratios of feeding area from the West Indies.

	Year	Predicted	Observed	SD
Iceland	1992	0.599950	0.60	0.050
Norway	1992	0.129233	0.13	0.057

Carrying capacity (K) and population size (N) estimates

	K	N_{2001}	$(N_{2001}/K)\%$	min(N)	max(N)
Gulf of Maine	546	542	99	2	546
Canada	3111	3109	100	2394	3114
Greenland	415	413	100	83	415
Iceland Total	7889	7887	100	6926	7896
Norway Total	1075	1076	100	369	1082
Iceland-West Indies	5536	4728	85	4286	5536
Iceland-Cape Verde	2353	3159	134	2244	3159
Norway-West Indies	205	139	68	50	205
Norway-Cape Verde	870	937	108	320	940
West Indies	9813	8931	91	6974	9813
Cape Verde	3222	4096	127	2963	4096
Total NA	13036	13027	100	9970	13036





Case B

Number of parameters = 9. Objective function value = 16.087421.

Single value for resilience parameter, A , estimated as 0.055502253.Depensation allowed, β estimated as 3.597113.

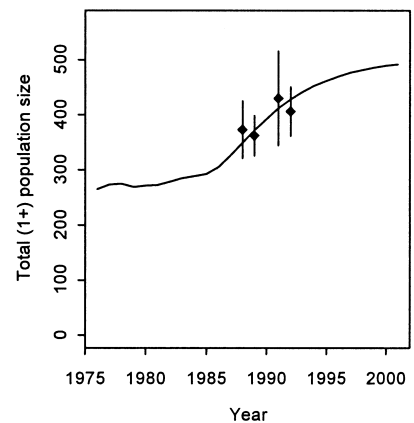
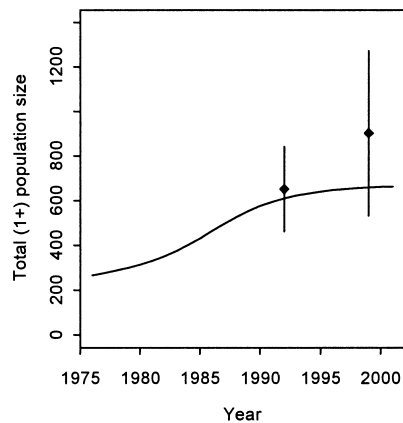
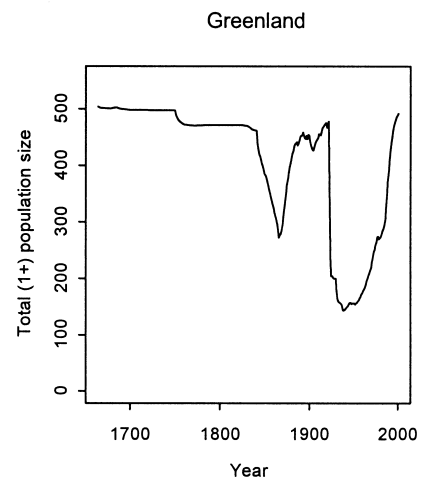
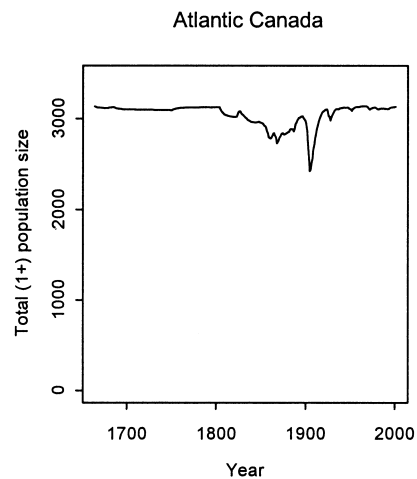
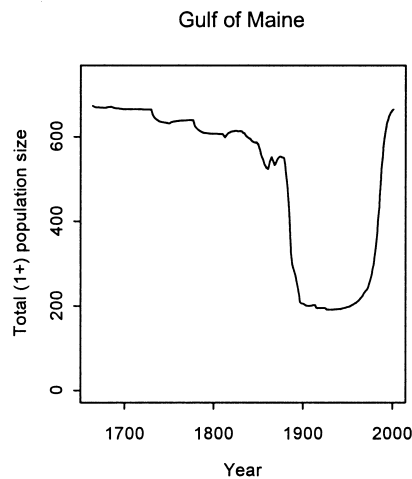
Gulf of Maine	Years	Predicted	Observed	SD
Rate of Increase	1979-1991	0.0612433	0.063	0.011
Average Fecundity	1995-2001	0.13457143	0.43	0.141

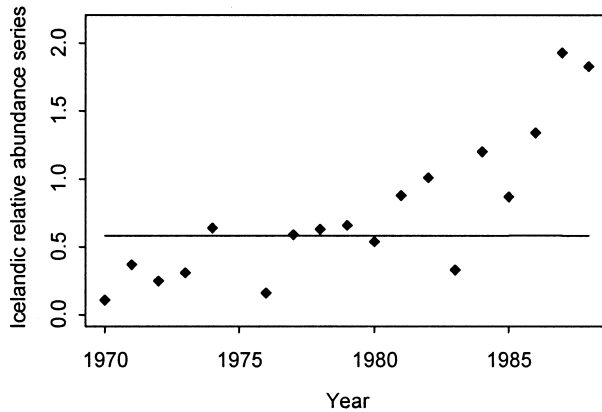
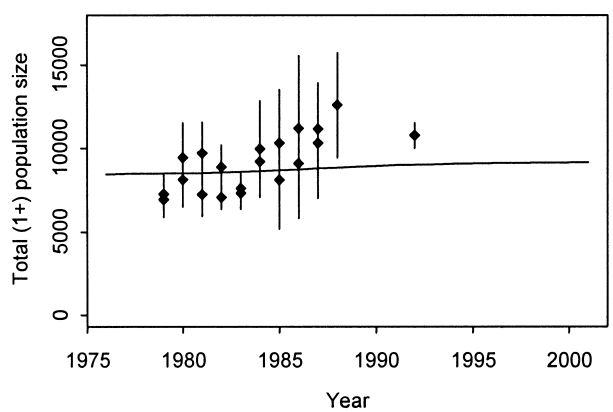
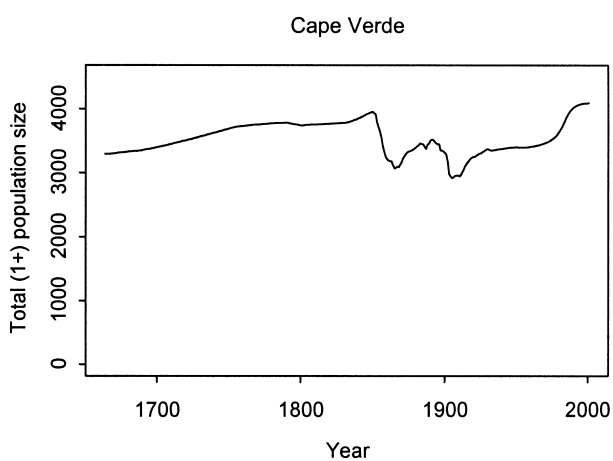
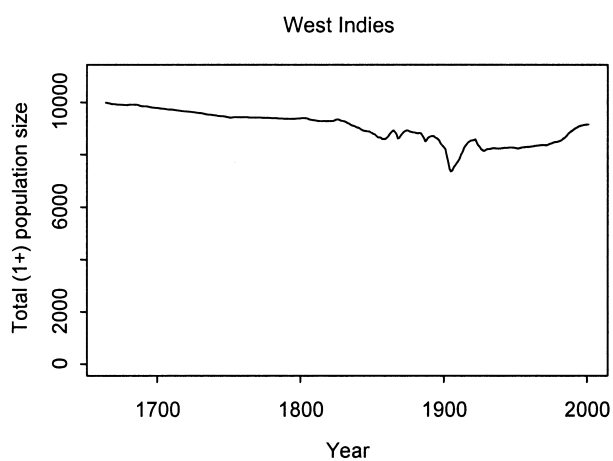
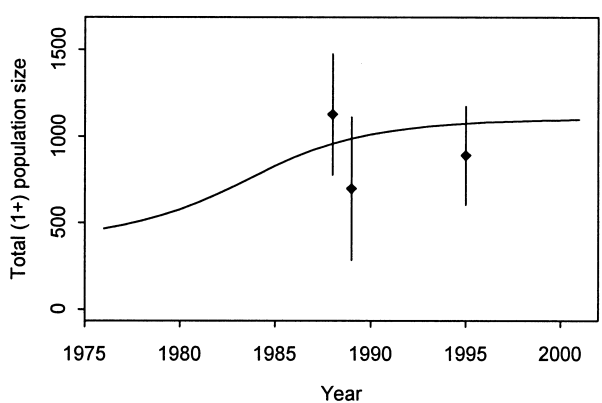
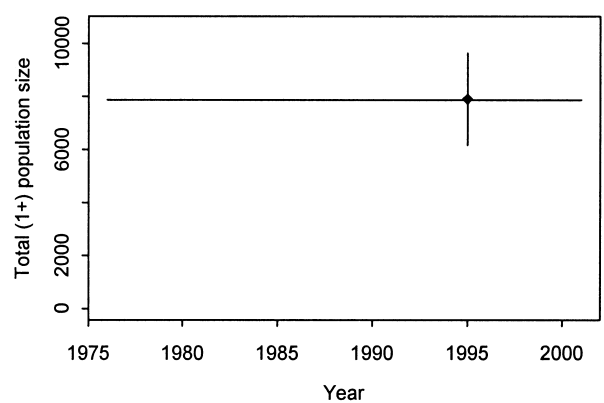
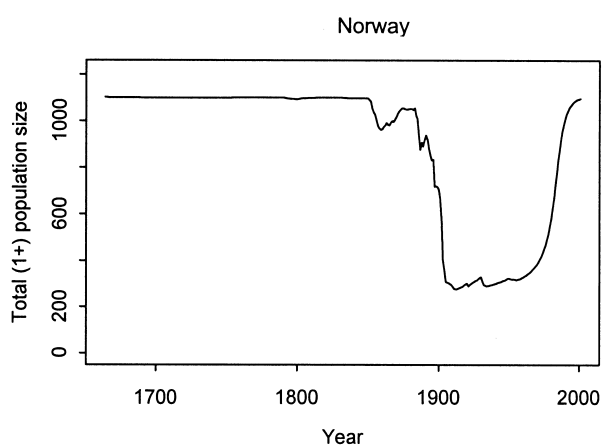
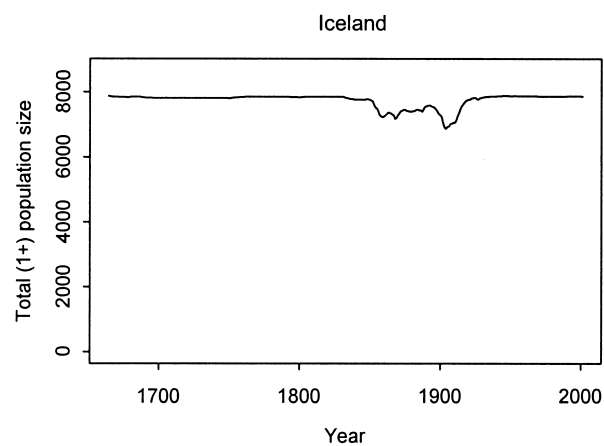
Ratios of feeding area from the West Indies.

	Year	Predicted	Observed	SD
Iceland	1992	0.600351	0.60	0.050
Norway	1992	0.136343	0.13	0.057

Carrying capacity (K) and population size (N) estimates

	K	N_{2001}	$(N_{2001}/K)\%$	min(N)	max(N)
Gulf of Maine	672	664	99	191	672
Canada	3135	3130	100	2424	3137
Greenland	504	492	98	143	504
Iceland Total	7866	7863	100	6864	7875
Norway Total	1101	1096	99	276	1101
Iceland-West Indies	5459	4717	86	4232	5459
Iceland-Cape Verde	2407	3146	131	2271	3146
Norway-West Indies	215	149	69	40	215
Norway-Cape Verde	886	946	107	237	946
West Indies	9984	9153	92	7359	9984
Cape Verde	3294	4093	124	2918	4093
Total NA	13278	13245	100	10277	13278





Case C

Number of parameters = 8. Objective function value = 16.9639.

Single value for resilience parameter, A , estimated as 4.24898.

Depensation not allowed.

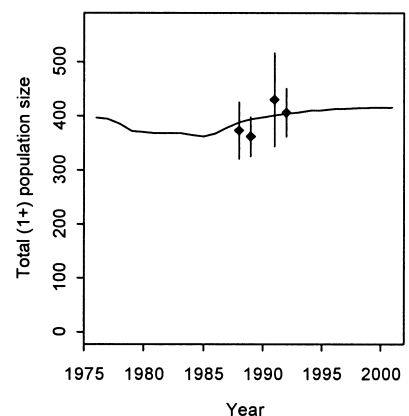
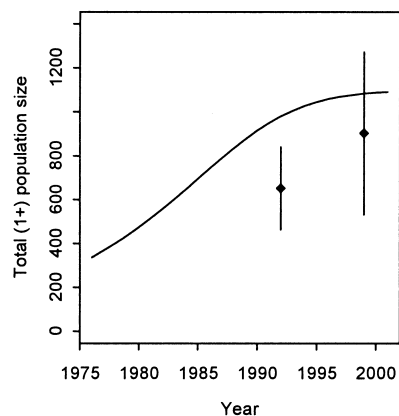
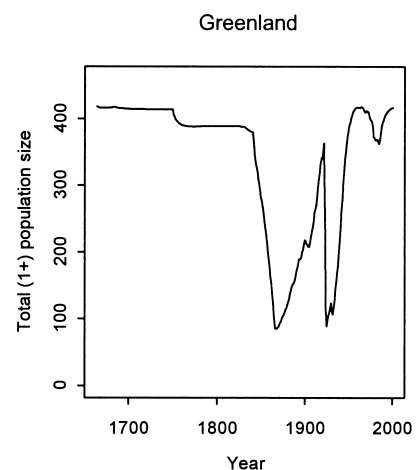
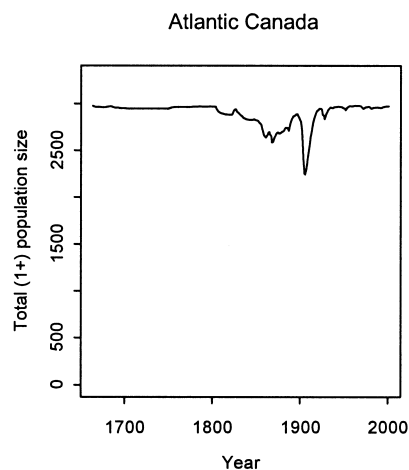
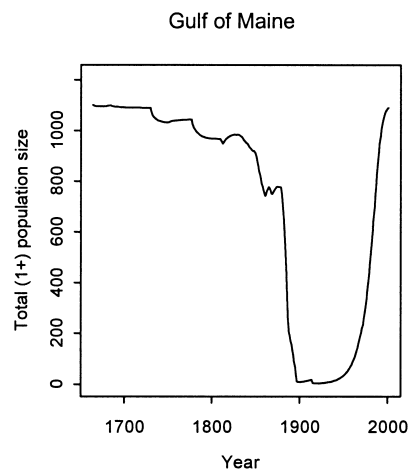
Gulf of Maine	Years	Predicted	Observed	SD
Rate of Increase:	1979-1991	0.0656379	0.063	0.011
Average Fecundity:	1995-2001	0.14	0.43	0.141

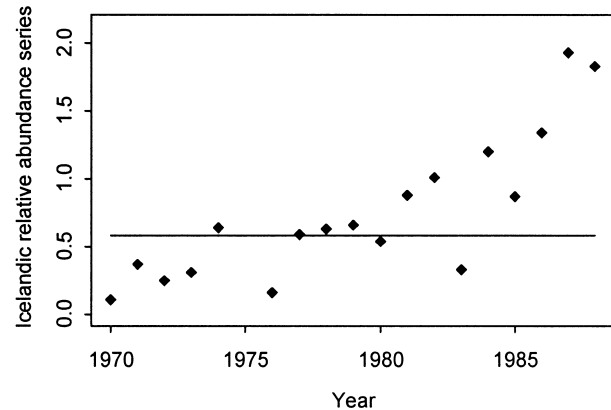
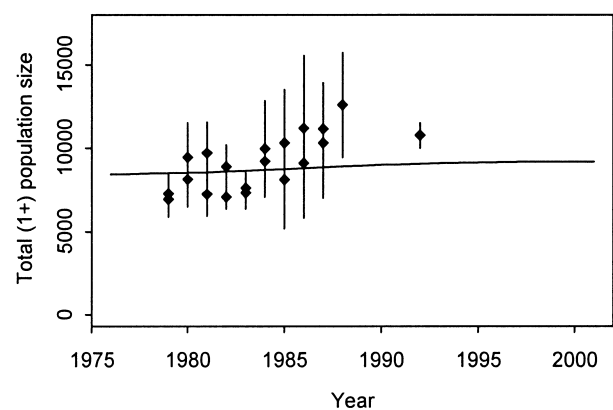
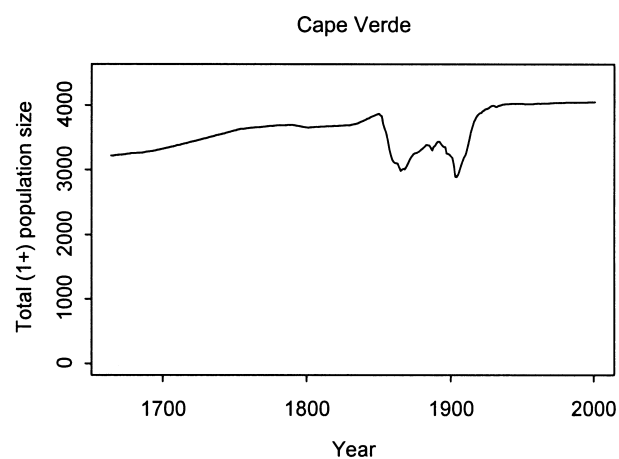
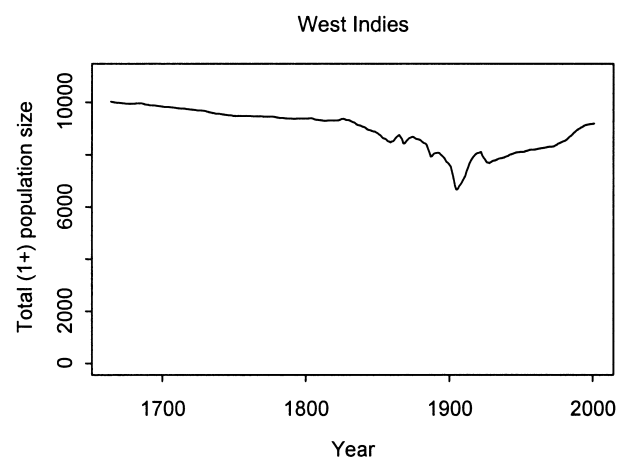
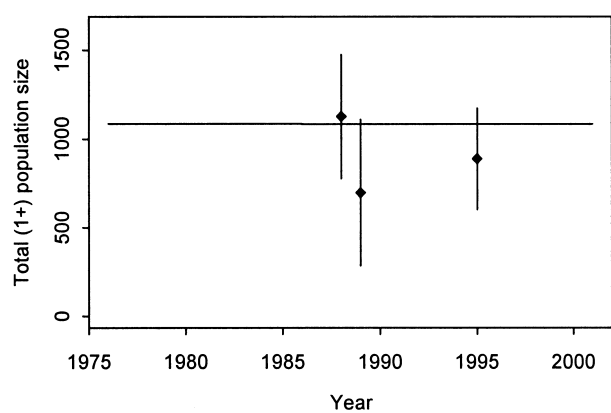
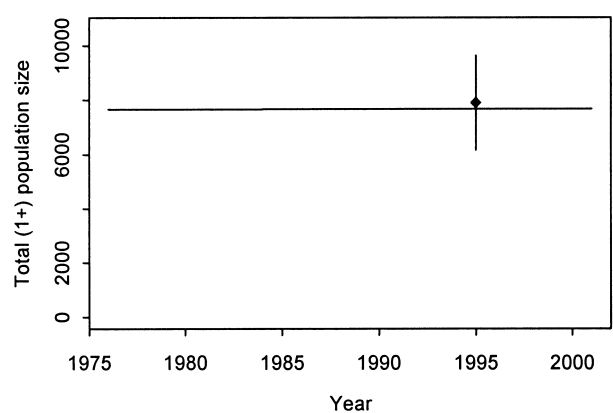
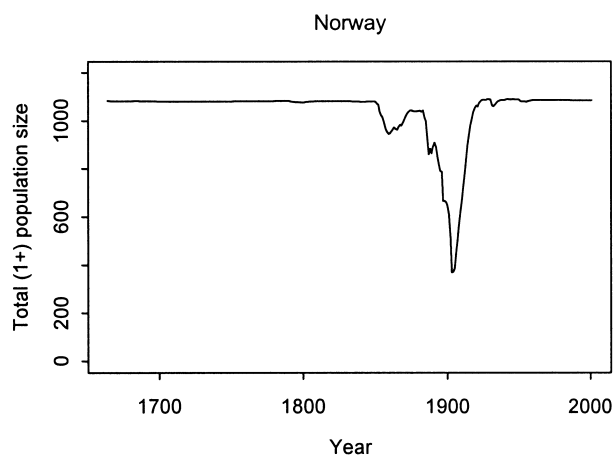
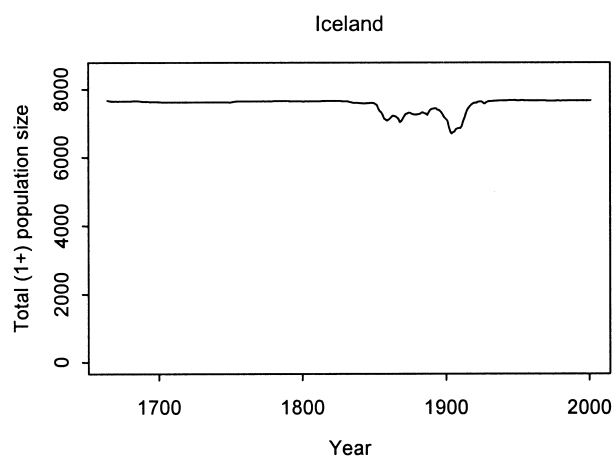
Ratios of feeding area from the West Indies.

	Year	Predicted	Observed	SD
Iceland	1992	0.596012	0.60	0.050
Norway	1992	0.128421	0.13	0.057

Carrying capacity (K) and population size (N) estimates

	K	N_{2001}	$(N_{2001}/K)\%$	min(N)	max(N)
Gulf of Maine	1101	1090	99	4	1101
Canada	2973	2971	100	2242	2976
Greenland	418	416	99	85	418
Iceland Total	7672	7670	100	6691	7679
Norway Total	1083	1084	100	368	1090
Iceland-West Indies	5331	4568	86	4121	5331
Iceland-Cape Verde	2341	3102	133	2201	3102
Norway-West Indies	203	139	69	49	203
Norway-Cape Verde	880	945	107	319	948
West Indies	10026	9184	92	6665	10026
Cape Verde	3221	4047	126	2892	4047
Total NA	13247	13231	100	9587	13247





Case D

Number of parameters = 8. Objective function value = 20.021.

Single value for resilience parameter, A , estimated as 1.49462.

Depensation not allowed.

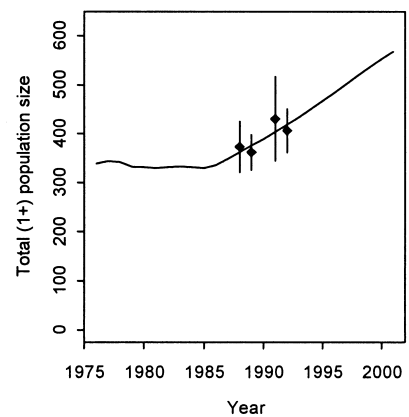
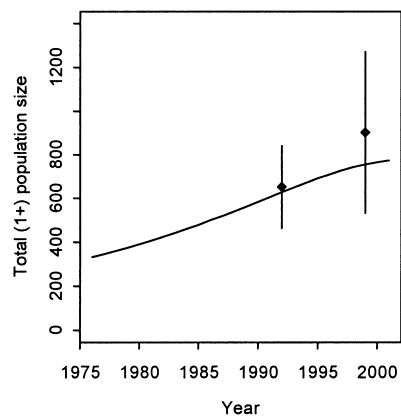
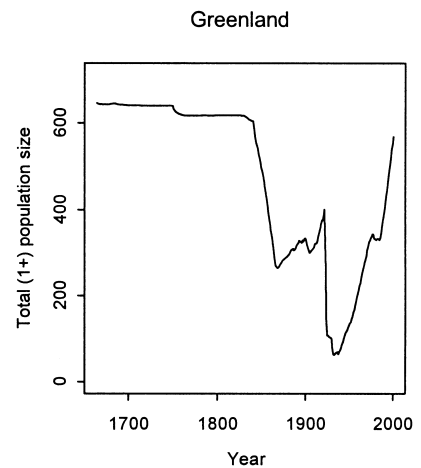
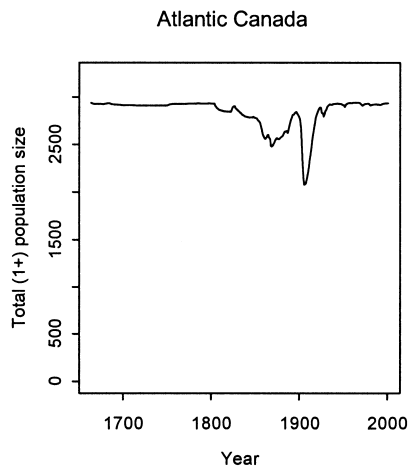
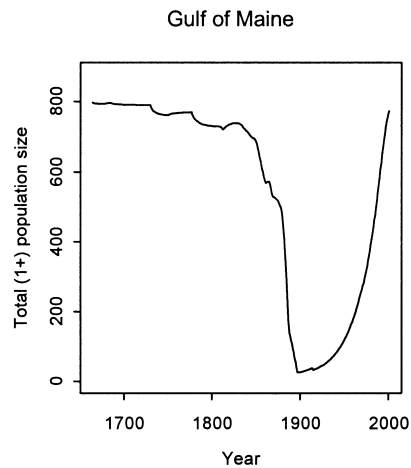
Gulf of Maine	Years	Predicted	Observed	SD
Rate of Increase	1979-1991	0.0400168	0.063	0.011
Average Fecundity	1995-2001	0.18085714	0.43	0.141

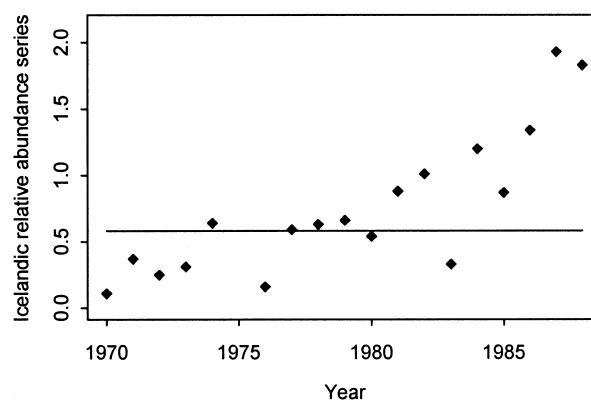
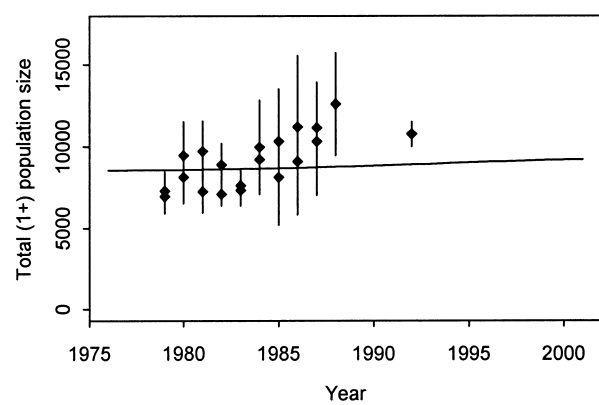
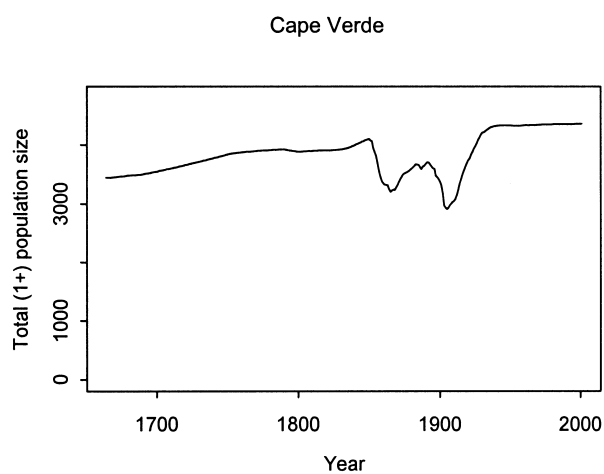
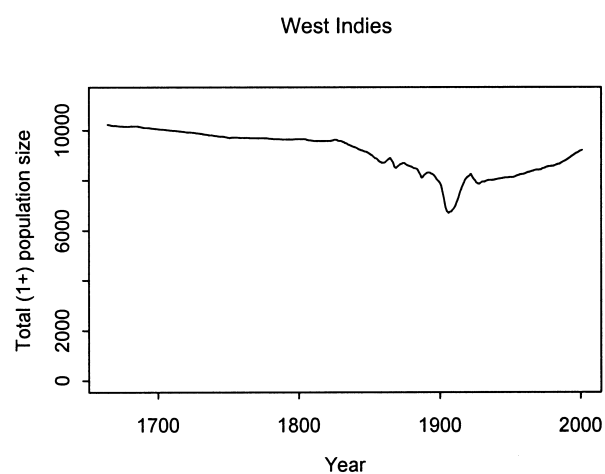
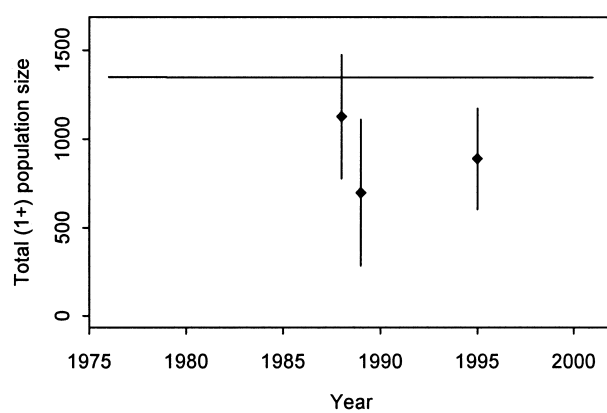
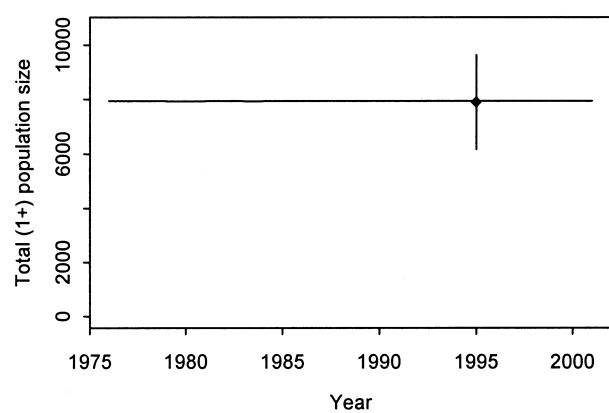
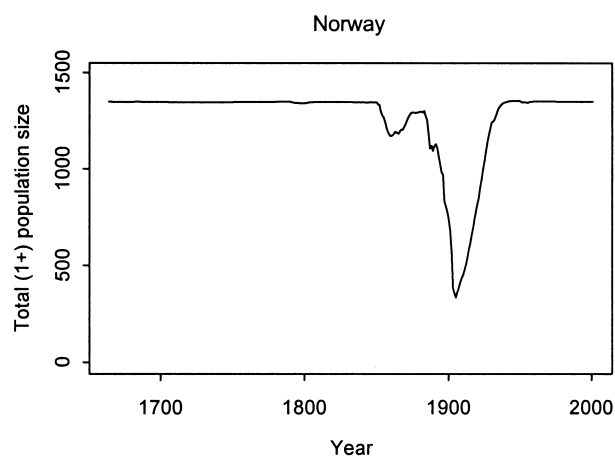
Ratios of feeding area from the West Indies.

	Year	Predicted	Observed	SD
Iceland	1992	0.599206	0.60	0.050
Norway	1992	0.126807	0.13	0.057

Carrying capacity (K) and population size (N) estimates

	K	N_{2001}	$(N_{2001}/K)\%$	$\min(N)$	$\max(N)$
Gulf of Maine	797	772	97	25	797
Canada	2937	2935	100	2080	2939
Greenland	646	567	88	62	646
Iceland Total	7939	7937	100	6854	7946
Norway Total	1347	1348	100	334	1353
Iceland-West Indies	5589	4752	85	4236	5589
Iceland-Cape Verde	2350	3185	136	2245	3185
Norway-West Indies	255	171	67	44	255
Norway-Cape Verde	1092	1177	108	290	1179
West Indies	10223	9198	90	6695	10223
Cape Verde	3442	4362	127	2913	4362
Total NA	13665	13560	99	9625	13665





Case E

Number of parameters = 12. Objective function value = 18.148139.

Depensation not allowed.

<i>A</i> _{par}	Gulf of Maine	Canada	Greenland	Iceland	Norway	Mean(<i>A</i> _{rel}) + <i>A</i> _{par}
4.36156	-0.03877	-0.00929	0.01272	-0.00942	0	4.35261

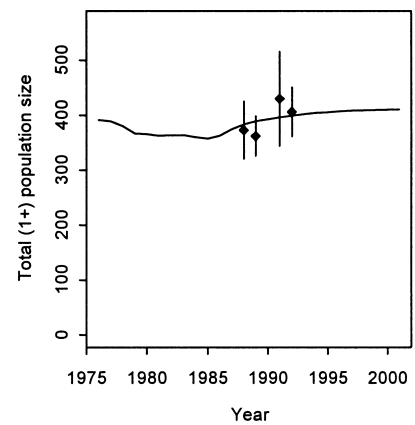
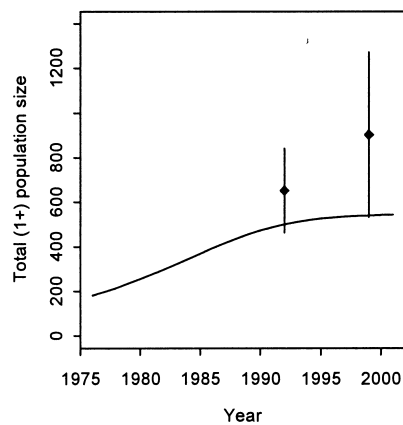
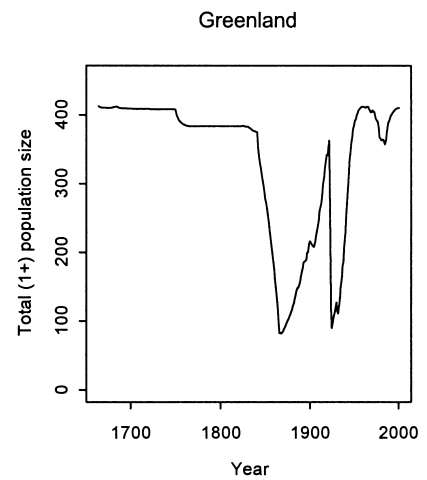
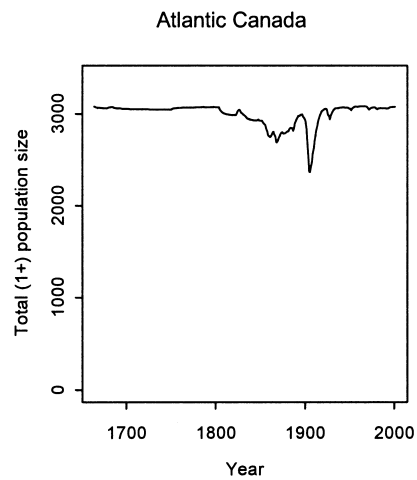
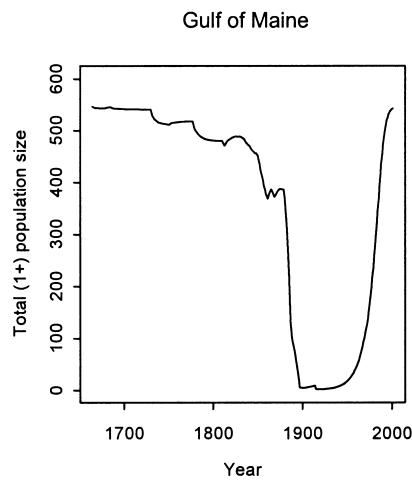
Gulf of Maine	Years	Predicted	Observed	SD
Rate of Increase	1979-1991	0.0617176	0.063	0.011
Average Fecundity	1995-2001	0.13214286	0.43	0.141

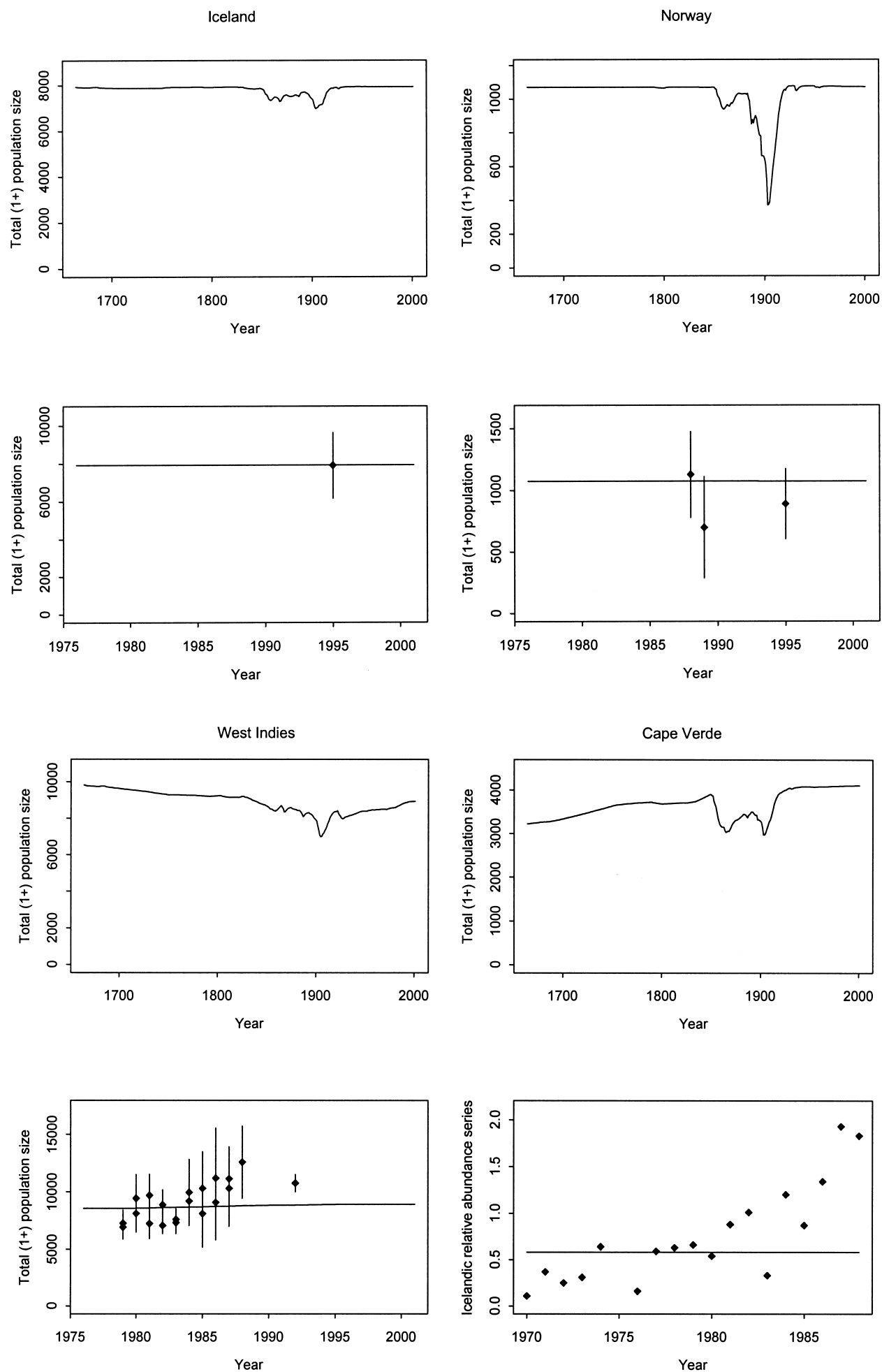
Carrying capacity (*K*) and population size (*N*) estimates

	<i>K</i>	<i>N</i> ₂₀₀₁	(<i>N</i> ₂₀₀₁ / <i>K</i>)%	min(<i>N</i>)	max(<i>N</i>)
Gulf of Maine	546	543	99	2	546
Canada	3080	3078	100	2366	3083
Greenland	412	410	100	82	412
Iceland Total	7932	7930	100	6973	7939
Norway Total	1071	1072	100	370	1078
Iceland-West Indies	5573	4759	85	4320	5573
Iceland-Cape Verde	2359	3171	134	2253	3171
Norway-West Indies	205	139	68	50	205
Norway-Cape Verde	866	934	108	320	937
West Indies	9817	8928	91	6981	9817
Cape Verde	3226	4105	127	2976	4105
Total NA	13042	13033	100	9990	13042

Ratios of Feeding area from the West Indies.

	Year	Predicted	Observed	SD
Iceland	1992	0.600580	0.60	0.050
Norway	1992	0.129376	0.13	0.057





Appendix 4

REPORT OF THE WORKING GROUP ON THE ANTARCTIC HUMPBACK WHALE CATALOGUE

Members: Baker, Carlson, Childerhouse, Clapham, Donovan, Garrigue, Pastene and Rosenbaum.

The Working Group discussed and clarified the following issues:

- (1) Access to IDCR/SOWER photos. Donovan clarified that members of the Scientific Committee should have full access to photographs collected on IDCR/SOWER cruises and that this is in line with standard IWC data policy. Members are able to approach the Secretariat and obtain access to these photographs (e.g. original negatives and proof sheets) but it is not clear (based on the contract with the College of the Atlantic (COA)) whether or not they can gain access to these same images which have been compiled in the COA Antarctic catalogue.
- (2) At present, access to all photographs in the COA Antarctic catalogue is only available to the Secretariat, contributors, and others on a case-by-case basis as agreed by contributors.
- (3) Presently, the only information associated with each photograph in the catalogue is catalogue number, the regional area where the photograph was taken, and the contact details of contributors.
- (4) The purpose of the COA Antarctic humpback catalogue was to centralise the collection and make accessible photographs of humpback whales from the Antarctic. Since its creation, photographs have been provided from other Southern Hemisphere areas, including breeding areas, and these have been included in the catalogue.
- (5) It was recognised that access to the catalogue was for contributors only but that a person or group desiring access to the catalogue only need submit a single

photograph to be considered a contributor and thereby gain access.

The Working Group proposed the following:

- (1) The Secretariat approach the COA and renegotiate access to images collected by IDCR/SOWER surveys stored in the COA Antarctic catalogue. This is with the aim of giving open access to these images to *everyone*, in accordance with IWC policy.
- (2) The Secretariat approach the COA and ask them to provide a list of addresses of contributors, which will be made available to Scientific Committee members upon request.
- (3) The Secretariat approaches the COA and discusses options for sorting all images by regional area.

After requests from the Secretariat for specific new contractual 'conditions', the following conditions were supplied, based on proposals 1 and 3 above:

- (1) Access to humpback photographs collected on IWC-funded research in the Antarctic (e.g. IDCR, SOWER surveys) held in the COA Antarctic catalogue is available over the web to *everyone*.
- (2) All humpback photographs collected on IWC-funded research in the Antarctic (e.g. IDCR, SOWER surveys) held in the COA Antarctic catalogue, are searchable by regional area where the photographs were taken.

The Working Group agreed that:

- (1) Members of the Scientific Committee should have full access to images collected on IDCR/SOWER cruises.
- (2) The new conditions listed above should be negotiated with COA as soon as possible.

Annex I

Report of the Working Group on Stock Definition

Members: Baba, Baker, Bando, Bannister, Berggren, Best, Bravington, Brownell, Butterworth, Childerhouse, Cipriano, Clapham, Clark, Dalebout, DeMaster, Diake, Dizon, Donahue, Donovan, Ensor, Etylina, Fujise, Gales, Garrigue, Givens, Goodman, Goto, Gunnlaugsson, Hammond, Hatanaka, Haug, Hester, Ishikawa, Kanda, Kasuya, Kato, Kawahara, Kell, Kim, Kingsley, Lens, Manzanilla Naim, Martien, Mattila, Minton, Morishita, Murase, Nagahata, Nagatomo, Northridge, Øien, Okamura, Palsbøll, Park, Pastene, Perrin, Pike, Polacheck, Punt, Rambally, Read, Reeves, Rennie, Robbins, Rogan, Rojas-Bracho, Rooney, Rose, Rosenbaum, Rowles, Sadler, Sakamoto, Santamaria, Schweder, Senn, Shimada, Simmonds, Skaug, Smith, Sohn, Sutaria, Suydam, Tamura, Tanaka, Taylor, Tomita, Urban-Ramirez, Van Waerebeek, Vikingsson, Wade, Wakako, Walløe, Williams, Witting, Yamamura, Yasunaga, Yoshida, Zeh, Zenitani, Zerbini.

1. ELECTION OF CHAIR AND APPOINTMENT OF RAPPOORTEURS

Bravington was elected Chair. Givens, Perrin and Rooney acted as rapporteurs.

2. ADOPTION OF AGENDA

The adopted agenda is given as Appendix 1. Discussion under Item 6 was in response to developments at this year's RMP meeting (SC/54/Rep1), rather than a direct continuation of issues raised in the Stock Definition Working Group (SDWG) last year.

2.1 Review of documents

New documents considered were SC/54/SD2-6, Taylor and Martien (2002) and Cui *et al.* (2002).

3. REPORT FROM INTERSESSIONAL WORKING GROUP

In 2001, the SDWG established an intersessional Working Group to guide the Testing Of Spatial Structure Models (TOSSM; see IWC, 2002, p.272). Pressure of work had prevented any substantive progress intersessionally. However, the SDWG reaffirmed the importance of the issues addressed by TOSSM, and agreed to continue the Working Group (see Item 6).

4. REVIEW OF HISTORICAL RESPONSES OF CETACEAN (SUB)STOCKS TO SEVERE DEPLETION

In 2000, the SDWG reviewed instances of (sub)stocks of large baleen whales that had been severely depleted, and had either been extirpated or had failed to recover after intense

harvesting stopped (Clapham and Hatch, 2000). That review highlighted several important factors: abundances had been reduced to no more than a few hundred animals; in most cases, neighbouring (sub)stocks had also undergone heavy harvesting; and in some cases, low-level human-induced mortality had continued after the end of the main harvest. At that time, the SDWG had noted that it would also be useful to review instances where heavily depleted (sub)stocks *had* subsequently recovered. No information on such cases had been provided to the authors of the 2000 review, and so the item was left on the agenda until such time as it could be usefully addressed.

Smith summarised the information in Best (1993), a review of 44 baleen whale stocks, most of which were thought to have been reduced below 10% of their original stock size. The exception was the eastern Pacific gray whale, for which depletion may not have reached that level. Critical issues addressed included the definition of stocks, the potential for monitoring them, and the likely rates of increase. While 12 of the stocks at that point were being or had been monitored, many were not being monitored and some were judged not to be monitorable. Significant rates of increase had been demonstrated for 10, and at least 10 others were believed to be increasing.

Best's study suggests which species would be potentially useful for addressing the question of recovery of (sub)stocks. While it does not address (sub)stock structure *per se*, it may be useful to reconsider Best's divisions of several of the species into 'stocks' both in terms of new information, especially from genetics (e.g. humpback whales in the North Atlantic). However, the lack of abundance monitoring for many of the stocks where (sub)stock structure might be expected (e.g. eastern Canadian bowheads in the Hudson Bay-Davis Strait) suggests that pursuing this question for many of these stocks may not reveal very many useful cases.

The group discussed other difficulties with the review of historical responses of stocks subjected to severe depletion. First, knowing the severity of the historical depletion is extremely important when considering subsequent recovery or recolonisation. However, this information is almost never known with sufficient precision to draw reliable conclusions. Also, interpretation of a failure to recover is also confounded by the historical and recent status of adjacent stocks. Failure to see recovery in one region might indicate that adjacent aggregations of whales were also extirpated, or that they are genetically distinct stocks that might never enter the vacated area. Interpretation of an observed recovery is also difficult because the increased abundance may be attributed to recovery of the stock or by habitat encroachment by another stock. Also, in some cases where recoveries are observed, the local recovery rate may be a positively biased indicator

of population recovery rates if increases in local abundance are driven more by social attraction/migration from other areas, than by intrinsic population growth.

The SDWG noted that recovery and genetic analysis of bones and other material from historic whaling areas and prospective studies of slowly recovering stocks might provide improved information on historical distribution, population structure, and range. It **strongly encouraged** the continuation of this work. A prospective approach could also be informative in areas with extreme variation in recovery; samples collected now could be useful for comparisons to future samples on decadal or generational time periods. Initial proposals for species and areas are presented in Appendix 2.

5. STATISTICAL AND GENETIC ISSUES PERTAINING TO STOCK DEFINITION

SC/54/SD3 observed that stock structures based exclusively on observations from a single species or region (e.g. western North Atlantic humpback whales) cannot be generalised for all other baleen whale stocks, because stocks/species are quite different from each other in life histories and behaviours. As an example, the authors described aspects of North Pacific minke whale life history that differ from that of humpback whales. Although humpback whales appear to learn their site fidelity to feeding grounds from their mothers, no such bonding between mothers and calves has been observed in minke whales. Several pieces of supporting evidence were presented: (1) no mother-calf pairs have been seen in the 1,287 sightings of minke whales made during JARPN and JARPN II cruises in the western North Pacific; (2) weaning occurs before the young-of-year reach the feeding grounds, due to the minkes' short lactation period; (3) time and space segregation by sex and maturity occurs during their migration; and (4) the final destination of immature individuals and mature females is different in the feeding ground, as mature females go further north in the Okhotsk Sea than immature whales. The authors cautioned against the use of very limited data to define stocks. For instance, in contrast to the very clear distinction between J and O stocks, the authors believed it would be premature to make a firm conclusion about the existence of a putative W stock based only on the evidence of slight genetic heterogeneity in mtDNA. Because patterns of stock structure can differ greatly within as well as between species, differentiation of stocks should be at least done species by species. It is critical to devote substantial research effort to gain understanding of the genetics, biology and ecology of the cetacean species in both breeding and feeding grounds.

In discussion, Pastene and Hatanaka emphasised the absence of mother-calf sightings during JARPN and JARPN II cruises, and also noted that cow/calf pairs were rarely seen in the whaling grounds (where there is a high density of mature females). However, Martien noted that most of the whales killed during JARPN and JARPN II were males. It was unclear whether any of this anecdotal evidence helped to clarify how calves learn the route to feeding grounds.

The group strongly **agreed** that data from both breeding and feeding grounds are sorely needed to better understand stock structure, migratory behaviour, and site fidelity in North Pacific minke whales. It can be difficult to draw conclusions on such complex issues from diffuse data gathered over large regions of the North Pacific, especially if the data are mostly feeding grounds or migration routes. Data on North Atlantic minke whales (e.g. Gill and

Fairburns, 1995) do reveal site fidelity, including feeding areas. Several members noted the difficulties in extrapolating minke behaviour in southerly coastal areas of the North Atlantic to northerly pelagic areas of the North Pacific.

To best address specific questions of North Pacific minke stock structure, a broad conceptual understanding of breeding/feeding ecology is necessary, both in comparison with other stocks/species and specifically for North Pacific minkes. What is the underlying reason for the evolution of variations in population structure? What research would be required to learn how juveniles learn their adult feeding grounds? What types of data are most useful? On this last question, it was noted that genetic data are not the only useful means of elucidating stock structure and site fidelity. For example, biological markers and tagging methods could be informative when used on breeding grounds, feeding grounds and migratory corridors. However, most of the relevant data currently available for North Pacific minkes are genetic, and it would be feasible to obtain this type of data from breeding grounds in the near future. If genetic data is collected using a carefully constructed survey design, it can provide detailed information about population structure.

SC/54/SD4 suggested methods for estimating dispersion or mixing rates from genetic data on kinship between pairs of animals. If dispersal is slow, average distances between closely-related animals are likely to be less than average distances between unrelated animals, because there has been less separation time for dispersal to move them apart since their family tree forked. Genetic data can be used to identify the probable degree of relationship between any two individuals ('pedigree reconstruction'), which in turn provides information on separation time. If age data is available, separation time can be inferred more precisely. Dispersion rates can be estimated by a modified regression of physical distance on estimated time-of-separation between closely-related pairs. If samples from different years are available, allowance can be made for the difference between 'within-group' and 'between-group' dispersal rates, the latter being the relevant management. Proposals are made for dealing with other important complications: uncertainty in kinship determination because of limitations in the number of loci examined, statistical allowance for uncertainty in separation time, uneven spatial sampling, and differing dispersion rates by sex. If the approach can be developed successfully, it could be applicable to the assessment of the appropriate space (and/or time) scale for management units. One advantage over methods based on gene frequency data, is that it is not necessary to make assumptions about the far-distant history of the population; kinship estimates of movement rates are based instead on recent movement patterns spanning a couple of generations at most. Simple calculations suggest that there are likely to be enough related pairs in (at least) North Atlantic and North Pacific minke samples to warrant further development of this approach.

The SDWG appreciated the creative approach introduced in this paper and noted that the general ideas seemed promising although they were still at a very early state of development. The author was **encouraged** to pursue this work further. The increased availability of new methods to get many loci from few individuals (e.g. SNPs and AFLAPs¹) might prove very useful for carrying out the sort of analysis envisioned in SC/54/SD4. Sampling of 20+ loci

¹ SNP: single nucleotide polymorphism; AFLP: amplified fragment length polymorphism.

per individual is already underway for several whale stocks, including Gulf of Maine humpbacks and fin whales (with a large number of biopsies and 20+ microsatellites), and for North Atlantic minke.

Several members commented on the applicability of the approach in SC/54/SD4, and made suggestions for future methodological work. Taylor suggested investigating the appropriateness of the smooth regression model fit by SC/54/SD4. If whales are not smoothly spatially distributed (e.g. two breeding populations that overlap on feeding grounds), then a simple linear surface might not be adequate to fit the observed data. If dispersal rate is extremely non-constant across the whales' range, the same problem might arise. Baker suggested that the approach in SC/54/SD4 could be compared to traditional Fisher-Wright diffusion approximation models, which use gene frequencies from numerous variable loci to see which is more powerful in various circumstances. Individual-based methods that must estimate numerous kinship linkages before estimating dispersion are likely to be less powerful if the estimation of kinship is imprecise. Coalescent approaches might also be more powerful. However, Skaug noted that the traditional approaches mentioned by Baker generally depend on relationships between individuals at long times in the past, whereas the SC/54/SD4 approach depended on current relationships. Baker replied that gene frequency analysis can be used on a generational basis, even with traditional drift migration models.

It was agreed that the approach in SC/54/SD4 would require thorough simulation testing, to determine how many samples and what information about demographic parameters would be needed, and to investigate robustness e.g. to spatial sampling bias. Pastene agreed that simulation was important, particularly to investigate the effect of sample bias, but noted that it was also important to test the method on real datasets.

It was noted that population genetic modelling methods for multi-locus genotyping is a particularly active area of current research. The SDWG **agreed** to try to involve additional expertise in this rapidly developing field.

Cui *et al.* (2002) outlined a Bayesian approach for comparing single with multiple stock hypotheses. Bayesian methods should be preferable to classical methods for hypothesis testing, because they have the potential to discriminate whether non-rejection of the null hypothesis of a single stock is indeed a reflection of only one stock being present, or rather of the low power associated with small sample size. The paper assumes a multinomial likelihood for gene frequencies, with a multivariate Dirichlet- β prior for allele frequency. Parameters of the prior were either determined using an empirical-Bayes approach, or assumed to be distributed according to a log-normal hyperprior (the 'full-Bayes' approach). The parameters of the full-Bayes hyperprior were based on a summary of the estimated empirical-Bayes parameters, so are not totally independent of the data. The empirical-Bayes and full-Bayes methods were examined using simulation. The performance of the empirical-Bayes method was found to be much worse than that of the 'Full Bayes' method. The latter performs adequately if applied to data for two stocks that differ substantially in haplotype frequency, or when sample sizes are large.

In discussion, the group recognised the value of distinguishing those situations where the null hypothesis is true, from those situations where data are insufficient to determine whether it is true. In order to use the approach in Cui *et al.* (2002), though, it emphasised the need to

investigate sensitivity of the analysis to the priors used. For this reason, and to interpret the results of any application, it is crucial that a method be developed to cast the parameters of the prior and hyperprior in a more interpretable light. Specifically, a user of the method or a reader of the results must be able to understand what assumptions about the level of differentiation between stocks are introduced through the priors. Punt responded that the authors were addressing this point in further work. Martien commented that the method in Cui *et al.* (2002) is conditional on an initial spatial classification of whales ('lines on maps'), and that the Boundary Rank method (discussed next) provided a practical solution to this problem.

Martien and Taylor summarised aspects of Martien and Taylor (2001) and Taylor and Martien (2002) concerning new features developed and tested for the Boundary Rank (BR) method (Martien and Taylor, 2001) over the example of North Pacific minke whales. There are two decisions to be made before BR can be applied to a dataset: how to draw the connectivity matrix and how to define initial groups. The connectivity matrix constrains the geographical form of the stocks defined by BR. It represents a prior belief about whale behaviour and movement patterns, and should therefore correspond to a biologically plausible model, such as isolation-by-distance. The sample size within initial strata relative to their haplotypic diversity can impact the performance of any genetic analysis, including BR. When sample size is low relative to haplotypic diversity, the degree of genetic similarity between units (as measured by any frequency-based statistic) tends to be biased upward. BR clusters units based on their genetic similarity. If the initial units are too small, then those with small sample size will be combined simply because they have small sample sizes, not because they really are similar. The authors have developed and tested the performance of a set of diagnostic statistics to help determine whether the results for a given set of initial units is likely to be strongly influenced by small sample size. These diagnostics identify when the number of samples in a proposed initial unit is low enough (relative to haplotypic diversity), that the results of any frequency-based genetic analysis (including BR) would likely be strongly influenced by low sample size rather than by the true structure of the population.

The group discussed the likely extent of sensitivity of BR results to the size and choice of initial clusters. As with any agglomerative clustering technique, the starting clusters can influence the results, especially if they are large enough to mistakenly link unrelated individuals. On the other hand, if there is high diversity and the clusters are too small, individual *p*-values for testing genetic similarity may be biased upwards, thereby reducing discriminatory power. The group considered whether it was appropriate to use the same data for specification of the initial groups as is used for the main analysis. It **agreed** that this should not be a serious concern because very different aspects of the data are used for the two tasks.

As well as the initial clusters, BR requires an *a priori* selection of possible linkages between the clusters, corresponding to different biological hypotheses such as isolation-by-distance or stepping-stone dispersal. It was noted that the sensitivity of results to different choices of linkage would need to be examined in any given application.

SC/54/SD5 described a permutation test for evaluating the general stock structure hypotheses investigated by BR, to see whether the level of separation suggested by BR could have arisen by chance from a panmictic population. The approach

is to generate artificial datasets with the same spatial sampling, initial units, and linkages as the real data, but with the haplotype of each sample chosen at random (corresponding to panmixia). BR is then applied to each artificial dataset, and the genetic similarity across the highest-ranking boundary is recorded. The set of these simulated genetic similarities constitutes the null distribution. The genetic similarity for the real data is then compared to this null distribution, to assess significance under the null hypothesis. Note that the location of the highest-ranked boundary will, of course, vary randomly in the simulated datasets. What is being tested is not the location of the particular boundary that BR suggests for the real data, but rather a null hypothesis of one stock versus a general alternate hypothesis of two stocks. Significance of a three-stock alternate hypothesis can be examined by comparing the genetic similarities across the final two boundaries. The authors used a simulation test to investigate whether the permutation test is biased if the null hypothesis is true. With a two-stock alternate hypothesis and $\alpha = 0.05$, rejection of the null occurred in 29 out of 500 trials (5.8%), indicating no bias.

SC/54/SD5 examined some of the stock structure hypotheses generated by BR for North Pacific minke whales. Different specific alternate hypotheses were examined, based on two different sets of initial units and, for one of the sets of initial units, for two different connectivity matrices. The power of the permutation test was investigated for two of these specific alternate hypotheses: two stocks with a boundary at 157°E and a dispersal rate of 0.002, and three stocks with boundaries at 147°E (dispersal rate 0.0035) and 157°E (dispersal rate 0.0008). These dispersal rates were estimated from real data conditional on the assumed boundaries. Power was estimated by simulating datasets corresponding to a specific alternate hypothesis, and then seeing how often the null hypothesis of panmixia was correctly rejected. Only two of the six permutation tests were significant at $\alpha = 0.05$. However, estimated power was relatively low (0.64 for two stocks and 0.63 for three stocks), indicating that the lack of significance for some of the permutation tests may be the result of low power. The authors planned to determine what value of α would be needed to equalise type I and type II error rates.

It was agreed that the permutation test in SC/54/SD5 is an unbiased method for testing a two-stock hypothesis against the null hypothesis of panmixia. Rejection of the null hypothesis indicates that the presence of population structure is reflected in gene frequencies. However, it does not mean that the selected boundary represents an absolute barrier, or unique barrier, between two non-overlapping populations. Rather, the boundary suggested by BR should be seen as the most effective partition (conditional on the possible partitions determined by the initial clustering) for sub-dividing the genetic samples.

There was some discussion regarding whether the test would have the correct type I error rate when testing a three- (or more) stock hypothesis. Concern arose over the multidimensional nature of the comparisons used by the test to determine significance. The authors reported that simulations of the type I and II error rates of the three-stock test had revealed no indication of bias, although this conclusion rested on the validity of a computational shortcut which still needed to be checked. After further discussion, it was noted that a simple modification of the existing technique would ensure an unbiased three-stock test. Given this minor change, the group **agreed** that the BR approach employing the permutation test should be a useful tool for

three-stock tests, as well. The relationship between the power of the test and the specific alternate hypothesis under investigation was also discussed. Several members were interested in seeing how power depended on the groups and linkages shown on the initial map. Taylor noted that if the groups are too small, power is reduced.

Based on the new work presented and on discussions held during this year's meeting, the group **endorsed** the value of BR for use in RMP *Implementations* and *Implementation Reviews*. The group also **encouraged** further development of the method. Some members noted, though, that there had been limited time available for in-depth consideration, and that the discussion had proceeded very rapidly, particularly given the language difficulties. The Chair apologised for the lack of time available during the meeting. However, he noted that it was of considerable importance to the RMP sub-committee to make a determination on the applicability of Boundary Rank in a timely fashion. If, after further consideration, any specific concerns do arise, then it is important that every effort be made to address them to the developers of Boundary Rank promptly, so that there is an opportunity for the concerns to be investigated intersessionally (as happened this year over permutation testing, for example).

Hypothesis tests are another tool often used to investigate issues of stock structure. The group **reiterated** its concerns about the value of conclusions based solely on the results of an hypothesis test, as expressed in IWC (2001, p.236). In brief: it is often not clear *a priori* what hypotheses should be tested; multiple hypothesis tests are a poor way of doing exploratory data analysis; stock definition analyses should begin with exploratory data analysis and proceed, where possible, to estimation (e.g. of dispersal rates) rather than to hypothesis testing.

In summary, the group noted that, it is important in any application of stock structure methods to examine the sensitivity of conclusions to different *a priori* decisions about the definition of initial units, and about which population structure hypotheses to examine.

5.1 Simulation testing

SC/54/SD6 discussed some of the issues to address when designing the performance tests to be undertaken by TOSSM. There are three primary steps in the design of performance analyses: formulating plausible population structure models; formulating plausible sampling schemes; and defining performance criteria. The final step is likely to be the most challenging. The authors identified two broad types of performance criteria, and presented preliminary analyses to illustrate the behaviour of different criteria. 'Exact' measures look at the proportion of the time that a method gets some aspect of stock definition (such as the number of stocks) exactly right. However, these types of measures are of limited utility in evaluating performance within a management context, since they generally do not take into account the management implications of a given error in stock definition. Rather, performance criteria should be based on how well the stocks defined by a technique would meet specific management objectives if they were to be managed under (for example) the RMP or AWMP. This will require the development of proxies for performance under these two management schemes. SC/54/SD6 also discussed the use of formal decision analyses in which specific costs are assigned to different stock structure scenarios and different types of stock definition errors. For instance, the errors of defining too few or too many stocks

can be assigned equal cost or, if a precautionary approach is taken, a higher cost can be assigned to the definition of too few stocks. These different cost structures can have a substantial impact on the relative performances of different methods.

The SDWG noted the useful points identified in SC/54/SD6. The process of spatial structure simulation (i.e. testing different techniques for identifying spatial stock structure, and for translating results into management units), is a crucial step in validating the applicability of current and future methods for analysing population structure. The group **confirmed** the Terms of Reference agreed last year (IWC, 2002, p.272) for TOSSM, noting that further consideration in TOSSM would be required to devise appropriate performance criteria. Substantial efforts will also be required to develop the operating model that governs the 'real' population structure and the 'real' management rule; it is important to strike an appropriate balance between 'too much realism' (excessive complexity, and problems in extrapolating conclusions to other situations) and 'too much simplicity' (conclusions irrelevant to practical management situations in IWC).

It was **agreed** that an intersessional workshop would be essential in order to make reasonable progress on spatial structure simulation soon. Apart from those interested in actually developing methods, this meeting would ideally require two other types of participant: (1) one or more Scientific Committee members with extensive experience in setting up large simulation trials, particularly in an RMP or AWMP context; and (2) experts from outside the usual IWC circles who can provide input on appropriate genetic, statistical, and ecological considerations to be used in developing the simulations. Further details are given in Appendix 3. It was noted that there is significant divergence between the terminology of IWC and of other scientific arenas, e.g. conservation biology. To avoid problems, a glossary of terms relevant to the management framework of (at least) the RMP and AWMP should be developed for distribution to participants. Givens noted that such a glossary already exists for the AWMP. There is no current equivalent for the RMP, although similar documents have been produced in the past. There was insufficient time to draw up a draft agenda before the Working Group finished, so it was agreed that a small group would prepare a draft agenda and report back directly to the full Committee.

6. TERMINOLOGY AND DEFINITIONS

6.1 Unit-to-serve

This year, the RMP sub-committee had extensive general discussions about *Implementations* and *Implementation Reviews*. These discussions were prompted by the unanticipated and prodigious duration of the North Pacific minke whale *Implementation* process, but have wide relevance to other *Implementations* and *Reviews*. One of the RMP sub-committee's conclusions, is that a lack of clarity over the unit-to-serve has been partly responsible for the difficulties and delays. Again, this is particularly significant for North Pacific minke whales because of the operational objective of maintaining a coastal fishery on a more-widespread population, but unit-to-serve is an extremely important issue elsewhere too: not just for RMP, but also for AWMP, and for management of mortalities of other cetaceans and other species whether inside or outside the IWC. During this meeting, therefore, the RMP sub-committee tasked the Stock Definition Working Group

with developing a list of potential definitions of 'unit-to-serve', and with clarifying the implications of different choices for management.

This is a different task than 'defining stocks'; it is also, perhaps, more useful, since it is more directly linked to management. Of course, many of the detailed issues are exactly the same; however, the change of emphasis is significant because it clarifies the need to think not just about biology, but also about explicit operational issues in the context of management. When considering possible definitions of unit-to-serve rather than stock, it is manifestly not within the remit of the group to propose a single candidate definition; instead, the SDWG will report back with a list and comments for consideration by the whole Committee and probably ultimately the Commission. These shifts in emphasis will actually help the group to provide something of clear value.

The group **strongly agreed** that working in terms of 'unit-to-serve' was likely to be much more fruitful than working in terms of 'stock', and provided a much better opportunity to clarify explicit operational issues in the context of management. It was agreed to seek clarification from the whole Committee, on whether the SDWG still needs to explicitly address 'stock definition' in addition to 'unit-to-serve'².

There was no opportunity to have a full discussion of unit-to-serve during this meeting, but preliminary discussions ranged over a number of points. These included (but were not restricted to) the following: (1) whether objectives related to aggregate yield alone might supply enough impetus for protection at disaggregated levels; (2) how the timescale for rebuilding from depletion varies over different sizes of unit-to-serve; (3) the link between tolerable risk and space/time scale; (4) reversibility; (5) the importance of management (i.e. where and when the harvest is) as well as biology; (6) the necessity of allowing case-by-case flexibility; and (7) the need for further development of realistic underlying biological theory. These and other issues all deserve to play a role in the development of practical definitions.

As a way of making progress on this issue, the group **encouraged** the submission of papers on unit-to-serve at next year's meeting, but with a specific focus on the operational implications of choosing each possible definition as a basis for management. It is important to ensure that papers do not simply put forward a definition without discussing its operational implications, because it is the latter that will need to be considered in reporting back to the Committee.

Any proposed definition should be accompanied by one realistic (or at least plausible) example. This relates to another new request from the RMP sub-committee, namely to draw up a list of archetypes for consideration in (any future) *Implementations*. The point of this is to provide a checklist of conceptual models of what whales do, so that when considering a new population the Committee will be obliged to give some (possibly very brief) consideration of the plausibility of the various different stock structures that are known to exist for other species and populations, rather than being tempted to assume a single default 'null hypothesis'. Although the archetypes list is separate from the list of possible choices for unit-to-serve, there is clearly a relationship between the two. The inclusion of (preferably

² Editor's note: It was subsequently agreed by the Committee that the SDWG should henceforth direct its attention towards 'unit-to-serve' rather than 'stock'. However, the SDWG will nevertheless retain its old name for pragmatic reasons.

cetacean) examples in papers about unit-to-convert is important, both to ensure that the unit-to-convert list is somehow related to the real world, and also to start the task of drawing up the archetypes list.

Papers on this issue will need to discuss how and to what extent (if at all) it could be made operational using the mechanisms of the RMP, and under what harvesting scenarios (i.e. times of year and places where harvesting is planned, relative to the annual life cycle of the species). The choice of unit-to-convert, the harvesting scenario, and the quality of available information can all affect how easy it is to arrive at an RMP *Implementation* that delivers the Commission's agreed management objectives: avoidance of risk of undue depletion of stocks, and making possible stable high yields (for exact words, see Kirkwood, 1992, pp.236-237). *Implementation* is very straightforward, for example, if the unit-to-convert is chosen to be the breeding stock, and the whaling grounds are also known to encompass the entire feeding range of one single breeding stock. Small Areas might not be defined at all, in which case catch-cascading or catch-capping would become irrelevant, no case-specific *Implementation Simulation Trials* would be needed, and the unit-to-convert would be at negligible risk of over-depletion because the RMP is an extremely risk-averse procedure in the absence of awkward population structure. 'Difficult' cases arise if the unit-to-convert is very small (e.g. a family group, to take an extreme case); or if the structure of the population is poorly understood at the level of the chosen unit-to-convert (e.g. if the unit-to-convert is the breeding stock, but the number and distribution of breeding stocks is unknown); or if the interaction between harvesting and population structure is complex (e.g. if animals are harvested on breeding grounds as well as on feeding grounds). The difficulties would likely be manifested in several ways: either very demanding requirements for data on population structure and movements, or much more uncertainty about important effects; low quotas combined with significant operational restrictions; and a long-drawn-out process of assessment and implementation.

The group considered the basic issues relevant to implementing the RMP on various definitions of unit-to-convert. Definitions of RMP-specific terms in this section may be found in IWC (1999). Overall quotas in the RMP may be set over a Medium Area using the CLA. When considering unit-to-convert, the CLA and Medium Area components can be regarded as non-negotiable: Medium Areas can be assumed to be 'larger' than the unit of conservation being considered, since any unit of conservation 'larger' than a Medium Area will not be of interest to IWC management. The operational flexibility of RMP-based management therefore lies effectively in the following areas:

- (1) spreading out the quota in space and/or time, by defining Small Areas and catch-cascading or catch-capping;
- (2) further spreading out the quota within a Small Area;
- (3) defining what information would be needed about stock structure, movement, and distribution in time and space.

Although the RMP definition (IWC, 1999) already contains an explicit basis (in principle) for selecting Small Areas, the group considered that it would not be helpful to adhere too strictly to that definition when considering the feasibility of management for some particular unit-to-convert. It has already been recognised in the Committee, that some slippage in the definition of a Small Area is necessary in

order to obtain sensible definitions in certain circumstances (e.g. harvesting on migration). When considering how to go about *Implementation* for a particular unit-to-convert, there is no *a priori* requirement that Small Areas need to be similar in size to the unit-to-convert; the issues are how and whether Small Areas (and the other operational aspects mentioned above) could be chosen to achieve effective management of the unit-to-convert.

Of course, all this is not to say that ease of implementation and compatibility with harvesting should be the sole, or even the primary, determinants of an appropriate unit of conservation. Ultimately, though, choices about conservation and harvesting do need to take account of practicality, and the scientific task is to spell out as clearly as possible what the implications of different choices would be.

7. WORK PLAN

The group expected that it would be able to deal with archetypes during the 2003 meeting, as this issue has been addressed in the past. The group agreed to try to do the same with unit-to-convert, but the issues involved are complex, and more time may well be required. Discussion will be stimulated by papers following the above guidelines. The group emphasised that there would be a need for a clear glossary of IWC-specific terms to avoid confusion among authors, especially those outside IWC circles, including some indication of what harvesting regimes are likely to be contemplated. In particular, the concept of 'unit to convert in the context of whaling' will be surprising to some biologists, and will need clear explanation.

Intersessional work

- (1) Develop and disseminate RMP glossary (Donovan to prepare).
- (2) Invite contributions on technical issues.
- (3) Spatial structure workshop (see Appendix 3).
- (4) E-mail group (TOSSM).

Provisional agenda items for the 2003 meeting

- (1) Statistical and genetic issues pertaining to stock definition, including review of TOSSM work.
- (2) Review of new information on responses to historical over-depletion.
- (3) Development of stock and harvesting archetypes suitable for consideration in whaling management.
- (4) Options for unit to convert, and implications for management.

8. ADOPTION OF REPORT

The report was adopted at 19:50 on 5 May 2002.

REFERENCES

- Best, P.B. 1993. Increase rates in severely depleted stocks of baleen whales. *ICES J. Mar. Sci.* 50(3):169-86.
- Clapham, P.J. and Hatch, L.T. 2000. Determining spatial and temporal scales for population management units: lessons from whaling. Paper SC/52/SD2 presented to the IWC Scientific Committee, June 2000, Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- Cui, G., Punt, A.E., Pastene, L.A. and Goto, M. 2002. Bayes and Empirical Bayes approaches to addressing stock structure questions using mtDNA, with an illustrative application to North Pacific minke whales. *J. Cetacean Res. Manage.* 4(2):123-34.
- Gill, A. and Fairburns, R.S. 1995. Photo-identification of the minke whale *Balaenoptera acutorostrata* off the Isle of Mull, Scotland. pp.

- 129-32. In: A.S. Blix, L. Walloe and O. Ulltang (eds.) *Developments in Marine Biology. 4. Whales, Seals, Fish and Man: Proceedings of the International Symposium on the Biology of Marine Mammals in the Northeast Atlantic. Tromsø, Norway, 29 November-1 December, 1994*. Elsevier, Amsterdam.
- International Whaling Commission. 1999. Report of the Scientific Committee. Annex N. The Revised Management Procedure (RMP) for Baleen Whales. *J. Cetacean Res. Manage. (Suppl.)* 1:251-8.
- International Whaling Commission. 2001. Report of the Scientific Committee. Annex I. Report of the Working Group on Stock Definition. *J. Cetacean Res. Manage. (Suppl.)* 3:229-38.
- International Whaling Commission. 2002. Report of the Scientific Committee. Annex I. Report of the Working Group on Stock Definition. *J. Cetacean Res. Manage. (Suppl.)* 4:261-81.
- Kirkwood, G.P. 1992. Report of the Scientific Committee, Annex I. Background to the development of revised management procedures. *Rep. int. Whal. Commn* 42:236-43.
- Martien, K.K. and Taylor, B.L. 2001. A new method of generating hypothesized population structures for continuously distributed species using genetic data. Paper SC/53/SD7 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Taylor, B.L. and Martien, K. 2002. Interpretation of Boundary Rank results for North Pacific minke whales. Paper SC/J02/NP2 presented to the Scientific Committee Workshop on North Pacific common minke (*Balaenoptera acutorostrata*) *Implementation Simulation Trials* held in Seattle, USA, 19-22 January, 2002 (unpublished). [Paper available from the Office of this Journal].

Appendix 1

AGENDA

1. Election of Chair and appointment of rapporteurs 2. Adoption of agenda 2.1 Review of documents 3. Report from Intersessional Working Group 4. Review historical responses of cetacean (sub)stocks to severe depletion	5. Statistical and genetic issues pertaining to stock definition 5.1 Simulation testing 6. Terminology and definitions 6.1 Unit-to-serve 7. Work plan 8. Adoption of report
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Appendix 2

POSSIBLE CANDIDATES FOR GENETIC STUDIES TO HELP DEFINE STOCKS

P. Clapham, S. Baker, M. Dalebout, H. Rosenbaum, T. Schweder and B. Taylor

Using whaling catch and recovery histories from particular areas to clarify stock structure is a difficult task. Clapham and Hatch (2000) noted several cases in which populations of whales were apparently extirpated by whaling, and where no recovery has occurred. These cases may highlight the historical existence of distinct stocks; however, it is possible that the observed lack of recovery reflects an absence of immigration into the area concerned from adjacent (extant) populations because those populations have themselves been reduced and have yet to expand. Distinguishing between these two explanations is of considerable importance to understanding long-term stock dynamics, and to developing

archetypes of cetacean population structure for management.

Table 1 below provides a list of areas and populations which might represent candidates for this type of work.

REFERENCE

- Clapham, P.J. and Hatch, L.T. 2000. Determining spatial and temporal scales for population management units: lessons from whaling. Paper SC/52/SD2 presented to the IWC Scientific Committee, June 2000, Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].

Table 1

Candidate areas/populations that may provide historical material for genetic analysis to clarify stock structure.

Species	Area/Population	Comparison areas	Remarks
North Pacific right whale	Gulf of Alaska	Other eastern North Pacific sites	Whaling station samples?
North Atlantic right whale	Europe	Western North Atlantic	Rosenbaum and colleagues have material and are attempting to collect more. Numerous modern comparative samples exist.
Southern right whale	Subantarctic	New Zealand mainland and Kermadecs	Subantarctic stock recovering but no recovery elsewhere.
Bowhead whale	Spitsbergen	Eastern Canada, Russian Arctic	Project already underway by Rosenbaum and colleagues.
Bowhead whale	Hudson Bay/Foxe Basin	Marble Island/Repulse Bay, Northern Foxe Basin	Historical whaling data. Bones and other material may be available.
Fin whale	Gibraltar	Mediterranean and eastern North Atlantic	May be museum and other sources (A. Aguilar, pers. comm.).
Humpback whale	South Georgia	Area II and Area III (western South America or eastern Africa)	Bones/baleen from whaling stations; biopsies available from comparison areas.
Humpback whale	New Zealand	Other areas of Oceania	Whaling station samples? Numerous modern comparative examples exist. Also suitable candidate for prospective approach.
Humpback whale	British Columbia	Alaska, California	Formerly high-density habitat has shown little recovery and is bordered by genetically distinct feeding grounds.
Blue whale	Western North Pacific or Gulf of Alaska	California/Oregon/Mexico	Whaling station samples (submerged bones?).
Sperm whale	Various	Various	Low current haplotypic diversity, so new haplotypes in historical samples easy to identify.
Northern bottlenose whale	North Atlantic	Nova Scotia?	Samples taken for age determination.

(For reference, populations listed by Clapham and Hatch (2001) as extirpated and unrecovered include: humpback and blue whales off South Georgia, humpback whales off New Zealand, blue whales off Japan, bowhead whales off Spitsbergen, fin whales off Gibraltar and North Atlantic right whales in much of their historic range.)

Appendix 3

INTERSESSIONAL WORKSHOP ON THE TESTING OF SPATIAL STRUCTURE MODELS

Introduction

The Committee has long recognised the importance of understanding population structure if whaling is to be properly managed. Numerous analytical techniques are available that use genetic data to investigate population structure. However, very few of these methods have been tested with respect to their performance in a management context. In light of the critical role of population structure in *Implementations* of the RMP, the Stock Definition Working Group formed the Testing of Spatial Structure Models (TOSSM) Working Group and asked it to assess the performance of different models that use genetic data to infer population structure.

This simulation exercise, which will be an iterative process over several years, will follow the general approach used in devising both the RMP and AWMP, of developing simulated datasets to developers, and of evaluating the performance of different methods when applied to those datasets. The purpose of the proposed workshop is to bring together experts in whale behaviour and biology, genetic analysis, and simulation-based performance testing, to design the overall testing framework. This includes choosing appropriate whale archetypes, realistic sampling schemes, different spatial whaling strategies, a worthwhile set of methods to test, and a range of performance criteria. The simulations will not be based on the details of any current or proposed IWC management situation; however, it is important to capture enough important factors to ensure the relevance of results. One of the tasks of the workshop will be to decide how to strike an appropriate balance here.

Terms of Reference

The Scientific Committee will host a workshop focused on designing simulation-based performance tests for evaluating methods used to infer population structure from genetic data. The goals of the workshop will be as follows.

- (1) Outline a set of simulations that capture the types of population structure likely to be encountered in migratory baleen whales.
- (2) Outline a set of realistic sampling schemes that reflect the types and sizes of samples likely to be available for migratory baleen whale species (e.g. sampling on feeding grounds, breeding grounds, migratory routes, or some combinations).
- (3) Design performance measures that reflect the likely performance of the analytical methods with respect to management under both the RMP and the AWMP¹.
- (4) Specify format of simulated datasets to be made available to developers.

Draft Agenda

1. Opening remarks
2. Election of Chair and appointment of rapporteurs
3. Review of documents

¹ The Committee recognises that it is unlikely that a final set of structure models, sampling schemes or performance measures can be specified during the workshop. Rather, it is anticipated that sufficient progress will be made to allow running of an initial set of performance trials, the results of which can be reviewed at the next annual meeting. At that point, any modifications suggested by the initial results can be made to the specifications set out during the workshop.

4. General review of whale biology and data on population structure
5. General review of whaling operational types
6. General review of IWC baleen whale management schemes (RMP and AWMP)
7. Discussion of which population structure archetypes to include
8. Review analytical methods of investigating population structure
9. Design of simulation models
 - 9.1 Scope of simulation models (e.g. nuclear DNA; mtDNA; other data such as pollution)
 - 9.2 How to capture the biology
 - 9.3 How to capture the relevant aspects of management
 - 9.4 How to simulate the collection of data
 - 9.5 Performance measures
 - 9.6 Format for datasets to distribute
10. Timeline for further work
11. Adoption of report

Items 1-6 are helpful in structuring the discussion and the report, but it is anticipated that they will be dealt with quickly in the meeting itself.

Participants

The steering group will comprise the members of the TOSSM intersessional e-mail group (Bravington, Goto, Kanda, Martien, Olson, Skaug, Taylor, Zerbini), plus Donovan. There was no time to select a convenor while in

Shimonoseki, therefore Bravington agreed to act as temporary convenor. Invitees will include IWC and non-IWC scientists with expertise in this area; an initial list of possible invitees names was developed in Shimonoseki. It is anticipated that attendance will not exceed 15.

Timing and location

The workshop will require four days and should take place sometime between September and November 2002. There would be a considerable saving in travel costs if the workshop runs back-to-back with the North Pacific Minke Whale Implementation Steering Group. Assuming this is possible, the likely venue would be Seattle, USA or perhaps La Jolla, USA.

Budget

Assuming a Seattle or La Jolla venue (for which the US would meet venue costs) and a back-to-back meeting with RMP, total costs are estimated at £16,500 (Table 1). However, the real cost would be somewhat lower because of shared travel for about five participants with the RMP meeting. The US is also willing to contribute a further £8,000, which leaves £7,000 of further funding required.

Breakdown of estimated cost.		
Per diem	15 x 5 x £100	£6,500
Travel	5 from US at \$200	£1,000
	10 from elsewhere at ~£900	£9,000
Total		£16,500

Annex J

Report of the Standing Working Group on Environmental Concerns

Members: DeMaster (Chair), Aguilar, Baldwin, Bando, Berggren, Bjørge, Brownell, Burt, Butterworth, Carlson, Childerhouse, Cipriano, Clark, C., Clark, E., Deimer, Diake, Donahue, Donovan, Ensor, Friday, Fujise, Fulford-Gardiner, Funahashi, Gales, Garrigue, George, Givens, Goodman, Grønvik, Guissamulo, Hakamada, Hatanaka, Haug, Hedley, Iniguez, Ishikawa, Kato, Kawahara, Kell, Kim, Kock, Krahn, Leaper, Lens, Manzanilla Naim, Matsuoka, Mattila, Morishita, Murase, Nagahata, Nagatomo, Nishiwaki, Northridge, O'Hara, Ohizumi, Ohsumi, Okamura, Oosthuizen, Palka, Parsons, Peddemors, Perrin, Pike, Polacheck, Rademeyer, Rambally, Read, Reeves, Reijnders, Rennie, Ridoux, Rogan, Rojas-Bracho, Rose, Rosenbaum, Rowles, Sadler, Sakamoto, Santamaria, Senn, Shimada, Simmonds, M., Sohn, Stachowitsch, Sutaria, Suydam, Swartz, Tamura, Tanaka, Taylor, Thiele, Tregenza, Tynan, Urban-Ramirez, Van Waerebeek, Víkingsson, Wade, Wakako, Walløe, Weinrich, Williams, Wilson, Yamamura, Yasunaga, Yoshida, Zeh, Zenitani, Zerbini.

1. CONVENOR'S OPENING REMARKS

DeMaster directed members of the Standing Working Group (SWG) on Environmental Concerns to the remarks of the Scientific Committee (SC) Chair regarding Commission directives and mandates from their last meeting. The following resolutions are particularly relevant to the workings of the SWG.

(1) *IWC Resolution 2001-4 on the Incidental Capture of Cetaceans* (IWC, 2002a) commended the work of the SC on the estimation of bycatch and other human-induced mortality and asked that it continue. This resolution also requested the SC to provide to the Commission at its 2002 meeting 'a summary of its work in recent years on the most feasible methods to mitigate the incidental capture of large cetaceans in fishing gear, and ways in which entangled large cetaceans may be removed from fishing gear with minimal risk to rescuers'.

(2) *IWC Resolution 2001-7 on Southern Hemisphere Minke Whales and Special Permit Whaling* (IWC, 2002b) endorsed the SC proposal to proceed with the review of Southern Hemisphere minke abundance and to present revised abundance and trend estimates at the 2003 meeting for the full three circumpolar sets of IDCR/SOWER surveys. However, it asked the SC to provide the 2002 Commission meeting with '(i) a list of plausible hypotheses that may explain this apparent population decline', and '(ii) the possible implications that such a decline in abundance may have for the management of minke whales in the Southern Hemisphere, and for ecologically-related species, in

particular other cetaceans, and the state of the Antarctic marine ecosystem'.

(3) *IWC Resolution 2001-9 on Interactions Between Whales and Fish Stocks* (IWC, 2002c) welcomed the plan to conduct a methodological/modelling workshop before the 2002 annual meetings to begin the examination of interactions between whales and fish stocks, and endorsed the recommendations regarding this workshop. The resolution also asked that FAO, regional fisheries management organisations, international research organisations and other appropriate organisations be asked to cooperate in the organisation and conduct of the workshop. Northridge, Chair of the Steering Group for the workshop, will contact FAO and ask if they can also advise on regional fisheries bodies.

DeMaster noted that, after last year's meeting, sub-committee Chairs had agreed that the workload of members was unacceptably high. The Chairs had therefore agreed to develop agendas for their sub-committees to limit the total number of sessions during the week. As was done last year, the SWG will concentrate its efforts on addressing agenda items raised by the Commission or agreed to by the SC. Other topics (and papers) will only be discussed if time allows. DeMaster asked the members of the SWG to limit the submission of SC documents to topics on the agenda in the future.

2. ELECTION OF CHAIR, APPOINTMENT OF RAPPORTEURS

DeMaster was elected Chair. Donahue and Thiele agreed to act as rapporteurs.

3. REVIEW OF AVAILABLE DOCUMENTS

Documents relevant to the Standing Working Group (SWG) included: SC/54/E1-14; SC/54/O3, 17, 22; SC/54/BC2, 6; SC/54/IA2, 6, 7; SC/54/SM5; SC/54/BRG14; SC/54/WW2; Bain (2002); Iceland (2002); Morton and Symonds (2002); Williams *et al.* (2002).

4. ADOPTION OF AGENDA

The adopted agenda is given as Appendix 1.

5. COOPERATIVE RESEARCH IN THE ANTARCTIC

5.1 Results from the SOWER 2000 Cruise

SC/54/IA7 presented a summary of circumpolar and regional trends in Antarctic climate. Two important questions raised in the paper concerned the IDCR survey

methodology relative to sea-ice. A more detailed description is reported in Annex G (Item 6.3.3.1). Minke whales may have moved into the pack ice and been 'missed' by the open-water IDCR surveys conducted later in the season. Information concerning this hypothesis is responsive to IWC Resolution 2001-7. Tynan noted that because trends in Antarctic sea-ice are highly regionally specific, the response of minke whales is also likely very regionally specific (Jacobs and Comiso, 1993; 1997). Decadal-scale trends in Antarctic climate show regional differences in sign, magnitude and rate of change. For example, temperature in the Antarctic Peninsula region has increased by $> 2.5^{\circ}\text{C}$ over the past 55 years, coincident with the retreat of the ice shelves. Trends of warming and loss of ice are greatest in the Bellingshausen Sea, Amundsen Sea and part of the Ross Sea. Climate change in the Antarctic has strong global connectivity on scales of seasons, years and decades to which minke whales may be responding. Important linkages between Antarctic climate (e.g. sea-ice extent and cover) and non-polar (extrapolar) climate are documented for several oscillations: the Semi-Annual Oscillation (SAO), the Southern Oscillation (SO) and the El Niño-Southern Oscillation (ENSO).

In discussion of the paper, Tynan noted that the complexities and connectivity of these oscillations are a basis for discussion of the environmental factors that may relate to changes in minke whale abundance, demography and ecology. Until such relationships between minke whale abundance and changes in ice can be quantified, a precautionary approach to Antarctic resource management is advised. Given that it has been six years since the last IWC-sponsored Workshop on Climate Change and Cetaceans (IWC, 1997) was held, Tynan further noted the need for an update on climate change issues related to cetacean ecology.

Japanese scientists stated that the past IDCR/SOWER cruise reports indicated that SSTs in Area I are relatively higher than in other areas but do not provide any evidence to support a decrease in abundance of minke whales. It was also stated that caution is necessary when considering the relationship between changes in the environment and cetacean abundance because the time series of sea-ice concentrations within the pack ice region for all Areas for the past 20 years do not confirm a long-term trend in changes in ice formation, except for Area I (Shimada *et al.*, 2001). It is necessary to distinguish the scale of events (ENSO vs more regional events such as change in ice formation) when trying to explain environmental impacts on marine living resources.

In discussion, it was suggested that sea-ice modellers might make a valuable contribution to the work of the SWG, specifically regarding the integration of climate data and information on the mechanisms mostly linked to sea-ice extent and concentration. Although a mechanism for such a contribution was not readily identified, it was generally agreed that this and other topics addressed by the SWG could benefit from the expertise of climate researchers. It was also recognised that investigations of climate change on top-level predators necessarily need to be conducted in cooperation with GLOBEC and CCAMLR.

5.2 Collaboration with SO-GLOBEC

Thiele summarised the second annual report on IWC collaborative research in the SO-GLOBEC Western Antarctic Peninsula study area. In 2001, a multi-year series of collaborative research cruises began. The US

SO-GLOBEC cruises are multidisciplinary and comprise standard mooring cruises, line transect surveys over a constant grid and process studies at selected locations, all within the Western Antarctic Peninsula study region around Marguerite Bay. A preliminary report on the first three cruises in this series was provided last year (Thiele *et al.*, 2001). SC/54/E12 presented preliminary results from the IWC collaborative studies conducted on the 2001 winter survey and the 2002 late summer mooring cruise, and provided a summary of research and preliminary results for the cetacean visual, biopsy and sonobuoy studies conducted on the two cruises since the last report. Results from the ARP (acoustic recording package) year-long deployments are reported in SC/54/O3.

The full colour version of SC/54/E12 and reports of all the IWC/SO-GLOBEC collaborative cruises can be found at: http://www.ccpo.odu.edu:80/Research/globec/iwc_collab/menu.html.

The *Nathaniel B Palmer* (NBP) (US SO-GLOBEC) survey cruise was conducted from 23 July to 1 September 2001 and the *Laurence M Gould* (LMG) mooring cruise was repeated in February 2002. Sea-ice cover was significantly more extensive earlier in the season in 2002. Only minke whales were observed in the study region in winter 2001, although humpback concentrations were seen as late as the end of May. Concentrations of humpbacks were seen in Marguerite Bay and east of Adelaide Island up until late May in 2001; and at the ice-edge in southern Marguerite Bay and the passages to the north in February 2002. Although geographic locations of concentrations of humpbacks are different between years, habitat remained consistent. Baleen whale calls detected on sonobuoys included blue, minke and possible fin whales. Autumn and winter multidisciplinary research cruises conducted last year under this programme will be repeated this year, and will include both passive acoustic and IWC visual/biopsy teams. Currently there are IWC visual, biopsy and collaborating sonobuoy teams on the US SO-GLOBEC LMG and NBP cruises (April–May 2002).

Since the Scientific Committee meeting last year, presentations of the data at different stages of analysis have been made: CCAMLR SC meeting in Hobart, Australia (October 2001); Biennial Meeting of the Society for Marine Mammalogy in Vancouver, Canada (November 2001); US SO-GLOBEC Planning Meeting in Washington, USA (December 2001); and Ocean Science Meeting in Honolulu (February 2002).

In September/October 2002 a small workshop will take place in the USA to assist with data integration analyses prior to the second International GLOBEC Open Science Meeting in China in October. Final submissions for a special issue of *Deep Sea Research* are due in November. Proposals from the group will be submitted to the NSF for funding under the synthesis and analysis phase of US SO-GLOBEC (2002/2004).

Thiele also summarised future plans for collaborative work by SO-GLOBEC, CCAMLR and IWC under the Antarctic Programme (Appendix 2). Beyond 2002/2003, one dedicated multidisciplinary survey per season for 5-10 years consisting of visual survey, biopsy sampling and fine-scale ecological studies, including passive acoustics work, is planned. It was suggested that a contribution of £25,000 per year for the next 5-10 years would be a minimum amount of support to continue IWC partnership in this programme. It was suggested that the Ecosystem Working Group of CCAMLR be approached in regards to further collaborative support of the GLOBEC cruises and

analysis of data previously collected by CCAMLR in the parts of the GLOBEC study region held in the CCAMLR database.

Finally, after some discussion regarding the need for the development of a standardised data collection protocol for sea-ice observations, the SWG created an *ad hoc* working group, chaired by Thiele (see Annex S). The group was asked to report back to the SWG next year concerning progress related to the process described in Appendix 3.

6. STEERING GROUP REPORT ON POLLUTION 2000+

Reijnders presented a progress report by the Steering Group of the IWC-sponsored research programme POLLUTION 2000+ (Appendix 4).

Activities conducted under the bottlenose dolphin sub-project included: (1) analyses of samples collected in Sarasota Bay, Florida; and (2) comparison of PCB concentrations in blubber samples from the three study sites (the Bahamas Islands and Charlotte Harbor, Florida, representing sites with 'low' pollution, and Sarasota Bay, a site with 'moderate' pollution). The sub-project also included a feasibility study to collect biopsy samples from the Mediterranean, where dolphins are likely to carry high levels of polychlorinated biphenyls (PCBs).

The second sub-project of the POLLUTION 2000+ programme involves the calibration of post-mortem time effect on changes of biomarkers and pollutants in harbour porpoise. This analysis will enable the utilisation of bycaught animals throughout the North Atlantic. In the summer of 2001, samples were collected in the Bay of Fundy for this purpose. Most of the samples were collected using the detailed field protocol previously designed and Reijnders noted that the successful collection of these critical samples was very much owed to Read and his colleagues.

From the funds provided by the IWC for POLLUTION 2000+, approximately £800 remains. In addition to funds provided by the IWC, substantial 'in-kind' funding has been received from several cooperating institutions (over £200,000), demonstrating strong endorsement of this IWC-initiative.

In addition to completion of analyses currently in progress, the 2002-2003 work plan for POLLUTION 2000+ will include an intersessional meeting to synthesise results among the laboratories involved, and an intersessional meeting of the Steering Group to finalise Phase 1 of this programme and to determine activities to be conducted under Phase II. Within this work plan, the highest priority projects are the collection of samples and PCB analyses, under the bottlenose dolphin sub-project, and completion of the harbour porpoise post-mortem calibration project. The budget to complete the entire 2002-2003 work plan will require £140,500, of which the majority will be sought through external direct or 'in-kind' funding. To complete the highest priority projects mentioned above, a request for £54,410 from the IWC was proposed.

The discussion of this report noted that the activities of Phase 1, primarily a data collection and validation/calibration stage, were successful in terms of the original goals of the programme. The synthesis of the analyses of these data and many more associated data will result in a comprehensive report on Phase 1 of POLLUTION 2000+ and multiple publications. To date, an enormous wealth of data has been accumulated and several findings of biological significance are emerging (e.g. changes in lipid content with age, and a negative correlation between testosterone and

PCB levels). The post-mortem calibration studies on harbour porpoises will be of enormous value with regards to the many harbour porpoise samples collected from stranded animals.

Several in the group expressed their appreciation for the enormous amount of work completed to date and recognised the importance of completing the analysis phase if the meaningfulness of Phase 1 is to be realised. A significant amount of development time has been invested in POLLUTION 2000+ and the programme has received continued endorsement from the Commission. It was also noted that the proposed budget to be provided by the IWC is substantially reduced, with the majority of funding being sought externally.

It was noted that in addition to reports from POLLUTION 2000+, the SWG welcomes at its next meeting other studies related to contaminant levels and health effects in large whales.

The Government of Japan expressed concern that this project is not consistent with the objectives of the IWC since the species dealt with by the current POLLUTION 2000+ are limited to small cetaceans.

7. HABITAT RELATED ISSUES

7.1 State of Cetacean Environment Report (SOCER)

The Commission had expressed its support for a comprehensive update on environmental events impacting cetaceans (IWC, 2001a). Despite the difficulties experienced in obtaining submissions and compiling the initial SOCER at last year's meeting, the Commission considered it an important contribution from the SWG, and reiterated support for its development in future.

During the intersessional period, a Steering Group from the SWG was charged with making recommendations for the development of a mechanism for the compilation, review process, style, structure and frequency of this type of report. The group had considered a wide range of proposals for the future style and content of SOCER, and these were presented and discussed within the SWG. The proposal recommended by the Steering Group involved taking a regional approach for each annual report (i.e. the six regions used in the original form of SOCER (Mediterranean and Black Seas, Indian, Pacific, Arctic, Southern and Atlantic Oceans) along with a seventh 'global' category). Each region would be covered on a rolling basis every 3-5 years, with scope for the inclusion of significant events on a global scale, or repeat events from particular regions to be updated on an annual basis. This would ensure the timely receipt of recent significant 'events' from any region, and those occurring on a global scale, for the consideration of the Commission.

The Steering Group developed a clear set of criteria identifying an appropriate scale and scope for material for SOCER, and a submission procedure that is easy to follow. The aim of implementing a clear process is to encourage submissions to SOCER from a wide range of sources, including member governments, individual scientists and a range of agencies and organisations. In the process of developing an improved SOCER process, a new form for submission of event information was developed (Appendix 5). Invitations to make submissions to the SOCER need to cover a broad scale of sources, and the SWG agreed that a covering letter be developed to facilitate this.

The SWG will aim to produce a SOCER for the meeting in 2003. However, the SC and the Commission should view this as a preliminary attempt at a form of the report that will be developed over the years into an objective product and an

easily followed submission process. Productive comments and suggestions on the first regional SOCER will be welcomed and incorporated wherever possible. The SWG regretted that it could not provide a SOCER this year and sought endorsement from the SC for its proposal for the future of SOCER.

Some members of the SWG recommended that the SOCER should be: (1) consistent with the competence of the IWC; (2) conducted in an objective manner; (3) cost-effective; and (4) reviewed by the SWG before sending to the SC for finalisation. It was further recommended that the usefulness of the SOCER and the efficiency of how the SOCER was prepared be evaluated by the SWG. After some discussion, the SWG accepted all of these recommendations.

7.2 Steering group report on workshop on habitat degradation

During the intersessional period the first meeting of the parties to ACCOBAMS (the Agreement for the Conservation of Cetaceans of the Black and Mediterranean Seas) occurred. At that meeting ACCOBAMS recognised the importance of developing work on habitat degradation in their region. The Meeting of Parties had established a list of priorities for the next three years and this included the Habitat Degradation Workshop proposed by the IWC. The issue of funding for the IWC workshop had not been resolved, but there is still considerable interest, and it is hoped that funding from outside sources might be found to at least contribute towards the meeting. It was noted that intersessional work relating to this workshop has continued (e.g. SC/54/E10).

It was noted by members of the SWG that this workshop had been proposed and given priority in the budget for some years now. It was agreed that the workshop was still a high priority for the SWG, although it appears unlikely that funds can be allocated this year, it is hoped that this proposal will receive very high priority for funding next year. The SWG concluded that the proposal concerning the habitat degradation workshop (Simmonds *et al.*, 2002) was still relevant to the SC.

SC/54/E5 described results from a study indicating that in areas where cetaceans are still harvested locally and there are public retail outlets, tissue samples are readily available for appraisals of contaminant burdens in cetaceans. Results of 17 samples of cetacean tissue from coastal waters in Japan were presented illustrating this method, which indicated that the level of contamination detected may be of concern regarding cetacean health. Sex and species identification were carried out by genetic analyses.

SC/54/E10 was presented as an implementation of the framework for assessment of habitat degradation advanced by the workshop in IWC (2001b). It was suggested that environmental trends could be integrated into a population model to assess degradation effects. A wide spectrum of potential trends in environmental impacts on southern resident killer whales was reviewed. Possible scenarios of reduced survival and fecundity were explored in simulations with the VORTEX population viability model package. It was argued that demographic stochasticity and climate-driven oscillations in prey abundance were insufficient to explain recent declines in survival and fecundity. The southern resident killer whales were recommended as a good model for implementation of the framework owing to the excellent record of life history data, their confined coastal habitat, their well-studied major prey species and the possibility for comparisons with other

populations that experience different habitat conditions. Projections of recent declines into the future predicted high probabilities of extinction in the short term.

SC/54/E11 presented an example of a modelling approach that incorporates environmental variables, particularly habitat. The Bering-Chukchi-Beaufort (BCB) stock of bowhead whales was used in this example. The BCB stock contrasts sharply with the case reported in SC/54/E10 in that habitat conditions are relatively undisturbed, but could change drastically with the onset of global warming, with consequent reductions in the amount of their preferred sea-ice habitat and increased shipping, oil development and changes in other factors. Population simulations predicted significant population declines, under the assumption that a combination of environmental factors would lead to reductions in calf and juvenile survival (e.g. episodic mortality due to oil spills). It was noted that the exercise was largely heuristic in value, but showed the worth of an integrative approach bringing together diverse sources of data and evidence. More specific data and better incorporation of uncertainty are necessary to make the predictions of such models of specific value to the management of cetaceans.

During discussion of SC/54/E10 and SC/54/E11 it was noted that these models are preliminary, and were reported here as possible approaches, which may, in time, be capable of integrating all of the data available on species and their environments. Analyses presented here have not integrated all of the possible environmental variables. Further, uncertainty associated with relationships among demographic parameters and environmental variables cannot be quantified at this time. It was recognised that the coefficients of variation (CV) associated with various demographic parameters in the model were underestimated. Further, incorporation of cumulative stochastic events would result in even higher CVs of demographic parameters in these analyses. Given the importance of incorporating environmental data into population models used in the management of marine resources, the author was encouraged to publish these results in peer reviewed journals.

7.3 Review of information regarding whalewatching activities and noise impacts

A summary of this discussion is reported in Annex L.

7.4 Competition between cetaceans and fisheries

Northridge provided an update on the status of plans for the workshop. Due to a number of changes in the planning process, some only recent, the workshop will now be held in La Jolla, California, USA (25-27 June 2002). The agenda for the meeting is provided in Appendix 6. The meeting has been planned to include an introductory overview on the modelling approaches currently being used to address related issues, followed by a discussion on aspects of data availability and reliability. Specialists have been invited to present their modelling work covering a range of approaches (e.g. food web, mass balance and minimum realistic models). The workshop will determine how best these approaches can be taken forward by the SC. It was also noted that the £10,000 from last year's SC budget is still available for the workshop and, therefore, additional funds were not needed. However, several members of the SC noted that one of the original purposes envisioned by the SC in supporting a venue in St Lucia for this workshop was to encourage the participation of scientists from developing countries. Therefore, the SWG **recommended** that the SC raise this

issue with the Commission this year and consider providing additional funding to support travel of scientists from developing countries to La Jolla.

SC/54/E1 provided an update on the status of the Ecopath/Ecosim model for the Eastern Bering Sea, which is being refined by a group at the National Marine Fisheries Service/Alaska Fisheries Science Center. The model is being calibrated to fit fisheries and food habits data from 1979 to present and is therefore particularly relevant to the planned workshop. A variety of steps is being taken to test and improve the model. Species groupings, which combined a number of similar species, have been modified to provide greater consistency in the diet composition of each grouping. Species of interest with sufficient data are being removed from species groupings and are being modelled as individual species groupings. Predictions from Ecosim simulations are being compared to available trend data for several species and projected diet composition results are being compared to current diet composition data. Sensitivity analyses of parameter values are being conducted, and the effects of environmental forcing are being explored. For Eastern Bering Sea cetaceans, model input data on abundance, biological parameters, distribution, seasonality and diet composition have been reviewed and updated for as many species as possible. Information on the diet composition of eastern Bering Sea cetaceans was used to determine new species groupings in the model. The model will be used to evaluate the effect of events such as the removal of large whales by commercial whaling over the past 50 years and the removal of groundfish by commercial fisheries since the 1970s.

SC/54/E6 provided a review of Norwegian studies of the feeding ecology of northeast Atlantic minke whales during the past decade. The review demonstrated how scientific whaling under special permit and subsequent establishment of a routine sampling scheme during commercial whaling operations have yielded a time series (1992-2001) that permits assessment of spatial, seasonal and year-to-year variations in diets, of foraging behaviour, of prey selectivity and of the total annual consumption by the whales. The collected data have also permitted multi-species modelling exercises with the minke whales involved. The dietary composition of the northeast Atlantic minke whales varies considerably both in space and time, presumably because of geographic differences in the distribution and abundance of potential prey. The whales exploit a multiplicity of species and sizes of fish and crustaceans. In general, they find capelin, herring and, occasionally, krill more preferable than other prey, which may have several contributory explanations such as mobility, schooling behaviour, prey refuge use and other anti-predator responses. Apparently, minke whales switched to other prey in years of low densities of herring and capelin, thereby reducing the mortality on these two fish species. Although results from the multi-species modelling exercises should be taken as tentative, they all point in the same direction, i.e. that minke whale abundance may affect important fisheries. They show that, for the Barents Sea, it is possible to make predictions regarding ecosystem changes, following a specific management manipulation or change in the ecosystem, that are accurate within an order of magnitude of the actual response. The results given demonstrate the usefulness of performing ecological investigations over a range of scales. To assess the large-scale variations on population level, information about the body condition of the whales is also of interest. To put the large-scale results in an ecological perspective, information about population size and structure

is needed plus, of course, large-scale information about the resource base. However, more detailed small-scale studies of prey selection must be supported with resource mapping studies that occur concurrently and synoptically with the sampling of whale diet data. Tamura noted that this was a very useful study in understanding the feeding ecology of cetaceans.

In discussion, Haug noted that they had conducted some studies using both acoustic and net sampling and these were reported in the published literature (see Lindstrøm and Haug, 2001).

SC/54/E13 described the possible impacts on sperm whales of a squid fishery off northern Peru that targets the main prey of these whales, the Humboldt Current squid (*Dosidicus gigas*). Sperm whale sighting records were compared between surveys conducted in the late 1950s and, more recently, in 2001. An apparent reduction in sperm whale numbers is proposed as being directly related to over-exploitation of the squid fishery.

SC/54/O6 on the population status of sperm whales was considered relevant here because sperm whales are such a dominant element in ecosystem models (including Ecosim and Ecopath). The paper highlighted areas where data can be found for models and the need for some abundance information for sperm whales to be reassessed in light of recent information.

SC/54/E7 provided information on a novel DNA-based method for identifying krill species present in the faeces of baleen whales. This method uses polymerase chain reaction (PCR) amplification of short DNA sequences that only occur in krill. The technique has been applied to blue whale faeces collected from two locations, and has successfully identified krill components of the diet down to species level. Based on the success of this group-specific approach, attempts are underway to develop similar techniques for identifying species from other key groups, including myctophidae, clupeiformes, gadiformes, cephalopods and amphipods. Feeding trials using a dolphin model will be conducted to test the efficacy of the techniques. The collection and storage of whale faeces was reported to be a simple exercise, its main limitation being the necessity to directly observe the defecation event. This limitation can largely be overcome through broad collaborations with scientists who routinely spend time working in the vicinity of feeding (and therefore defecating) whales. Collections made via such collaborations have few (if any) implications for permits, and can facilitate the accumulation of large sample sizes across a strategically targeted range of cetacean species, locations and times. The authors believe that continued development of this technique will provide a widely applicable, non-invasive method capable of unambiguously determining the entire assemblage of species represented in cetacean diet. Furthermore, the application of this technique, in conjunction with other diet assessment techniques, will address some of the significant problems associated with biases found in techniques such as stomach content analysis.

There was some discussion about the difficulty of collecting faecal samples from large whales. Some considered the method described in SC/54/E7 practical, while others did not. It was noted that when large whales feed they defecate, and this takes place at or near the surface for physiological reasons. The rate at which an animal is feeding will determine the rate at which it defecates. It was also recognised that there are biases associated with any of the techniques used to investigate the food habits of cetaceans, and that a combination of methodologies was

likely the only way to circumvent biases associated with particular techniques. The comment was made that though the collection of faeces by netting may be considered difficult at present, a similar concern was raised relative to the collection of skin samples from cetaceans by netting, and yet, the latter proved a very effective method.

Appendices 1-4 of SC/54/O17 described the food habit of common minke whales sampled by JARPN II 2000 and 2001 in the western North Pacific. Seven prey species consisting of 5 fishes, 1 squid and 1 euphausiid were identified. There were geographical and seasonal changes of prey species of minke whales. In sub-area 7, spatial segregation was observed between minke and Bryde's whales. Both species feed mainly on Japanese anchovy and krill. However, the size composition of Japanese anchovy consumed by the two whale species was reported to be different. Tamura noted that there was direct interaction between minke whales and fisheries (e.g. Pacific saury from summer to autumn in the western North Pacific). In addition the food habits of Bryde's whales sampled by JARPN II 2000 and 2001 in the western North Pacific were described in appendix 2 of SC/54/O17. Nine prey species consisting of 6 fishes and 3 krill were identified. Monthly differences in prey use by Bryde's whales were reported. Tamura noted that there was some indirect interaction between Bryde's whales and fisheries (i.e. competition for prey species, such as skipjack tuna from summer to autumn in the western North Pacific). Thirdly, the food habits of sperm whales sampled were described in appendix 3 of SC/54/O17. Thirty-three prey species consisting of 29 squid, 1 octopus and 3 fishes were identified. There were geographical and temporal differences in stomach contents of sperm whales. It was estimated that the contribution rate of squid in the surface layer ranged from 0-96%, where the average percentage was 17%. The stomach contents' weight ranged from 9.0-236.7kg. These weights were equivalent to under 1.0% of the body weight of sperm whales. Appendix 4 of SC/54/O17 reported on estimates of the prey consumption of minke whales and Bryde's whales using two methods. One method was calculated from diurnal change in stomach content weight. The other method was calculated from basal metabolism. Estimates of the daily prey consumption rate obtained by the first method were 4.6 and 4.0% of the body weight of minke whales and Bryde's whales, respectively. Estimates of the daily prey consumption rate obtained by the second method ranged from 1.4-8.2% and 3.3-8.2% of the body weight of minke whales and Bryde's whales, respectively. The average estimated total prey consumption weights of minke whales during the feeding period in each sub-area were 22 tons for immature males and females, and 33 tons and 43 tons for mature males and females, respectively. For Bryde's whales, the average estimated total prey consumption weights were 68 tons and 61 tons for immature males and females, respectively, and 101 tons and 115 tons for mature males and females, respectively.

SC/54/O17 (appendix 5) presented a preliminary analysis of prey preference of common minke and Bryde's whales in the western North Pacific using 2000 and 2001 JARPN II feasibility study data. Whale sighting, whale sampling and prey surveys using a quantitative echo sounder and mid-water trawl were carried out concurrently in the study. Biomasses of Japanese anchovy, walleye pollock and krill were estimated. Cheeson's index was used to assess the prey preference of cetaceans. Preliminary results indicated that minke whales prefer to forage on Japanese anchovy, and seem to avoid krill. Preference for pelagic shoaling fish was similar to that in the eastern North Atlantic (see SC/54/E6).

Foraging success is measured by maximisation of energy intake rate and minimisation of time necessary to obtain nutrients. Caloric values of Japanese anchovy, walleye pollock and krill were 6,402, 6,192 and 3,556 kJ/kg, respectively (as described in appendix 4 of SC/54/O17). Japanese anchovy were concentrated shallower than 50m water depth, while walleye pollock and krill were distributed deeper than 100 and 150m, respectively. Considering that the usual foraging depth of minke whales is in the upper 100m, the authors predicted that Japanese anchovy would be the preferred prey species, which would maximise the energy intake with minimum dive time. Bryde's whales were reported to prefer feeding on Japanese anchovy in August 2000, but such a preference could not be detected from May to July in 2001. In the earlier season, Japanese anchovy were less abundant, except for their larva in the area occupied by Bryde's whales. Though results of the prey preference study are preliminary, it suggests that the concurrent whale and prey surveys adopted in the JARPN II feasibility survey could establish whether cetaceans have specific prey preferences. It was also noted that during the feasibility survey, the autumn season when Pacific saury were abundant could not be surveyed. Because Pacific saury are consumed extensively by minke whales, it will be important to conduct whale and prey surveys in September and October to assess whether minke whales prefer to feed on saury. Further, because pelagic fish biomass is known to fluctuate widely, the authors noted the importance of developing an ecosystem model appropriate for the western North Pacific.

In discussion, Tynan commented that the prey preferences of fish species and the changes in prey preference with ontogeny of fish need to be incorporated in modelling efforts. Many fish species are cannibalistic on their eggs and larvae. The removal of older, and larger, fish by whales may lessen intraspecific predation by fish on eggs and juvenile stages, thus promoting survival and recruitment of larval juvenile fish. In addition, predation by whales on fish could affect interspecific predation by fish on eggs and juvenile fish. Predation by whales on zooplankton could lessen grazing pressure on phytoplankton patches upon which larvae of some fish species depend. The complete role of whales in the structure, function and productivity of ecosystems should be incorporated into any modelling efforts of cetacean-fisheries interactions.

Other questions were raised regarding estimates of the whale biomass, prey biomass and whale consumption rates in the western North Pacific, and how these estimates compare with similar estimates for minke whales from the NE Atlantic. Haug and Walløe responded that both Japanese methods of assessment have resulted in higher daily rates of intake than Norwegian studies. In the Norwegian studies the estimated consumption rate was 120kg per day for minke whales. They noted for reference a recent NAMMCO workshop held in September 2001. The details and report of this workshop can be found on the web at: <http://www.nammco.no/news.htm>.

7.5 Mitigation of incidental capture of large cetaceans in fishing gear

This item was discussed in a joint session with the Bycatch Working Group (Item 5.6). It was noted that this agenda item was in response to IWC Resolution 2001-4 (IWC, 2002a).

During the intersessional period a number of scientists with expertise in cetacean bycatch issues attended a meeting (convened by WWF) in Annapolis, Maryland (USA) in January 2002. The objectives of the meeting

were to produce a strategy to eliminate unsustainable bycatches of cetaceans and to ensure over the long term that cetacean populations are restored to, or maintained as, functional components of their ecosystems. The strategy was developed in recognition of bycatch as a major threat to whales, dolphins and porpoises and is summarised in SC/54/BC6. A section of the report deals specifically with the release of entangled whales, but it was noted that the information included in the report would be covered in the discussion of SC/54/BC2. Read noted that a final report will be available in the near future.

SC/54/BC2 provided the report of the intersessional working group on large whale entanglements. The report outlined advice on the handling of large whale entanglements, developed from the experience of personnel involved in long-term disentanglement programmes, particularly from the East Coast of the USA. Examples of entanglement rates for some species of large whale have been calculated for this region (North Atlantic). For instance, 71% of humpbacks and 62% of North Atlantic right whales had been entangled at some stage in their lives, with an annual rate of entanglement of 10-31% for humpbacks and 10-28% for right whales. Appendix 7 contains a summary of information from SC/54/BC2 on disentangling large whales from fishing gear.

There have been few studies to quantitatively measure the survival of disentangled large whales, although some efforts have been made to monitor the survival of stranded cetaceans after release. Although this is only a qualitative measure of the effectiveness of the procedure, it appears that the release may be successful in many instances. The likelihood of a successful release of an animal that has been entangled and stranded for a significant enough period of time to cause internal damage is low (as it is for otherwise healthy animals that have been beachcast for long periods). However, disentangling procedures on entangled southern right whale calves in South Africa, appear to have been successful. In these cases the calves had been entangled for less than 24 hours and their mothers appeared to wait offshore. It was suggested that photographs of the scarring patterns on entangled animals be recorded as a matter of course to assist with the assessment of survival. Small whales, like minke, are more likely to die quickly if entangled in nets, while larger whales can carry off even heavy gear that eventually causes immobilisation, infection and/or death.

Disentanglement programmes exist in a number of regions, including Oman, South Africa, Eastern Canada, Gulf of Maine and the Western Mediterranean. It was clear from the discussion that disentanglement is a very dangerous task, with great potential for serious injury or death of persons involved. It was clear that disentanglement of entangled cetaceans should only be attempted by experienced personnel. It was noted that Dave Mattila's group in the western North Atlantic has extensive experience in disentangling large whales and has held training/advisory workshops in the past.

Reports of disentangling large whales were included in the Progress Report of the Government of Japan. Some members of the SWG requested information on disentanglement strategies. Reference was made to a brochure on disentanglement of large whales, which is only available in Japanese. Some members of the SWG requested that a translated copy be made available to the SWG next year.

Many countries are currently making efforts towards developing effective marine mammal conservation and rescue measures and many member countries and individual scientists are likely to benefit from the information contained in SC/54/BC2 and SC/54/BC6. The SWG agreed that the authors of these reports should ensure widespread distribution of the recommendations to key government agencies.

8. OTHER

8.1 Review of Arctic issues

SC/54/E3 provided a research proposal on biocomplexity in the Arctic submitted under a US National Science Foundation programme called 'Biocomplexity in the Environment'. The proposal promotes comprehensive, integrated investigations of environmental systems. The proposed study seeks to understand how climate variability influences the distribution of bowhead whales and ultimately the continued existence of traditional lifestyles for native communities that hunt marine mammals in Arctic Alaska. It is a multi-faceted and multi-disciplinary study. On the local scale, the results of the research will provide a greater understanding of the factors influencing the dynamics of bowhead whales and the subsistence whaling tradition, which is particularly vulnerable to changes in resource availability in response to both environmental changes and human-generated pressures. On a wider scale, the proposed research will address how multiple physical, biological and anthropogenic factors are linked in a coupled natural-human system that may be critically affected by climate variability. The interactions in this coupled system will be quantified using a combination of retrospective analyses coupled with biological-physical modelling of the atmosphere-ice-ocean system, and the climatic variability therein, and local monitoring of oceanographic conditions to verify model predictions during the study. Two major climate regimes that have been identified in the western Arctic Ocean and are associated with wind driven circulation patterns modulated in part by the Arctic Oscillation (AO) will be modelled. The proposed study will focus on two communities, Barrow and Kaktovik, near where bowhead whales traditionally aggregate and where regular, sustained subsistence harvests are integral to the culture and viability of the communities. To understand the linkages between climate variability, bowhead whale distributions and subsistence whaling, the following set of questions will be addressed in the study.

- (1) What are the oceanographic conditions favourable to the development of zooplankton aggregations in the study areas?
- (2) How does zooplankton species composition differ at each location between the two climate regimes (positive Arctic Oscillation phase versus negative phase)?
- (3) Can bowhead residence time near whaling villages be predicted by the phase of the Arctic Oscillation, resultant oceanographic conditions and concomitant prey availability?
- (4) How does whale distribution impact the success of bowhead whaling and the subsistence economy of the whaling villages?

The study will be conducted in close coordination and consultation with the native communities and will include community outreach and education components. If funded, the programme described in SC/54/E3 would last on the order of 3-5 years.

Thiele summarised the parts of SC/54/O3 relevant to this agenda item. She noted that the National Marine Fisheries Service had undertaken research using autonomous, underwater recording devices that are capable of recording the vocalisations of large whales for periods up to 12 months. To date, instruments have been deployed in the eastern Bering Sea, the northern Gulf of Alaska, and the Southern Ocean in the vicinity of the Antarctic Peninsula. It was also noted that because an array of these instruments is deployed, not only is it possible to gather presence-absence type information for large whale species, but it is also possible to estimate the location of vocalising whales. In waters off Alaska, these instruments have been deployed to address the seasonal distribution of the North Pacific right whale.

During discussion, it was noted that the cost for each unit is several thousand pounds, the recorders have to be retrieved to obtain the data and there are plans to make them record at higher frequencies (currently they record up to 500 Hertz), which would be more appropriate for medium to small sized cetaceans.

8.2 Preparation for review of Arctic research next year

After some discussion, it was **recommended** that a mini-symposium (i.e. 2-3 sessions) on the high-latitude climate change research and the effects of such changes on cetacean populations should be recommended to the SC as a primary focus of the SWG next year. An intersessional Steering Group, chaired by Thiele, was established to organise the mini-symposium (see Annex S).

8.3 Procedures for contaminant data submission

IWC Resolution 1999-4 expressed concern about human health effects related to the consumption of cetacean products (IWC, 2000). Considerable uncertainty exists about how the World Health Organisation (WHO) would like concentrations of contaminants in cetaceans reported, because WHO has high standards for submissions to its Global Environment Monitoring System (GEMS). There is a new manual that provides details of the requirements for data to be submitted to the WHO/GEMS. Krahn briefly reviewed the information presented in this manual and summarised the steps necessary for data submission (SC/54/E2). Although data could be formatted manually, it would be more efficient for laboratories to automate the procedures if large quantities of data need to be submitted. Thus, if the IWC would like to have cetacean contaminant data submitted on a large-scale or regular basis to the WHO/GEMS database, Krahn recommended that the IWC provide funds for creation of a spreadsheet or database to automatically convert chemical contaminant data for cetaceans into a format that would be acceptable to WHO.

The SWG expressed its appreciation to Krahn for the considerable time spent collating and simplifying a very complex submission process.

8.4 Other

SC/54/E4 considered the current status of the ozone layer and the success of the 'Montreal Protocol on Substances that Deplete the Ozone Layer'. It was noted that there was a general trend of decreasing Antarctic ozone levels since the early 1980s, with the largest ever 'ozone hole' (28.4 million km²) occurring in the 2000/01 season. The 'ozone hole' in the 2001/02 season was greater than 25 million km². Despite the success of the Montreal Protocol in curbing the worldwide consumption and production of ozone depleting substances, the ozone layer remains extremely vulnerable

and some considerable challenges remain to be resolved. Antarctic ozone depletion is predicted to increase over the next 5-20 years and level off in the first half of this century. Following this, recovery is expected to take several more decades. Arctic ozone depletion is predicted to become more severe in the near future, with the possibility of an ozone hole occurring within 20 years or so of similar magnitude to the hole that currently develops annually over the Antarctic. Recovery might be significantly delayed by other factors such as a predicted increase in atmospheric nitrous oxide, volcanic activity and interactions with climate change and other stratospheric meteorological phenomena. Recovery predictions generally assume full compliance with the Montreal Protocol, which the author suggested was not a realistic scenario. SC/54/E4 concluded that it was a matter of great concern that cetaceans would be exposed to both direct and indirect effects of increased exposure to ultraviolet radiation corresponding to current predictions of ozone depletion. A member of the group questioned if there were indications that skin pathologies are becoming more evident in stranded cetaceans. The author noted there were a few observations of pox marks in southern right whales that had been reported previously to the SWG and that these were thought to be related to ultraviolet exposure and changing levels of ozone, but only through inference.

SC/54/E9 presented a study on the distribution of retinoids (Vitamin A) in tissues of the common dolphin. In mammals, retinoids are essential for many physiological functions, for example, the immune system, growth and reproduction. Some pollutants, PCBs in particular, are known to induce depletion of body retinoid levels and, consequently, to have an adverse impact on populations. Because of this, retinoids have been selected as target biomarkers in the IWC's POLLUTION 2000+ programme. However, baseline studies are needed to understand the patterns of retinoid distribution in the body of cetaceans in order to design sampling protocols. Results of the study show that blubber is a main site for retinoid storage. In terms of quantity, this location was found to be even more significant than the liver for retinoid storage. Biopsy samples of blubber can therefore be used to monitor the retinoid status of free-ranging individuals. Because some anterior-to-posterior and dorsal-to-ventral variability in retinoid concentrations has been observed, it is recommended that sampling be standardised with respect to body location as much as possible.

In the discussion of this paper, three issues were raised. The first issue concerned the possibility of sample treatment prior to analysis affecting measured retinoid concentrations. Aguilar responded that although vitamin A is a critical constituent of the skin's outer layer, it does not reach very high levels in the epidermis. Rather, this constituent is more abundant in the layer under the epidermis, which is very rich in fat. Thus, analysis of retinoid concentrations in blubber samples is not likely to be confounded by the presence of epidermis in the samples. The second issue argued for the necessity for verification that retinoid concentrations detected in blubber are correlated with concentrations in target organs and accurately reflect retinal status of the animal. Aguilar explained that the described study did not address this more complicated issue but that future work will examine the correlations between retinoid levels in serum, organs and blubber, the latter being a significant place for retinol deposition in the body. The final issue raised emphasised the importance of studying the relationship between retinoid concentration in blubber and thyroid disorders. Aguilar noted that he did not know of any such

studies relating retinoid concentrations in the blubber and thyroid disorders, although he commented that there are many studies in the literature indicating that low levels of retinol are associated with skin, reproduction, growth, and immune disorders and certainly has the capacity to influence other functions.

Morton and Symonds (2002) was briefly summarised. It was considered more fully in the sub-committee on Whalewatching (Annex L). A long-term study was conducted in two areas of British Columbia, Canada, to determine the effects on killer whales of acoustic harassment devices (AHDs) used by fish farming operations in one of the study areas to deter predation on fish pens by harbour seals. The area where AHDs were employed showed a significant decline in killer whale occurrence, while other parts of the study area, not impacted by AHDs, did not. Killer whale occurrence returned to original levels when the use of AHDs was discontinued. The study concluded that noise from the AHDs caused the displacement of killer whales in this area.

Results from a portion of the JARPN feasibility studies were also discussed (SC/54/O17, appendices 13-15). As part of a comprehensive monitoring system of pollutants in the marine ecosystem, SC/54/O17 appendix 13 described preliminary results on accumulation and temporal trends of trace elements, such as Mn, Fe, Cu, Zn, Se, Cd, Pb and Hg (total and organic form), in minke whales collected from the western North Pacific during JARPN and JARPN II surveys between 1994 and 2000. The relationship between trace element concentrations and biological data, such as sex, body length and age, were examined in addition to the temporal trends in these concentrations. SC/54/O17 appendix 14 described the preliminary results of measurements of persistent organochlorines in the air and the sea surface waters in the western North Pacific during the JARPN II survey that are being monitored to determine global transport of these substances. Persistent organochlorine levels (PCBs, DDTs, HCHs, HCBs and CHLs) were monitored in western North Pacific minke whales during the JARPN survey. The objective of the study described in SC/54/O17 appendix 15 sought to address a SWG request made during the 2000 meeting to compare the concentrations of trace elements in skin tissue with those found in liver, kidney and muscle tissues. Concentrations of Mn, Cu, Zn, Se, Cd, Pb and Hg (total and organic form) were determined in the liver, kidney, muscle and skin of 15 minke whales taken in the western North Pacific during JARPN surveys in 1995-1999. There was a significant correlation between levels of toxic elements and iron in some organs and skin. No such correlation of essential elements between these organs and skin was found. Results pertaining to toxic elements in the liver were consistent with those from Antarctic minke whales; however, regarding essential elements there was no consistency between concentrations in the skin and internal organs. The authors recommended that the use of biopsy methods to monitor for trace elements in cetaceans needed further examination.

In the discussion of these appendices, it was asked if it was known why concentrations of mercury between some organs and skin were correlated in minke whales from the western North Pacific but not in Antarctic minke whales. It was noted that investigation of this result was still being explored. One factor that is being examined further is the potential effect of prey types consumed by minke whales in these two areas. Also being considered is the possibility that the relatively low concentrations found in Antarctic minke whales may preclude the detection of such a correlation. It was suggested

that information be presented on DDT derivatives (i.e. DDE and DDD) and PCB congeners. Also, this information was considered to be relevant in assessing the effect of contaminants on the health of stocks because PCB congeners vary in their toxicity. In response, it was indicated that some information on congener-specific concentrations was available and would be provided at the next meeting of the SC.

In response to a question from Fujise about the scope of POLLUTION 2000+, M. Simmonds noted that in discussions of the Working Group considering the JARPN II proposal, the relationship of the proposed pollution work to the POLLUTION 2000+ research programme arose. He noted that it had always been his understanding that the POLLUTION 2000+ project was carefully developed over a number of years and was based on a number of cetacean species, which existed along a gradient of pollution levels and where suitable samples and data were available, such that progress could be made within a reasonable amount of time. He added that the suggestion that the JARPN II programme might compensate for the lack of direct data collected for baleen whales under POLLUTION 2000+ to date was not appropriate because the POLLUTION 2000+ programme was already aimed at developing results applicable to all cetaceans. Some members of the SWG did not agree with this position, and considered the results on contaminant levels from JARPN II important in regards to the effect of pollution on the management of large whales. In addition it was noted that the POLLUTION 2000+ programme currently does not include any direct study involving any large whale species.

Peddemors presented a report on the recent categorisation of South African cetaceans according to the 2001 IUCN Red List Criteria (SC/54/O22). Under these recent IUCN criteria, environmental factors influenced many categorisations, and several cetaceans were classified as vulnerable because of environmental factors.

Rojas-Bracho presented information on a potential major tourist development ('Nautical Steps') being proposed in Baja California, Mexico. The proposed development would involve more than 4,000km of coastline and would include a system of new marinas along the entire coastline of the Baja California Peninsula and the coasts of Sonora and Sinaloa in mainland Mexico. Both the Pacific coast of Baja California and the Sea of Cortes are considered important breeding and feeding grounds for many species of marine mammals. Many baleen whales occur in these waters, including fin, sei, Bryde's minke, humpback, gray, right and blue. A distinct resident population of fin whales is found in these waters, which are also one of the two known breeding grounds for North Pacific blue whales. Potential impacts of the 'Nautical Steps' development should be carefully considered and possible threats to cetaceans and other marine life in the area should be identified and minimised. One author specifically noted the potential for major physiographic disturbance during construction and maintenance of this development, especially with respect to numerous proposed marinas, whose exact locations and configurations have not been identified yet. Additional information on the 'Nautical Steps' development is reported in Appendix 8.

The SWG **recommended** that the Commission request information from the Government of Mexico on the specific locations and types of construction that comprise this development project. Further, the SWG **recommended** that the Commission request the Government of Mexico to take steps to ensure the maintenance of this important cetacean habitat.

SC/54/BRG14 reported observations of western North Pacific gray whales on their feeding grounds in relation to seismic exploration. This paper was addressed primarily in the BRG sub-committee, and specific recommendations resulting from their discussions can be found in the report of that group.

Regarding the seismic exploration referred to in SC/54/BRG14, the authors were asked whether they had measurements of the noise caused by the seismic exploration. It was reported that data concerning these seismic activities were being collected but remain confidential property of the company conducting the activities. The SWG agreed that when considering the potential adverse effects to cetacean populations from exposure to seismic exploration activities associated with oil and gas development, it would be useful to exchange information on the specific biological concerns for cetaceans with the oil and gas industry operating in a given area. Therefore, the SWG **recommended** that scientific experts on the western North Pacific stock of gray whale and oil and gas industry experts regarding operations off Sakhalin Island hold one or more workshops to identify specific potential risks to this population from oil and gas exploration activities and to identify potential alternative methodologies to mitigate any potentially harmful effects.

SC/54/SM5, presented in the sub-committee on Small Cetaceans, also contained information relevant to the work on habitat degradation by this SWG and is noted here as a cross-reference.

9. WORK PLAN FOR SC/55

The following intersessional groups were agreed.

- (1) SOCER: Rose and Stachowitsch
- (2) Whale-Fish Interactions: Northridge
- (3) CCAMLR/SO-GLOBEC: Thiele
- (4) POLLUTION 2000+: Reijnders
- (5) Arctic Issues: Moore
- (6) Habitat Degradation Workshop: M. Simmonds
- (7) Mini-Symposium on High Latitude Climate Change Effects: Thiele

The SWG outlined the main items for consideration at next year's meeting. The following work plan for SC/55 was agreed.

- (1) Report from Whale-Fish Interactions Workshop (priority: major topic with 2-3 sessions).
- (2) High latitude climate change mini-symposium (priority: major topic with 2-3 sessions).
- (3) Review progress on the State of the Cetacean Environment Report (SOCER) (priority: minor topic with less than 1 session).
- (4) Review results from Workshop on Habitat Degradation (priority: minor topic with less than 1 session).
- (5) SO-GLOBEC/CCAMLR update (priority: minor topic with less than 1 session).
- (6) POLLUTION 2000+ update (priority: minor topic with less than 1 session).
- (7) Arctic issues (priority: minor topic with less than 1 session).
- (8) Other (e.g. preparation for workshop on the effects of noise on cetaceans).

The SWG agreed the following budget request:

Table 1
SWG budget request.

Title	Funds required (£)	Justification
POLLUTION 2000+	54,410	(see SC/54/E14)
SO-GLOBEC	25,000	(see Appendix 9)
Habitat Degradation Workshop	15,500	(see Simmonds <i>et al.</i> , 2002).
Preparation of SOCER	3,000	2 months salary, copying charges, phone costs

M. Simmonds commented that, as was the case last year, he and other members of the SWG were hopeful that they would be able to secure an additional £15,500 for the Habitat Degradation Workshop from sources outside of the IWC.

The Chair of the SWG was asked to note for the record the reservation of the SC delegates from the Government of Japan regarding budgets for some of the programmes supported by this working group that are not related to the purpose of the IWC, including SO-GLOBEC, POLLUTION 2000+, the Habitat Degradation Workshop, and the preparation of the SOCER.

10. ADOPTION OF REPORT

The report was approved on 5 May 2002 at 17:15. The SWG thanked DeMaster, Thiele and Donahue for all of their effort in running the meetings of the SWG and preparing the report.

REFERENCES

- Bain, D.E. 2002. A model linking energetic effects of whale watching to killer whale (*Orcinus orca*) population dynamics. *Mar. Mammal Sci.* :Submitted.
- Iceland. 2002. Reykjavik declaration on responsible fisheries in the marine ecosystem. [Available from: <http://www.refisheries2001.org>].
- International Whaling Commission. 1997. Report of the IWC Workshop on Climate Change and Cetaceans. *Rep. int. Whal. Commn* 47:293-319.
- International Whaling Commission. 2000. Chairman's Report of the Fifty-First Annual Meeting. Appendix 5. IWC Resolution 1999-4. Resolution on health effects from the consumption of cetaceans. *Ann. Rep. Int. Whaling Comm.* 1999:53.
- International Whaling Commission. 2001a. Chairman's Report of the Fifty-Second Annual Meeting. Appendix 1. Resolutions adopted during the 52nd Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2000:55-8.
- International Whaling Commission. 2001b. Report of the Meeting of the IWC Scoping Group of the Habitat Degradation Workshop, 11-12 June 2001, Rome, Italy. Paper SC/53/E16 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- International Whaling Commission. 2002a. Chair's Report of the 53rd Annual Meeting. Annex C. Resolutions Adopted During the 53rd Annual Meeting. Resolution 2001-4. Resolution on the incidental capture of cetaceans. *Ann. Rep. Int. Whaling Comm.* 2001:55-6.
- International Whaling Commission. 2002b. Chair's Report of the 53rd Annual Meeting. Annex C. Resolutions Adopted During the 53rd Annual Meeting. Resolution 2001-7. Resolution on Southern Hemisphere minke whales and special permit whaling. *Ann. Rep. Int. Whaling Comm.* 2001:57.
- International Whaling Commission. 2002c. Chair's Report of the 53rd Annual Meeting. Annex C. Resolutions Adopted During the 53rd Annual Meeting. Resolution 2001-9. Proposed resolution on interactions between whales and fish stocks. *Ann. Rep. Int. Whaling Comm.* 2001:58.
- Jacobs, S.S. and Comiso, J.C. 1993. A recent sea-ice retreat west of the Antarctic Peninsula. *Geophys. Res. Lett.* 20:1171-4.
- Jacobs, S.S. and Comiso, J.C. 1997. Climate variability in the Amundsen and Bellingshausen Seas. *Journal of Climate* 10:697-709.
- Lindström, U. and Haug, T. 2001. Feeding strategy and prey selectivity in common minke whales (*Balaenoptera acutorostrata*) foraging in

- the southern Barents Sea during early summer. *J. Cetacean Res. Manage.* 3(3):239-49.
- Morton, A.B. and Symonds, H.K. 2002. Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia, Canada. *ICES J. Mar. Sci.* 59:71-80.
- Shimada, H., Murase, H., Segawa, K. and Kimura, N. 2001. Analyses on Antarctic sea ice coverage in the austral summer 78/79 to 00/01 using the SSMR and SSM/I satellites data, with some notes on relationship between ice coverage and abundance estimation. Paper SC/53/1A15 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Simmonds, M., Notarbartolo di Sciara, G., Reijnders, P., Taylor, M., Fortuna, C., Perry, C., Stachowitsch, M. and Fossi, C. 2002. Report of the Scientific Committee. Annex J. Report of the Standing Working Group on Environmental Concerns. Appendix 3. Report of the Scoping Group Meeting for the Habitat Degradation Workshop, 11-12 June 2001, Rome, Italy. *J. Cetacean Res. Manage. (Suppl.)* 4:314-7.
- Thiele, D., Hofmann, E., Friedlaender, A., Moore, S. and McDonald, M. 2001. Preliminary report on IWC-SO-GLOBEC collaborative research in the western Antarctic peninsula study area, March-June 2001. Paper SC/53/E8 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Williams, R., Bain, D.E., Ford, J.K.B. and Trites, A.W. 2002. Behavioural responses of male killer whales to a 'leapfrogging' vessel. *J. Cetacean Res. Manage.* 4(3):305-10.

Appendix 1

AGENDA

1. Convenor's opening remarks 2. Election of chair, appointment of rapporteurs 3. Review of available documents 4. Adoption of agenda 5. Cooperative research in the Antarctic 5.1 Results from the SOWER 2000 cruise 5.2 Collaboration with SO-GLOBEC 6. Steering group report on POLLUTION 2000+ 7. Habitat related issues 7.1 State of Cetacean Environment Report (SOCER) 7.2 Steering group report on workshop on habitat degradation	7.3 Review information regarding whalewatching activities and noise impacts 7.4 Competition between cetaceans and fisheries 7.5 Mitigation of incidental capture of large cetaceans in fishing gear 8. Other 8.1 Review of Arctic issues 8.2 Preparation for review of Arctic research next year 8.3 Procedures for contaminant data submission 8.4 Other 9. Work plan for SC/55 10. Adoption of report
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Appendix 2

FUTURE COLLABORATION BETWEEN THE IWC, SO-GLOBEC AND CCAMLR IN THE ANTARCTIC

D. Thiele and S. Moore

CURRENT 2001 AND 2002 FIELD WORK

Multidisciplinary research was conducted under national Antarctic programmes in two focus areas: the Western Antarctic Peninsula (WAP); and East Antarctica. The US SO-GLOBEC effort consisted of six survey and process cruises (three each year) to the Marguerite Bay WAP study area. The German programme consisted of one cruise in April/May 2001 to the WAP study area, and an area of oceanic ice-edge to the west of Alexander Island. Off East Antarctica, Australia conducted a fine-scale krill survey (early 2001). The IWC participated in the US and German programmes and reports of this work and preliminary findings have been presented in Thiele *et al.* (2001), SC/54/E12 and SC/54/O3. Thiele will present future cetacean research conducted under the Australian programme to the IWC.

This initial two-year field season for SO-GLOBEC will be completed in late winter 2002. Preliminary analysis of data from the two-year field season has quickly revealed that the ecological processes are long-term in nature and thus require a research effort on a similar temporal scale. A longer term program similar to SO-GLOBEC is being planned.

TIMETABLE

Presentations and papers from the current cruises have been made at:

(1) 2001 and 2002 US SO-GLOBEC Planning meetings; (2) Vancouver Society for Marine Mammalogy Meeting (November 2001); and (3) Honolulu Ocean Science Meeting (February 2002).

Mini krill-whale data integration workshop

Planned for August-September 2002 in the USA.

October 2002 Second International GLOBEC meeting in Qingdao, China

Presentations from all disciplines involved in US SO-GLOBEC, and Australian and German programmes will be made here. Moore and Thiele will be involved in the planning meeting of SO-GLOBEC national program leaders for the follow-on SO-GLOBEC design.

November 2002 Deep Sea Research special issue

Manuscripts for this special SO-GLOBEC issue are to be submitted.

2002/2003 Synthesis and modelling phase

The scale and complexity of data from the wide range of disciplines collected through SO-GLOBEC studies will require a significant effort if useful integration of data series is to occur. This integration process is essential to understanding ecosystem processes and to the development of future research programmes. Therefore, the US National Science Foundation will be supporting a synthesis and modelling phase as the immediate follow-on to the SO-GLOBEC field work. The IWC will be included in this process at extremely low cost to itself.

Future SO-GLOBEC

Planning will take place at the International GLOBEC meeting in China (Hofmann, other national program leaders, Thiele and Moore). The US plans to conduct a 5-10 year (at least) multidisciplinary programme in the Amundsen and Bellingshausen Seas. Australia plans to conduct a similar long-term effort at a new 'at sea' CEMP (CCAMLR Ecosystem Monitoring Programme) site off Mawson base in East Antarctica (~60°S, 70°E). Germany is planning three cruises over one year in the Weddell Sea (2004/05) as its SO-GLOBEC contribution.

Field work planned for 2002/03 and beyond

2002/03: IWC and passive acoustics collaboration (four berths) confirmed for UK British Antarctic Survey (BAS) combined CCAMLR/SO-GLOBEC studies in the Scotia Sea in January-February 2003. At least one-year deployment of passive acoustic recorders; possibility of long-term passive acoustics and other field work in this area (visual survey, possible biopsy study and sonobuoy deployment).

2002/03 to 2012/13: Visual survey, biopsy and fine-scale ecological studies with passive acoustics collaboration on one dedicated multidisciplinary survey per season for 5-10 years. Year-round acoustic moorings to be deployed long-term. Six berths confirmed for Australian SOCEP programme under Antarctic Marine Living Resources Program (AMLR) at annual CEMP site (off Mawson). CCAMLR and SO-GLOBEC related multidisciplinary studies.

2004/05: IWC participation under development with a series of three SO-GLOBEC cruises over one year to a study site in the Weddell Sea. At least one full year deployment of passive acoustic recorders; possibility of long term deployment. Visual survey, possible biopsy study and sonobuoy deployment. These cruises are planned for December/January 2004/05 and March/April and July/August in 2005.

IWC collaboration and funding

Moore, Hildebrand and Thiele have formed a collaborative group to access significant external funding. Proposals exist to fund the majority of IWC participation in field and analysis work for the next 5-10 years (National Governments and Private Trusts). IWC participation forms a core part of

these proposals. The proposals have been developed in collaboration with SO-GLOBEC (Eileen Hofmann), CCAMLR and national Antarctic programme leaders. The existing network of national programmes and international organisational links shall continue to be built on to provide extensive opportunities to utilise platforms of opportunity for work of importance to the IWC in this region.

This collaboration has been formed to facilitate the development of an integrated approach to cetacean ecological research, which can in time provide a significant increase in understanding of seasonal and interannual changes in distribution and movements of baleen whales in relation to physical and biological processes and system variability at all scales, throughout the Antarctic. It incorporates the use of year-round Acoustic Recording Devices (see SC/54/O3); visual survey, biopsy and sonobuoy field programmes on deployment vessels; and at least two fine-scale ecology sites (USA Amundsen and Bellingshausen Seas, Australian at-sea Mawson CEMP site) which will provide the opportunity to return to one study area every year and conduct experimental ecological studies in a multidisciplinary context. These field sites will allow ground-truthing of data collected from moorings and deployment cruises.

The programme will:

- (1) ensure the continued collaboration of the IWC in SO-GLOBEC and CCAMLR national field and analysis efforts;
- (2) ensure that passive acoustic, visual/biopsy and biological oceanography field studies are conducted simultaneously and in a standardised manner;
- (3) facilitate the deployment of passive acoustic recorders (see SC/54/O3) on a circum-Antarctic scale, and throughout the Indian Ocean (where there appears to be a greater diversity in possibly geographically distinct blue whale calls);
- (4) facilitate the simultaneous collection of visual/biopsy/sonobuoy field work on vessels deploying ARPs;
- (5) ensure the continued integration of cetacean data in ecosystem analysis and modelling.

In order to maintain IWC collaborative status within these programmes it is essential that a small core of funds be allocated on an annual long-term basis from the budget. These funds will be used to support coordination of IWC participation, planning and involvement in analysis.

REFERENCE

- Thiele, D., Hofmann, E., Friedlaender, A., Moore, S. and McDonald, M. 2001. Preliminary report on IWC-SO-GLOBEC collaborative research in the western Antarctic peninsula study area, March-June 2001. Paper SC/53/E8 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].

Appendix 3

A PROCESS FOR DEVELOPING AND EVALUATING A DATA COLLECTION SYSTEM FOR ICE DATA ON ANTARCTIC CETACEAN FIELD PROGRAMMES

D. Thiele, P. Ensor, S. Hedley, S. Moore, V. Peddemors, H. Shimada and C. Tynan

The importance of understanding the linkages between ice-ocean processes; whale distribution, abundance and movements; and the dynamics of other Antarctic marine biota, particularly whale prey species has been highlighted in several presentations this year. Field experience in this region and work alongside sea-ice and other marine science disciplines has highlighted the need for a standardised ice data collection method for use on whale research platforms in the ice. The development and implementation of a standardised method for these data would provide comparability between datasets (many of which have common standardised methods of sighting survey data collection), which are not currently possible. The implementation of this system will also provide scope for ensuring that biologically useful ice information is routinely collected.

This intersessional group proposes to develop a relatively simple and practical standardised data collection system from sea-ice observation protocols developed by sea-ice physicists (currently available in CD format and used by national programmes throughout the Antarctic). The complexity and practical application of the whole, or parts, of this programme for whale research will be assessed on the basis of experience on sighting survey platforms and qualitative understanding of the components of sea-ice that may be influencing whale ecology. After initial assessment of the CD, and comments from the group, a series of pull-down menus might be developed and adapted for inclusion in the current Wincruz Antarctic computer-based sighting program. This program is used extensively in the Antarctic, and is both practical and amenable to the inclusion of some additional pull-down menu functions.

It is expected that this form of data collection will result in the production of an extremely useful data series to be used in studies explaining the observed distribution of high-latitude whale species. For example, these data will allow the formulation of hypotheses based on quantitative data of both a biological and physical nature. These hypotheses should assist with designing research programmes to address issues relating to the seasonal and interannual variability in whale distribution and abundance in sea-ice habitat, and the role of climate change impacts over time.

Field trials using the system will be conducted in 2002/03 on a number of Antarctic cruises where possible (IWC/CCAMLR, SOCEP, IWC/SO-GLOBEC). Changes

may be made to the protocol after the trials. A document will be presented next year for discussion in relevant sub-committees. It is hoped that approval for the protocols to be recommended for use by the IWC Scientific Committee can be obtained once discussions in sub-committees have been taken into account.

These data should prove to be of considerable use to the work of the IWC SC, as there are very few simultaneously collected whale-ice data series available for analysis from this region at present.

Outline of tasks for group:

- (1) Thiele to distribute Australian Antarctic Division Sea-Ice Data Collection CD to group members.
- (2) Thiele to consult with Moore regarding ice data collection methods in the Arctic and assess usefulness/applicability to Antarctic.
- (3) Thiele to pass these on to Peddemors to include in his review.
- (4) Peddemors to conduct initial review of CD material and make recommendations for content of pull-down menus for Wincruz Antarctic and/or possible simultaneous use of CD.
- (5) Tynan to consult with sea-ice groups and other disciplines to determine their definitions of the 'ice-edge'. These will be reported in the assessment at next year's meeting.
- (6) Members of group receive Peddemors' recommendations and make comments.
- (7) Group decides on a system to trial before October 2002.
- (8) Members to test any adjustments to Wincruz Antarctic before field trials to remove possible bugs.
- (9) Allow time before field trials to have any bugs corrected.
- (10) Hedley to liaise with Rob Holland to allow inclusion of pull-down menus in Wincruz Antarctic prior to field season (austral summer 2002/03). Adjustments to be made by November 2002.
- (11) Members and colleagues use trial system.
- (12) Report of trial program to group compiled by Thiele.
- (13) Appropriate amendments made to protocols.
- (14) Paper and example of protocols/system finalised prior to the 2003 Scientific Committee meeting.

Appendix 4

PROGRESS REPORT ON POLLUTION 2000+: 2001-2002

P. Reijnders, R. Wells, T. Rowles, A. Aguilar, A. Bjørge, G. Donovan and T. O'Hara

INTRODUCTION

The Steering Group (SG) for POLLUTION 2000+ further implemented the programme during the year, mainly through e-mail. For the bottlenose dolphin sub-project, activities centred on: (1) analyses of bottlenose dolphin samples from Sarasota Bay; and (2) comparison of PCB-concentrations in blubber samples from the three study sites: Bahama Islands and Charlotte Harbor (representing 'low polluted' sites) and Sarasota Bay (representing a 'moderately polluted' site). Under the harbour porpoise post-mortem calibration study, activity centred on the collection and initial processing of samples from bycaught porpoises.

BOTTLENOSE DOLPHIN SUB-PROJECT PROGRESS DURING 2000-2002

Introduction

Original plans called for biopsy darting of dolphins in: (1) the Mediterranean Sea to obtain samples from dolphins likely to carry high concentrations of PCBs in blubber; and (2) the Bahama Islands to obtain samples from relatively 'clean' dolphins. Blubber (and other) samples were also to be obtained during capture/release operations in Sarasota, Florida (a site presumed to be intermediate in terms of PCB pollution). The small sample masses obtained from biopsy darting did not permit sufficient testing for the full suite of potential biomarkers. Problems encountered in access to the Bahamian field site following initial sampling led to exploratory biopsy darting to obtain blubber samples from dolphins in Charlotte Harbor, Florida, a less-developed estuary south of Sarasota Bay.

Capture-release operations in Sarasota Bay provided detailed information on health and body condition, as well as the larger blubber sample masses and samples of blood and urine needed for 'ground-truthing' the potential biomarkers.

A major feature of the Sarasota Bay study is that research on the bottlenose dolphin community has been ongoing since 1970 and a wealth of information is available for each individual (and the genetic relationships between individuals). The Sarasota-based research programme has also been developing methods for assessing the population status and health of coastal bottlenose dolphins, not only to monitor the risks to the populations themselves, but also to assess their use as sentinels of the health of marine ecosystems. At least 60% of inshore dolphins on the west coast of Florida are individually identifiable from dorsal fin features, facilitating direct counts and mark-recapture estimates. Using photographic identification techniques (Scott *et al.*, 1990) it is possible to define individual home ranges (e.g. relative to contaminant sources) and measure female reproductive success as well as monitor population-level trends in abundance, losses, and other vital rates (Wells and Scott, 1990).

Results

Sample collection

BIOPSY DART SAMPLING

Eleven samples were collected from the Bahama Islands (7 males : 4 females) during 2000, and from Charlotte Harbor (9 males : 2 females) during 2001. Three samples were collected from the Mediterranean Sea (Aguilar and Borrell, 2001).

CAPTURE-RELEASE SAMPLING

Matched blubber, blood and urine samples were collected from 47 dolphins from Sarasota Bay during June 2000 and 2001. The sample included a representative cross-section of the resident dolphin community (~120 individuals), with sampled dolphins ranging in age from 2-50 years (Table 1).

Table 1
Sarasota Bay bottlenose dolphins sampled during 2000-2001.

Age Class	Females	Males
0 - 10	11	10
11 - 20	5	5
21 - 30	1	2
31 - 40	4	3
41 - 50	4	2
Total	25	22

Sample analyses

Many of the proposed analyses have been completed. The central analyses for evaluation of the biomarkers, measurement of PCB concentrations in blubber, have been completed. These analyses resulted in data relative to the parameters indicated in Table 2, along with measures of % lipid.

The numbers and masses of samples available for each of the specific analyses varied with the type of tissue required, the difficulty of obtaining the sample, and the timing of identification of the analysis as part of the programme. For the Sarasota Bay dolphins sampled during capture/release, analyses of blood samples for chemistry, haematology, reproductive hormones, thyroid hormones, and immune function are either underway or have been completed; the remaining blood, blubber and urine sample analyses remain to be completed (Table 2).

Discussion

In-depth interpretation of the POLLUTION 2000+ data relative to biomarkers and PCB concentrations will occur upon completion of sample analyses; it would be premature to present interpretation of initial results at this time. Many of the data have become available only recently, while some of the analyses remain to be completed. Once all of the sample analysis data are available, it will be necessary for the principal investigators to reach consensus concerning

Table 2

Status of analyses supported by samples collected from Sarasota Bay.

Tissue	Analysis	Total	Females	Males	Status
Blubber	PCB Concentration	47	25	22	Complete
	Immunohistochemistry	47	25	22	In progress
	Enzyme Induction:	21	11	10	In progress
	Activity				
	Luciferase	16	9	7	Pending
Blood	Retinol (Vitamin A)	47	25	22	Complete
	Chemistry, Haematology	47	25	22	Complete
	Reproductive Hormones	47	25	22	Complete
	Thyroid Hormones	47	25	22	Complete
	Immune Response	47	25	22	Nearly complete
	Total PCBs	21	11	10	To be decided
	Coplanar PCBs	21	11	10	To be decided
	Porphyrins	47	25	22	To be decided
	Luciferase	47	25	22	To be decided
	Vitamin A	47	25	22	To be decided
Urine	Porphyrins	38	16	22	To be decided

statistical analyses of the data to the level of evaluating potential biomarkers, and to collaborate on analyses, interpretation and report preparation.

The dynamics of PCB accumulation in the Sarasota bottlenose dolphin community appear to follow classical patterns described from other studies (Cockcroft *et al.*, 1989; O'Shea *et al.*, 1998). In general, males accumulate PCBs in their blubber throughout their lives, while females begin to depurate PCBs when they begin nursing their first calf. As a result, older males have high concentrations of PCBs, while older females have lower concentrations in their blubber. For both young males and young females, the apparent maternal contribution of PCBs appears to be quite significant.

During the first year of the POLLUTION 2000+ programme, eleven biopsy samples were collected by darting. However, it emerged that continued sampling would not be feasible in the Bahamas, for political and logistical reasons, so the possibility of an alternative site was investigated. Charlotte Harbor, about 50km south of Sarasota Bay, is considered to be one of the most pristine estuaries remaining in Florida, and is currently the site of an intensive, long-term research programme by Mote Marine Laboratory. Mean PCB concentrations of biopsy dart samples collected from dolphins in Charlotte Harbor were compared to those from the Bahama Islands (Table 3). Comparison of PCB concentrations between these sites suggested that dolphins from Charlotte Harbor and the Bahama Islands were not significantly different in their PCB loads in blubber, but Charlotte Harbor male concentrations were significantly lower than for males from Sarasota Bay.

HARBOUR PORPOISE SUB-PROJECT DURING 2001-2002

Harbour porpoises are frequently bycaught throughout the North Atlantic area. In order to utilise samples from bycaught animals, it is of basic importance to calibrate for post-mortem time. Sampling of harbour porpoises for this purpose has been possible in the summer of 2001 in the Bay of Fundy.

Sampling

Sampling results are given in Tables 4 and 5.

Table 3

Preliminary PCB concentrations in dolphin blubber from three study sites: Bahama Islands (BI), Charlotte Harbor, Florida (CH) and Sarasota Bay, Florida (SB).

	Total PCBs (ppm, lipid)	
	Mean	n
Males		
Bahama Islands	9.5	7
Charlotte Harbor	10.1	9
Sarasota Bay: all males	102.0	22
Sarasota Bay: males > 5 years old	142.4	14
Females		
Bahama Islands	5.1	4
Charlotte Harbor	7.6	2
Sarasota Bay: all females	13.5	25
Sarasota Bay: females > 5 years old	7.8	18

Table 4

Summary of Bay of Fundy harbour porpoises sampled during summer 2001 for the post-mortem calibration study.

Estimated age class*	Females	Males
< 1		1
Sexually immature 1-3		3
Mature	1 (pregnant)	1
Total	1	5

*Based on length, age estimation using growth layer groups in teeth.

ACKNOWLEDGEMENTS

Sample collection and analyses would not have been possible without the support of the National Marine Fisheries Service, the Chicago Zoological Society, Mote Marine Laboratory, the Conservation Medicine Center of Chicago, and Dolphin Quest. These groups funded the first year of Florida sample collection for the IWC project and analyses entirely, and supplemented IWC support for the second year. Aleta Hohn (NMFS) determined the ages of the dolphins for which ages were not already known from long-term observational studies. Anna Sellas collected biopsy dart samples from Charlotte Harbor dolphins, and conducted the genetic analyses of these samples. Kim Parsons collected the Bahama Island samples and analysed them genetically. Stephanie Nowacek, Sue Hofmann, and the staff and volunteers of the CZS Sarasota Dolphin Research Program were essential to the collection of the samples from the Sarasota Bay dolphins. Sampling was conducted under permit from the National Marine Fisheries Service.

Sample collection of harbour porpoises would not have been possible without the cooperation of the weir fishermen of Grand Manan. Funding was provided by Duke University and various sources. Tara Cox assisted sample collection and processing.

Contributors to this POLLUTION 2000+ project are (in alphabetical order): Assuncion Borrell, Bram Brouwer, Ruth Ewring, Christina Fossi, Gina Ylitalo, Heather Koopman, Michael Moore, Andy Read, Howard Rhinehart, Anna Sellas, Ursula Siebert, Jeff Stott, Victoria Tornero, Joanna Wilson.

BUDGET ACCOUNTING

Table 6 gives a breakdown of the IWC funding.

Table 5
Types of samples collected from the Bay of Fundy harbour porpoises in summer 2001.

Sample	Analysis	Number of samples collected at each time point					Status
		Immediate	3 hr	9 hr	24 hr	48 hr	
Blubber	PCB	5	6	5	6	6	Pending
	Immunohistochem	5	6	6	6	6	Pending
	Enzyme Induction	5	6	6	6	6	Pending
	Luciferase	5	6	6	6	6	Pending
	Retinol	5	6	6	6	6	Pending
Blood	Miscell. Analyses*	5	0	0	0	0	Pending
Liver	Enzyme Induction	1	0	0	0	6	Pending
	Porphyryns	1	0	0	0	6	Pending
	Retinol	1	0	0	0	6	Pending
Histopath		0	0	0	0	6	Pending

*Chemistry, reproductive hormones, thyroid hormones, immune response, PCB, Co-planar PCB, porphyrin, retinol, luciferase.

Table 6
Pollution funds available (through IWC), in £.

Brought forward from 2000-2001	54,326
Funds approved in budget	8,200
Total	62,526
Expenditure	
<i>Sarasota samples analyses</i>	
PCBs	7,025
Retinol	4,045
Imm. funct/inflamm. Mediat.	13,630
Enz. Ind. Activity	8,345
Enz. Ind. Immun. Histochem.	2,515
Total	35,560
<i>Harbour porpoise samples</i>	
PCBs	3,145
Retinol	3,535
Imm. funct/inflamm. Mediat.	1,450
Enz. Ind. Activity	6,395
Enz. Ind. Immun. Histochem.	1,925
Thyroid hormones	40
Porphyryns	780
Luciferase	7,810
Serum chemistry	90
Lymphnodes (histology)	1,000
Total	26,170
Sub-total	61,730
Balance still available	796

In-kind funding

It needs to be stressed that in addition to the funds provided by IWC, a considerable amount of 'in-kind' funding has been provided and offered by the cooperating institutions. This is crudely estimated at over £200,000. This is extremely encouraging and underlines that this IWC-initiative is widely endorsed and supported.

WORKPLAN 2002-2003 AND RELATED BUDGET

Work plan

- (1) Review of data from completed and ongoing analyses of *Tursiops* samples.
- (2) Integrated multi-variate analyses of the results from PCB- and biomarkers analyses.
- (3) Decisions on complementary collection of bottlenose dolphin samples (number and type) from Charlotte Harbor and the Mediterranean or alternative sites.

Table 7
Budget (£).

Bottlenose dolphin sub-project		
Collection blubber/skin samples from Charlotte Harbor and Mediterranean animals, 25 per area (including shipping costs)		12,500
Analyses	PCBs	7,500
	Retinol	4,300
	Luciferase	11,600
	Enz. Ind. Activity	8,900
	Enz. Ind. Immun. Histochem.	2,700
Sub-total		47,500
Harbour porpoise p.m.-calibration project		
Additional sampling in Bay of Fundy (fieldwork, shipping costs)		8,000
Analyses*	PCBs	5,300
	Retinol	5,900
	Enz. Ind. Activity	10,700
	Enz. Ind. Immun. Histochem.	3,210
	Porphyryns	1,300
Sub-total		34,410
Intersessional laboratory meeting		20,000
Data management, statistical analysis		2,000
Project management		
Coordination, fundraising		15,000
Intersessional meeting SG		4,000
Total budget required to complete Phase I		122,910
First priority activities		
Harbour porpoise p.m.-calibration project		34,410
Bottlenose dolphin sub-project		
	collection of samples	12,500
	PCB analyses	7,500
Requested budget from IWC		54,410

*Imm. funct/inflamm. Mediat., Thyroid hormones, Serum chemistry and Lymphnodes (histology) have no longer been included here because no change over time since death has been found; a decision for inclusion of Luciferase is pending.

- (4) Coordination analyses on further *Tursiops* samples.
- (5) Review of data of the harbour porpoise post-mortem calibration sub-project thus far and consider how far the sampling and results (including sex- and age-class composition aspects) have gone towards meeting the objectives of this sub-project. Based on this determine the extent (if any) of further sampling required and any further steps.

- (6) Intersessional meeting of involved laboratories to: (a) complete process of synthesising and integrating results from multi-variate analyses of all datasets (under 1, 2 and 5); (b) decide on reporting (type/number and time-schedule of publications and authorship); and (c) recommend on execution of planned activities under Phase II of POLLUTION 2000+.
- (7) Intersessional planning meeting of SG to finalise Phase I and decide on activities under Phase II, including time-frame.

Budget

A breakdown of the budget is given in Table 7. Recognising the budgetary situation of the IWC, the necessary work has been prioritised, taking into account the possibility of obtaining external funding and in-kind funding as well as scientific priorities. The requested budget from the IWC is £54,410.

REFERENCES

- Aguilar, A. and Borrell, A. 2001. Results of the bottlenose dolphin biopsy feasibility fieldwork and pollutant level assessment for the *POLLUTION 2000+* project. Paper SC/53/E20 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Cockcroft, V.G., De Kock, A.C., Lord, D.A. and Ross, G.J.B. 1989. Organochlorines in bottlenose dolphins, *Tursiops truncatus*, from the east coast of South Africa. *S. Afr. J. mar. Sci.* 8:207-17.
- O'Shea, T.J., Reeves, R.R. and Long, A.K. 1998. Marine mammals and persistent ocean contaminants: Proceedings of the Marine Mammal Commission Workshop, Keystone, Colorado, 12-15 October, 1998. [Available from: www.mmc.gov]
- Scott, M.D., Wells, R.S. and Irvine, A.B. 1990. A long-term study of bottlenose dolphins on the west coast of Florida. pp. 235-44. In: S. Leatherwood and R.R. Reeves (eds.) *The Bottlenose Dolphin*. 1st. Edn. Academic Press, San Diego, California. 653pp.
- Wells, R.S. and Scott, M.D. 1990. Estimating bottlenose dolphin population parameters from individual identification and capture-release techniques. *Rep. int. Whal. Commn* (special issue) 12:407-15.

Appendix 5

STATE OF THE CETACEAN ENVIRONMENT REPORT (SOCER):
STANDARDISED FORM FOR DATA ENTRY

Principal editors: Michael Stachowitsch and Naomi Rose

I. CATEGORY OR TYPE OF EVENT

Event*	Category/ies**	Positive***	Negative	Unknown

*e.g. An oil spill; stranding; population trend (e.g. calf count increase/decrease); prey base number increase/decrease. **a - chemical pollution; b - physical or biological degradation; c - effects of fisheries; d - noise; e - disease and mortality events; f - ozone and UV-B radiation; g - climate /environmental change; h - life history changes; i - ship strikes; j - biotoxins; k - other/unknown. ***Positive - improvement from previous condition/level; negative - deterioration from previous condition/level.

II. TAXONOMIC EXTENT

Number of cetacean species involved:	1	2-3	4-5	6-7	>7

Scientific name(s)	Common name(s)	Conservation status*	Relative numbers of animals involved**				
			1	2	3	4	5

*e.g. IUCN, EU habitats Directive, CMS - international or regional. **On a scale of 1 to 5, with 1 being lowest and 5 being highest, indicate with a check mark numbers of animals involved in event relative to estimated stock/population numbers.

III. ECOLOGICAL SCOPE

Relative ecological impact*	1	2	3	4	5

*On a scale of 1 to 5, with 1 being least and 5 being most, indicate with a check mark the relative impact on the environment, based on numbers of habitats and numbers of species (including non-cetacean species) affected.

Other marine species affected, if known	Scientific name(s)	Common name(s)

IV. GEOGRAPHIC EXTENT

Name of geographic area affected	Coordinates if known	Area affected in km ²				
		<10	11-100	101-1000	1001-5000	>5000

V. TEMPORAL EXTENT

Duration*	Days	Weeks	Months	Years	Decades

*Relative duration - check appropriate box.

VI. PRINCIPLE CAUSE

- ☐ Natural
- ☐ Anthropogenic
- ☐ Unknown

VII. SOURCE OF INFORMATION

☐ Published: peer-reviewed non-peer-reviewed (circle one)

Full citation: _____

☐ Unpublished*

☐ Web based

URL: _____

*If unpublished, state origin of information (e.g. personal observation, second-party observation).

VIII. ADDITIONAL INFORMATION AND REMARKS (ADD ADDITIONAL SHEETS/SPACE AS NECESSARY)

IX. REPORTER

Name:

Address:

Phone:

Fax:

Email:

Appendix 6

IWC MODELLING WORKSHOP ON CETACEAN-FISHERY COMPETITION, 25-27 JUNE 2002, LA JOLLA, USA

INTRODUCTION

At its 51st Annual Meeting, and in response to a request by the Commission, the Scientific Committee considered how it might best address the subject of competition between whales and fisheries (IWC, 2000, p.40). An intersessional e-mail group began the development of a central objective and terms of reference for the Scientific Committee's work on this subject. These were finalised at the 52nd Annual Meeting in Adelaide and it was agreed that the Scientific Committee's future work on this subject would be guided by a central question, also the main objective of future deliberations:

How are changes in abundance of cetaceans likely to be linked (in the short- and long-term) to changes in fishery catches?

Guidelines for the SC's work on this topic were also agreed:

- (1) Review the past work of the Scientific Committee on competition between cetaceans and fisheries, giving attention to the questions asked, the data reviewed, the conclusions reached and the advice given.
- (2) Review recent published literature and contributed papers relating to competition between marine mammals and fisheries: critique methods, determine whether

conclusions are supported by the data, summarise and synthesise conclusions.

- (3) Review all relevant case studies of marine biological interactions.
- (4) The Committee agreed that it is only appropriate to study such issues on a case specific level, not a global level. Because of logistical constraints, work should focus on one or two regions where sufficient data are likely to be available, and where there is the potential for significant competition. Consider portion(s) of the Southern Ocean as ecosystem(s) for which research on the competition issue can be carried out/sponsored by the Scientific Committee. Develop detailed recommendations for relevant items of research that could be potentially carried out as part of the current Scientific Committee-sponsored ecosystem research in collaboration with CCAMLR and other agencies. Also consider the Barents Sea or a larger portion of the North Sea as an area in which the Scientific Committee could augment or cooperate with ongoing research to model ecosystem structure and function with respect to competition between cetaceans and fisheries.
- (5) Select multi-species modelling approach(es) for the selected region(s) and identify data needs, considering, for example, all or some of the following components, not necessarily in this order (various modelling approaches may have different components, data requirements and uncertainties):
 - (a) Estimating removals by cetaceans and other predators.
 - (b) Estimating removals by fisheries.
 - (c) Assessing dietary overlap with humans.
 - (d) Determining methods for assessing links between cetacean abundance and fishery catches emphasising quantitative modelling approaches.
 - (e) Estimating effects of changes in cetacean populations on fisheries.
 - (f) Estimating effects of prey reduction by fisheries on cetaceans.

WORKSHOP

Some of the above terms of reference were initially intended to have been addressed by a symposium and conference on competition between cetaceans and fisheries during 2001, but funding was not obtained to pursue this. Instead, at the 53rd meeting of the Scientific Committee, a more focused workshop was proposed in order to address specific modelling approaches that the SC might find useful in addressing the main objective (IWC, 2001, p.47). The terms of reference for the workshop were agreed at the 53rd meeting of the Scientific Committee and a Steering Group was formed to oversee the implementation of such a workshop. The US government, at very short notice, kindly agreed to host the workshop at the Southwest Fisheries Science Center in La Jolla, California. The dates of the workshop will be 25-27 June 2002.

Workshop Terms of Reference

- (1) Review existing modelling approaches that might be used to address the overall objective.
- (2) Identify the constraints and data requirements in the existing models or modelling approaches that limit our ability to answer the above question.

- (3) Describe the advantages and disadvantages of the various approaches, bearing in mind the areas for which they were developed.
- (4) Identify those approaches most likely to answer the above questions, and provide some guidelines as to when and where they might be used (for example, depending on the level of data availability).

Draft Agenda

Day 1

1. Overview of existing models. Including structure, function and data requirements (John Harwood).
2. Data requirements. Review of the types of data available – considering limitations, availability, reliability and natural variability (see notes).
 - 2.1 Marine mammal population size and structure.
 - 2.2 Fisheries catch data and effort data.
 - 2.3 Prey species population size and structure.
 - 2.3.1 Commercial species.
 - 2.3.2 Non-commercial species.
 - 2.4 Consumption rates by marine mammals.
 - 2.5 Diet composition.
 - 2.6 Linkages – inter/intra-species predation.
 - 2.7 Other data requirements?

Day 2

3. Individual model structures. A critical review of individual modelling approaches and their likelihood of meeting their own objectives.
 - 3.1 Mass balance/energy flux models.
 - 3.1.1 Ecosim – ‘bottom up’ (Kerim Aydin).
 - 3.1.2 Ecosim – ‘top down’ (Alida Bundy).
 - 3.2 Minimum realistic models.
 - 3.2.1 Bormicon
 - 3.2.2 Multispec (Sigurd Tjelmeland).
 - 3.2.3 Multispecies VPA (Morten Vinther).
 - 3.3 Food web models.
 - 3.3.1 Extended food web models (Peter Yodzis).
 - 3.3.2 Antarctic food web model (Andrew Constable).

Day 3

4. Synthesis.
 - 4.1 Predictive abilities.
 - 4.1.1 Cetacean effects on fisheries.
 - 4.1.2 Fishery effects on cetaceans.
 - 4.2 Validation – verification/falsification of predictions.
5. Review approaches likely to meet the IWC objective.
 - 5.1 Identification of key modelling approach(es) that require further modelling work to meet the IWC objective.
 - 5.2 Identification of key data requirements.
6. Identification of further work.
7. Review of report.

REFERENCES

- International Whaling Commission. 2000. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 2:1-72.
- International Whaling Commission. 2001. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 3:1-82.

Appendix 7

REPORT OF THE INTERSESSIONAL WORKING GROUP ON LARGE WHALE ENTANGLEMENT

Members: Clapham (Chair), Berggren, Leaper, Mattila, Robbins. [Also participating: P. Hamilton, W. Ledwell, J. Lien, C. Mayo, G. Salvador and S. Todd.]

The following information has been extracted from SC/54/BC2.

The Working Group was convened in response to Resolution 2001-4 (IWC, 2002) viz that the Commission:

REQUESTS the Scientific Committee to provide to the 54th Annual Meeting of the Commission a summary of its work in recent years on the most feasible methods to mitigate the incidental capture of large cetaceans in fishing gear, and ways in which entangled large cetaceans may be removed from fishing gear with minimal risk to rescuers.

INTRODUCTION

Entanglement in fishing gear of cetaceans and other wildlife is a major problem worldwide (Perrin *et al.*, 1994). The introduction of synthetic net and rope in the middle of the 20th century, together with enhanced fleet and gear mobility, greatly exacerbated this problem. Entanglement may be a serious factor affecting the recovery of small populations. For example, it is known to be a significant source of mortality among the critically endangered North Atlantic right whale (*Eubalaena glacialis*), whose failure to recover is largely attributable to anthropogenic impacts (IWC, 2001, pp.33-35; Knowlton and Kraus, 2001). There is also evidence from scarification data that the reproductive success of female humpback whales (*Megaptera novaeangliae*) is negatively impacted by a history of entanglement (Robbins and Mattila, 2001).

Concerns have also been expressed about the status of the minke whale stock in the Sea of Japan due to the levels of fisheries bycatch (Baker *et al.*, 2000).

Several types of fishing gear are involved in entanglement. These include a number of different types of gillnet fisheries and trap fisheries (e.g. for crab and lobster) involving bottom-set gear marked by surface floats. In the North Atlantic, at least, these are probably the two single-largest types of fishery involved in entangling whales. In Japan and Korea, set or trap net fisheries have the highest reported levels of large whale entanglement. Fishing weirs, seines, trawls, long line, scallop cable and other gear have also been implicated in some cases. Fixed or anchored gear of almost any type represents a major entanglement threat; this can also include gear used for non-fishing purposes, such as shark exclusion nets off beaches.

Any part of the trap and gillnet gear can be involved in a serious (life-threatening) entanglement (Clapham, pers. comm.). This includes the groundline (the line between each trap or between the net and the anchors), the endlines (the line going from the end of the string of traps or net panels to the surface), and the buoyline (the end section of the endlines which terminates in one or more buoys at the surface). Fig. 1 shows a diagram of a typical set-up for trap gear and gillnet. Furthermore, many parts of an animal's body can be involved in the entrapment. This includes the mouth, head, flippers, peduncle and tail.

Disentanglements of large whales have been attempted on an occasional basis in several places in the world, from Oman to New Zealand. Extensive dedicated rescue programmes are in place only in eastern Canada (primarily

Newfoundland), as well as in the Gulf of Maine and elsewhere on the US east coast; these programmes have undoubtedly reduced large whale mortalities in the areas concerned. Canadian disentanglements began in the 1970s, while the US programme was started in 1984; these efforts are led by Memorial University (St John's, Newfoundland) and the Center for Coastal Studies (Provincetown, Massachusetts), respectively. It is recommended that anyone with a serious interest in establishing a disentanglement programme elsewhere in the world contact both of these institutions for advice, since they have freed well over a thousand large whales from entanglements in various types of gear.

The Natal Sharks Board in South Africa has also developed specialist whale rescue teams to assist in releasing whales from shark nets. These teams have been successful in releasing approximately 80% of entangled baleen whales alive (Peddemors, 2001). Another disentanglement network has been established in West Australia.

Attempts to establish disentanglement programmes also need to take into account the legal implications of the regulations regarding cetaceans for each country. In

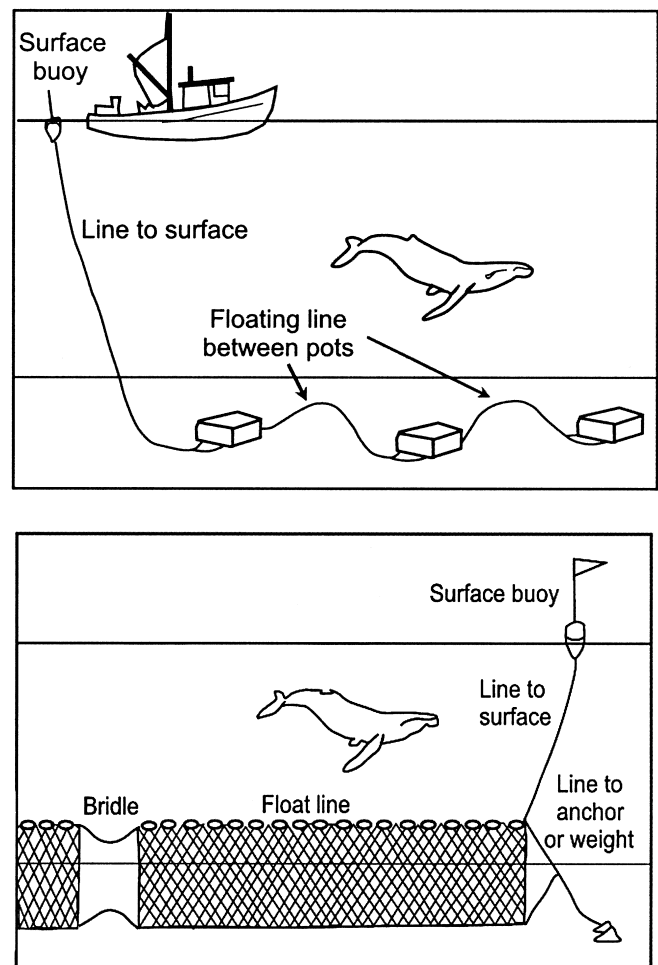


Fig. 1. Diagram of typical lobster pot gear (above) and gillnet (below). Whales typically become entangled in the ground lines between traps, the anchor lines, the endlines (to the surface) or (in a gillnet) the net panels themselves. Graphics courtesy of the Center for Coastal Studies.

countries where there is a market for cetacean products, education programmes to enable fishermen to identify protected species (which should be released alive if possible) may also be required.

Because of the considerable experience with this problem in eastern North America, this document briefly reviews entanglements in this region, with an emphasis on methods of disentangling large whales. It should be noted, however, that some members of the Working Group were concerned that producing a 'manual' for whale disentanglement would encourage inexperienced individuals to undertake this work, at considerable risk to themselves. The Group noted that it is very difficult to 'teach' disentanglement without providing hands-on experience. Consequently, this report is written with these major caveats in mind.

ENTANGLEMENT: RATES AND MORTALITIES

Entanglement of large whales in fishing gear is a major problem on the eastern seaboard of the United States. In particular, entanglement affects humpback whales and North Atlantic right whales. Other species are also observed entangled to a lesser extent, including minke whales (*Balaenoptera acutorostrata*), fin whales (*B. physalus*) and blue whales (*B. musculus*).

Off Newfoundland, humpback and minke whales are the two species most often involved in entanglements. However, over the past several decades a total of 11 different species have been entrapped and released from fishing gear. Between 1978 and 2000, approximately 1,150 reports of entangled whales were received by Memorial University. Prior to 1990 most entanglements of humpback and minke whales were in cod traps (47%). Groundfish gillnets entrapped 37% of reported humpback entanglements and 30% of minke whales (Lien *et al.*, 1990). The nature of the Newfoundland fishing industry has changed since the collapse of groundfish fisheries in the early 1990s. Effort has been dramatically reduced through reducing the number of fishermen, fish quotas and fishing seasons and continuing moratoria on groundfish stocks. The industry has changed focus from traditional small boats under 35 feet in length that used fixed fishing gear near shore to bigger offshore boats that fish snow crab and turbot to the 200 n.mile limit and beyond. There are now approximately 10,000 fishermen registered in Newfoundland holding a variety of licenses. Because of reduced quota, few cod traps have been fished since the early 1990s and almost all inshore entrapments occur in gillnets. However, an entrapment problem is emerging with the offshore fleet. Throughout the 1990s reports in offshore turbot and crab gear have been increasing.

Two studies have used photographic documentation of entanglement scars on the bodies of live whales to estimate the rate at which whales become entangled. Robbins and Mattila (2001) estimated from scarring around the caudal peduncle that at least 71% of humpback whales in a sample of 99 animals from the Gulf of Maine had been entangled at one time or another, and that, on average, between 10% and 31% of the population had such encounters each year. Using similar methods, Hamilton *et al.* (1998) estimated that 61.6% of the North Atlantic right whale population has been entangled in fishing gear. A subsequent study by Knowlton *et al.* (2001) indicates that between 10% and 28% of the right whale population contacts fishing gear each year (a remarkably similar percentage to that from the humpback whale study). Both studies found that while juvenile whales

were significantly more likely than adults to become entangled, animals from the latter age class were also susceptible to such events.

Entanglements vary in severity from trivial to lethal. Mortality due to entrapment may vary by species. In Newfoundland, mortality of reported entrapments was 16% in humpbacks but 70% in minke whales (Lien, 1994). Robbins and Mattila (2001) estimated from scarring data that 1% to 3% of humpback whale entanglements in the Gulf of Maine were severe; however, the mortality rate from entanglement is unclear, since studies of this type can observe only surviving whales. It is apparent from the scarring data that, in many cases, humpback and right whales become only briefly entangled in line or other gear which is quickly shed, leaving minor rope scars. For large whales, it is likely that many entanglements are not immediately fatal, since the animals are often powerful enough to carry large amounts of gear away with them. In these cases, however, the ability of the whales to move and feed may be compromised by the weight of gear, and death may eventually occur months later as a result of starvation. In other cases of severe entanglements, the line or other gear may create a pathway for chronic infection, and this can also lead to the eventual death of the animal.

Some fishing gear (notably that involving long strings of large traps) is heavy enough to render an entangled whale immobile, and if the entanglement occurs below the surface, death will inevitably result. This has been frequently observed off eastern Canada, where significant numbers of humpback and minke whales have been killed by such entanglements.

DISENTANGLEMENT

General approach and caveats

First and foremost, it is absolutely critical to recognise that disentangling large whales from fishing gear is a dangerous task that should never be undertaken lightly or by inexperienced individuals.

Whales are very large, powerful animals. Errors in judgment on the part of either the whales or the people attempting to help them can result in serious injury or death. In recent years, the press has reported several incidents in which well-intentioned but inexperienced individuals have attempted to remove fishing gear from humpback whales, notably by getting into the water with the animal concerned. That no one has yet died from such an encounter is more a matter of good fortune than anything else.

Anyone attempting to disentangle a large whale should, at a minimum, possess great seamanship skills and common sense. Indeed, seamanship—which includes the ability to safely handle lines and other equipment, as well as the boats being used—is equally important in whale rescue as experience with whale behaviour. With appropriate care and knowledge of some of the techniques outlined below, competent fishermen can successfully disentangle whales of some species as long as they attempt this with caution and common sense. However, having some knowledge of whale behaviour is obviously desirable in such situations.

Before any attempt is made to disentangle a whale, an objective assessment should be made of the seriousness of the entanglement. It is important to realise that not all entanglements are serious. Attempting to free a whale from an entanglement that is not life-threatening is unnecessary and potentially dangerous—the more so because the whale is likely to be stronger and healthier than an animal that has been involved in a protracted and serious entanglement

event. 'Non life-threatening' is not always easy to define in the field, but broadly includes entanglements involving simple, non-constricting wraps of line or net that do not appear to pose an infection risk and which are not accompanied by a quantity of heavy trailing gear.

Other factors to consider in such an assessment include the age (relative size) of the animal (e.g. the potential for it to grow into a loose wrap of gear); where the gear is on the animal (considering the relative risk to rescuers versus the risk of the process making the situation worse); and —even if the gear is not heavy —does the existing gear pose a significant threat to further entanglement, either on another body part or in other gear that the whale may swim through.

If, in the best judgment of the individuals on the scene, the entanglement is not serious, no attempt should be made to remove the gear. Such attempts represent too great a risk to the people (and the whale) involved, for no good reason.

The reactions of whales to rescue efforts vary considerably by species. When properly dealt with, humpback whales can be relatively tractable, particularly if they have been the victim of a prolonged entanglement and are thus tired or otherwise in sub-standard physical condition. Considerable experience with this species off the eastern coast of North America has indicated that most humpbacks are unlikely to react to rescue efforts with overt aggression and evasion; however, some animals have proven to be exceptions to this. Minke whales are always evasive. However, any animal of this size, no matter how docile it may seem, has the potential to inadvertently kill or injure a human being; a startled whale may thrash or make some other sudden unexpected movement of the tail, flippers or head, and the sheer size of the moving body part involved represents a serious danger to anyone in close proximity to the whale.

Some other species may not be as cooperative as humpback whales. Experience has shown that right whales often respond with considerable aggression to disentanglement attempts; this behaviour, together with the fact that right whales are much more powerful than most other mysticetes, makes this species particularly dangerous for potential rescuers. Indeed, in one case in the Gulf of Maine in 2001, a disentanglement team from the Center for Coastal Studies would not consider a rescue attempt on an adult male right whale unless the animal was sedated¹.

It is strongly recommended that, where possible, potential rescuers wear appropriate protective gear. This includes a helmet (a US football helmet with the face guard removed is a good option) and a life jacket; immersion suits (e.g. those manufactured by *Mustang* or *Stearns*) provide both flotation and protection from cold. In addition, the individuals concerned as well as the rescue boat should be as free as possible of any non-essential gear that could become entangled in a line. They should also carry with them a small closed knife (such as a parachute knife) attached to their body with a lanyard capable of extending to arm's length; this would be used to cut oneself free of gear in an emergency situation.

¹ This right whale had thick rope deeply embedded in the rostrum, presumably as a result of rolling after contacting a ground line from offshore trap gear. The rope created a pathway for chronic infection and the animal's condition deteriorated over the summer. Sedation was then successfully applied repeatedly over several attempts, in increasing doses, with only minimal observed effect at the highest dose. Unfortunately, the disentanglement efforts failed and there is no doubt that the whale is now dead. It should be noted that sedation of whales remains a largely undeveloped technique, and its use is not generally recommended at this time.

Many individuals involved in disentanglement strongly advise against getting into the water with an entangled whale under almost any circumstances, and note that no whale is worth the risk involved in such a scenario. The potential for a diver to become entangled in the fishing gear on the animal is very real, with obvious fatal consequences should the whale decide to dive.

Whenever possible, the vessel involved in the disentanglement operation should be accompanied by a second, standby boat. This is very important for safety reasons, and in case additional assistance is required.

Approaches to disentanglement

Anyone reporting an entanglement should be encouraged to stand by the animal concerned if this is possible. Many entangled whales cannot be freed because their location is not monitored after the initial report, and the whale is lost.

Methods of disentangling large whales depend in part on the type of entanglement, notably on whether the whale is stationary or free-swimming. In the Gulf of Maine, most entangled whales fall into the latter category; off Newfoundland, there have been many cases of whales which were essentially anchored in gear. In Newfoundland if a whale is freely swimming the first step in any rescue effort is to stop the whale. This has been done by attaching additional ropes to entangling lines on the animal and attaching them to a large vessel. When assistance was not available from a large vessel, depending on the bottom characteristics, an anchor was used. Other techniques for dealing with free-swimming whales are described in a separate section below. General approaches to disentanglement are given here.

Many entanglements involve the mouth of the animal. In mysticetes, line tangled in the baleen is quite common; while this is sometimes pulled through the baleen from the drag of the trailing line or other attached gear, this process may be arrested by knots, floats or some other obstruction on the line.

Tight wraps of line or net around an appendage are also very common. These presumably result from the whale rolling as a reaction to the initial entanglement, with constriction effected by the weight of attached gear. For example, a whale becoming entangled in a floating loop of groundline between lobster traps may well cause the line to wrap around the flipper; the considerable weight of the traps on either side will then cinch the line tightly around the appendage, in many cases embedding it into the tissue.

Approach, assessment and cutting the gear

Entangled whales should be approached slowly and carefully so as not to startle them. Moving down from the whale's head (where it can more easily see the boat when the latter initially gets close) may be a better strategy with some animals than approaching from behind, but this will vary with the whale. Use of a small but stable vessel (e.g. an inflatable boat) which is low to the water is helpful since it allows easier access to the animal. Inflatable boats are less likely to be damaged if a whale lashes out in a startle response, and the lack of a keel on these and some other vessels is useful in cases where a whale comes up under the boat. Inflatables are also easily towed behind a whale when attached to the gear, and they appear to minimise startle reactions relative to other types of boat.

Initial approach to the whale should not be directly behind until the extent of any trailing gear has been determined; the driver of the vessel should be continually vigilant to ensure that there is no possibility of a line becoming entangled in the

propeller(s). Furthermore, if an outboard engine is being used, the driver should be constantly aware of what is happening and be ready to release and immediately pull up the engine out of the water at any moment; again, this is to prevent any line from becoming entangled in the propeller or shaft housing. Lightweight engines are preferable in this regard. Rescuers in Canada consider it essential that a haul-back line is available, attached to a nearby boat or anchor, which can be used to quickly move the rescue boat back away from the whale if it becomes aggressive or active.

An initial assessment of the entrapment is essential. Determining exactly how the animal is trapped will allow the release crew to plan a release strategy. This phase of a release effort was particularly important in Newfoundland as fishermen cooperated with the release programme because a skilled release of the entrapped whale would save their fishing gear. To do this, precisely placed cutting had to be based on good information. Hence, a good survey around the whale with a mask and snorkel while leaning over the side of the boat is an important first step. It is very useful to have a second person monitoring and even sometimes holding onto the individual engaged in the assessment or cutting, especially if these actions require the latter to lean out of the boat.

Randomly cutting gear from a whale is a bad idea. Removing some net or a few lines without attempting to first determine the full nature of the entanglement may make it more difficult to free the whale completely and may do little to remove those parts of the gear with the potential to kill the animal in the long run. For example, if a whale is dragging a number of heavy traps behind it, cutting the trap line will make it much easier for the whale to swim away, but may leave the animal with line that tightly constricts an appendage (notably the flippers or tail). In this case, the whale may die from infection if the line is not removed—but it will now be much more difficult to disentangle because it has been freed of much of its burden and so can easily 'escape'. Consequently, it is important that rescuers attempt to determine the full nature of the entanglement and plan a strategy before any gear is removed. Aerial photographs, when available, are also a very useful (albeit limited) means of assessing entanglements.

Equipment used in disentanglement is sometimes specially designed, but for the most part consists of items available to any fisherman. These include small sharp knives, a variety of gaffs, and small grappling hooks (thrown to grab onto the gear on a free-swimming whale; see Fig. 2). Knives used in cutting gear can be anything from regular commercially available knives to custom-designed blades (Fig. 3). Any knife used should be extremely sharp, allowing for efficient, rapid cutting; a sharpening device should be carried on board at all times. The Center for Coastal Studies notes that many of the looser lines on a whale can be effectively cut from a short distance away using a semi-circular knife blade welded onto the end of a long aluminum pole. Another variant of this design has the blade being detachable from the pole, and secured with a piece of line, the other end of which is made fast to the boat; in this manner, if a whale is moving, the friction generated by the animal's towing of the vessel should result in the blade cutting through the line.

Tighter wraps of line may not be able to be cut using a pole-mounted knife, and it may be necessary for the rescuers to get right up to the animal and cut the rope (or slip a semi-circular blade beneath it). This is frequently the situation in Newfoundland, where rescue personnel feel that

having a whale within 'hand's reach' is usually necessary. In such cases, the rescuers will be touching the animal and in extremely close proximity to it; thus, extreme caution should be exercised at all times. Whales are less likely to startle if all movements and approaches are slow, noise (e.g. banging on the boat) is minimised, and any touching of the animal is done as gently as possible.

With immobile whales, it is important to use buoys on the gear, and especially to buoy off the haul-up rope before it is cut it from the whale; this is to ensure that the fisherman's gear is not lost after the animal has been freed. In some cases this procedure may mean that the gear can be retrieved for later analysis; knowledge of gear type on entangled whales can assist future management policy concerning this issue.



Fig. 2. Grappling tools and quick-release snap hooks. Photo: Center for Coastal Studies, <http://www.coastalstudies.org>.



Fig. 3. Knives and other cutting tools used in disentanglement. Photo: Center for Coastal Studies, <http://www.coastalstudies.org>.

Stopping a free-swimming whale

The first issue that arises when dealing with a free-swimming entangled whale is how to stop the animal so that gear can be removed from its body. The Center for Coastal Studies employs a technique which is a modified version of what 19th century Yankee whalers referred to as 'kegging'. Kegging involved attaching barrels or other large buoyant objects to a harpoon line after the whale was struck; these served to not only allow the whalers to better follow the

animal when it was below the surface, but also to tire the whale out.

In disentanglement attempts, a line is snapped onto some part of the entangling gear, and large plastic floats are then attached to the line to increase drag. These floats vary in diameter from 50cm to more than a meter, and are usually the heavy-duty type that are used (for example) to mark moorings or gear, or to attach to harpoon lines used in fisheries for swordfish, bluefin tuna and other large game fish. They are attached with quick-release snap hooks, and are prevented from sliding by the presence of knots placed at intervals in the line.

As the whale tires, the floats can be repositioned on the line closer to the animal, which has the effect of further decreasing its mobility. Depending on the size and species of whale involved, the number of floats which are required to slow or stop the whale will vary from a few to more than a dozen. Most humpback whales will eventually tire and 'give up' when sufficient buoyancy has been applied to the line; they will often then remain at the surface, allowing rescuers to approach and cut the gear free. As noted above, however, this relatively placid response should not be taken as inevitable in any whale, and extreme caution should always be exercised in close proximity to the animal. Adult right whales are sometimes capable of towing many floats (and also even moderate sized vessels with engines going full astern); see the caveat above on this species.

Education and community involvement

Whenever possible, it is important to involve local fishermen in efforts to disentangle whales. There are several reasons for this. Fishermen are the individuals most likely to encounter an entanglement and to be able to respond to it. They are also usually far more skilled in seamanship and the practicalities of dealing with gear and lines than any whale biologist. In addition, they can often serve as the safety boat which stands by the primary disentanglement operation. Finally, fishermen are much more likely to become involved in freeing whales if they are taught how to do this themselves, rather than having to rely on others (who frequently will not be able to get to the location concerned in a timely fashion). A long-term campaign to involve fishermen in disentanglements in Newfoundland waters has been very successful, and has resulted in the survival of many whales in that area.

Community involvement is also important in the reporting of entanglements. Fishermen and whalewatching vessels have been particularly good sources of such reports off the eastern coast of North America. Creating an expanded reporting network is highly desirable; the scarring study by Robbins and Mattila (2001) suggested that only about 3% of

entanglements in the Gulf of Maine were reported, despite the existence of a reasonably well-developed entanglement network in this region.

Finally, some countries (such as the USA) have laws which prohibit individuals from working with marine mammals without a permit. Anyone who becomes involved in a disentanglement programme should be aware of these regulations beforehand.

REFERENCES

- Baker, C.S., Lento, G.M., Cipriano, F. and Palumbi, S.R. 2000. Predicted decline of protected whales based on molecular genetic monitoring of Japanese and Korean markets. *Proc. R. Soc. Lond. Ser. B*. 267:1191-9.
- Hamilton, P.K., Marx, M.K. and Kraus, S.D. 1998. Scarification analysis of North Atlantic right whales (*Eubalaena glacialis*) as a method of assessing human impacts. Paper SC/M98/RW28 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March 1998, Cape Town, South Africa. [Available from the Office of this Journal].
- International Whaling Commission. 2001. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 3:1-82.
- International Whaling Commission. 2002. Chair's Report of the 53rd Annual Meeting. Annex C. Resolutions Adopted During the 53rd Annual Meeting. Resolution 2001-4. Resolution on the incidental capture of cetaceans. *Ann. Rep. Int. Whaling Comm.* 2001:55-6.
- Knowlton, A. and Kraus, S. 2001. Mortality and serious injury of northern right whales (*Eubalaena glacialis*) in the western North Atlantic Ocean. *J. Cetacean Res. Manage.* (special issue) 2:193-208.
- Knowlton, A.R., Marx, M.K., Pettis, H.M., Hamilton, P.K. and Kraus, S.D. 2001. Scarification analysis of North Atlantic right whales (*Eubalaena glacialis*): monitoring rates of entanglement interaction. Report to the US National Marine Fisheries Service under contract 43EANF030107. [Available from New England Aquarium, Central Wharf, Boston, MA 02110].
- Lien, J. 1994. Entrapments of large cetaceans in passive inshore fishing gear in Newfoundland and Labrador (1979-1990). *Rep. int. Whal. Commn* (special issue) 15:149-57.
- Lien, J., Todd, S. and Guigne, J. 1990. Inferences about perception in large cetaceans, especially humpback whales, from incidental catches in fixed fishing gear, enhancement of nets by 'alarm' devices and the acoustics of fishing gear. pp. 347-62. In: J.A. Thomas and R. Kastelein (eds.) *Sensory Abilities of Cetaceans: Laboratory and Field Evidence*. Plenum Press, New York and London. xiii+710pp.
- Peddemors, V.M. 2001. A review of cetacean interactions with fisheries and management thereof in South Africa. Paper SC/53/E17 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Perrin, W.F., Donovan, G.P. and Barlow, J. (eds.). 1994. *Report of the International Whaling Commission (Special Issue 15). Gillnets and Cetaceans*. International Whaling Commission, Cambridge, UK. 629pp.
- Robbins, J. and Mattila, D.K. 2001. Monitoring entanglements of humpback whales (*Megaptera novaeangliae*) in the Gulf of Maine on the basis of caudal peduncle scarring. Paper SC/53/NAH25 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].

Appendix 8

A WORD OF CAUTION FOR THE NAUTICAL STEPS TOURIST DEVELOPMENT

L. Rojas-Bracho, P. Clapham, J. Urban-Ramirez, S. Manzanilla Niam, R. Brownell, B. Taylor, F. Cipriano and S. Swartz

Both the Pacific coast of the Peninsula of Baja California and the Gulf of California are considered important breeding and feeding grounds for many species of marine mammals. It has been estimated that about 42% of all the cetacean species of

the world have been reported in these waters including blue, fin, sei, Bryde's, minke, humpback, gray and right whales. At least one of these species, the fin whale, has a distinct resident population in the Gulf of California, which is also

one of the two known breeding grounds for blue whales in the North Pacific. The region is also the habitat of many odontocete species including the critically endangered vaquita.

Currently, in waters of the Pacific coast of the Baja California Peninsula and the Gulf of California, these species are relatively undisturbed due to the virtual absence of major cities, coastal development, industry and military exercises. However, there is a chance for potential change if the Nautical Steps or Nautical Route tourist development occurs, as has been proposed by Mexico's Bureau of Tourism. The project consists of a mega-development which would cover more than 2,500 miles of coast; it is aimed at attracting 1.6 million boat owners in California and other nearby US states into a new system of harbours, wharves, hotels, restaurants, golf courses, airports and airstrips. Marinas of the Nautical Steps network would link ports beginning in Ensenada, just south of San Diego, California, to marinas located along the entire western and eastern coasts of the Baja California Peninsula. No more than 120 miles apart, some of the marinas would also be along the main coast of Mexico in Sonora and Sinaloa states, which face Baja across the Gulf of California. Only five such marinas currently exist; others would be expanded or built from scratch.

Additionally, the plan calls for an 84-mile highway route for towing boats from one side of the peninsula to the other. This feature will allow boat travellers quick access to either body of water for those without time or interest in sailing around the southernmost tip of Baja California Sur or to facilitate the return trip due to the strong currents running south. Furthermore, the plan calls for improving the road between Mexicali and San Felipe to allow cross border access to the Upper Gulf of California for larger boat towing rigs. The plan also calls for improvements in 10 existing airports and 10 airstrips to make it easier for tourists to get to the chain of marinas. In this manner, Mexico hopes it will attract year-round mooring and rental income.

In support of the project, Mexico's FONATUR (national fund for the promotion of tourism) anticipates that once completed, no less than 52,000 American boat owners will navigate to those destinations and a significant number will permanently moor in the various marinas. Moreover, the Director of FONATUR estimates that 32,500-76,400 boats will be cruising Baja coastlines by 2010 and that by 2014 there will be 5.4 million nautical tourists (today there are 1.65 million registered boats in the southwestern United States).

According to FONATUR 'the project is not only sustainable from an environmental point of view, but also in terms of profits, and it will improve the socio-economic situation of the communities and local populations, which provides service in the tourist centers, as a way of fighting poverty'.

It is hard to imagine that such a mega-development is 'sustainable from an environmental point of view'. Such a massive development is likely to represent a major blow to the conservation objectives of the natural protected areas in the region: the Biosphere Reserve of the Gulf Islands, the Loreto Bay National Park, the Vizcaino Biosphere Reserve and the Upper Gulf of California and Delta of the Colorado River Biosphere Reserve. From an environmental point of view, this project seems totally incompatible with the Sustainable Development Program of the Sea of Cortes.

If the Nautical Steps project is not carefully planned to be a low-impact development, it will represent a major threat to cetaceans and other marine life in the area. Major potential problems include:

- (1) Increased vessel traffic. The project goal is to increase the number of vessel arrivals from the current approximately 8,000 to 61,500-76,400 by the year 2014. Collision with motorised vessels is a well-known mortality factor for many species of large whales. According to Laist *et al.* (2001), 11 cetacean species are known to be involved in collisions with ships. Mention should be made that except for the right whales (which have occasionally been reported in Mexican waters), all the other species often involved in ship strike fatalities (fin, blue, humpback, gray and sperm whales) are commonly found in the Sea of Cortes and west coast of the Peninsula of Baja California.
- (2) Increase in whalewatching activities along the Baja California coast and outside the breeding lagoons, which will be difficult to control and enforce.
- (3) Noise level. Many of the man-made noises in the ocean occur in the lower frequency range and have a high level of output, which could interfere with or mask the gray whales sounds or possibly damage their hearing (Jones *et al.*, 2003).
- (4) Disturbance of important feeding, breeding and nursing behaviours from increased boat traffic.
- (5) Pollution and ecosystem disturbance from increased sewage, freshwater run-off, fuel spills and other development-related problems.

We propose that the Scientific Committee recommend that the Commission request the Mexican government to take steps to ensure the maintenance of this important cetacean habitat, particularly in the light of the proposed Nautical Steps Project.

REFERENCES

- Jones, M.L., Swartz, S.L. and Dahlheim, M.E. 2003. Census of gray whales in San Ignacio Lagoon in response to unusually low whale counts recorded during an acoustic playback study of noise-effects on gray whales. *J. Cetacean Res. Manage.* 5(1):In press.
- Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. and Podesta, M. 2001. Collisions between ships and whales. *Mar. Mammal Sci.* 17(1):35-75.

Appendix 9

IWC/SO-GLOBEC/CCAMLR COLLABORATION

D. Thiele and S. Moore

This Appendix documents plans for long-term IWC collaboration in circum-Antarctic multidisciplinary, multi-agency approaches aimed at investigating long-term ecological processes in the Antarctic

Presentations, workshop participation, publications and the current timetables for these and field and analysis work under the IWC-SO-GLOBEC collaboration are included in Appendix 2.

FUNDING REQUEST 2002/03

The plans for research are long-term and require a signal from the IWC of its long-term commitment. An annual seeding fund of £25,000 for the next 5-10 years is requested. This funding request should be acknowledged in the context of considerable outside funds from national programmes in support of berths and major scientific initiatives (in the order of US\$100,000,000 per year, and funds from other sources for cetacean programmes (in the order of US\$1 million per year).

WORK TO DATE AND FUTURE PLAN

So far, in the IWC-SO-GLOBEC and IWC-CCAMLR collaborations we have been involved in a number of surveys (Hedley *et al.*, 2001; Thiele *et al.*, 2001) with national programmes that do not usually include cetacean research components in their marine science programmes. Aside from the preliminary results of the surveys, and the involvement of the IWC in analyses, we believe this participation has resulted in a reassessment of the importance of cetaceans in the Antarctic, by many individuals, programme leaders and government agencies, and that this alone is a significant achievement in an area where cetaceans were previously left out of major research initiatives.

Preliminary analysis of data from the two-year field season with SO-GLOBEC has resulted in one overwhelming scientific conclusion: the ecological processes we are attempting to study are long-term in nature and thus require a research effort on a similar temporal scale. It is also clear, that attempting to investigate variability in the complex and diverse environments of the Antarctic ecosystems requires efforts on a large spatial scale, encompassing complimentary fine scale studies.

A follow-on SO-GLOBEC effort is therefore being planned by a group of nations active in Antarctic marine research (USA, Germany, Australia, UK). Each national programme will focus some part of their field and analysis work over the next 5-10 years on achieving the objectives of SO-GLOBEC. This provides the IWC with an enormous opportunity, particularly given the correspondence in objectives between SO-GLOBEC and the IWC noted in previous reports.

RELEVANCE TO THE WORK OF THE SCIENTIFIC COMMITTEE

The SO-GLOBEC (and related initiatives, i.e. CCAMLR) umbrella provides a unique collaborative framework of national science programmes that provide the IWC with an unprecedented opportunity to work alongside all of the marine science disciplines involved in this region, and to make considerable breakthroughs in our knowledge of the complex linkages between physical and biological processes, variability and trends in the system linked to climate, and climate change scenarios. This multidisciplinary, multi-agency approach is well recognised as probably the only means by which we can obtain some predictive capacity in determining the likely impacts of climate change effects on both the physical Antarctic environment and for the marine biota, including whales.

Not only does the work outlined here directly address the recommendations of the participants in the IWC Climate Change Workshop held in 1996 (IWC, 1997), it also directly addresses the directives from the Commission to the SC to investigate climate change impacts on cetaceans. It will also result in significant contributions to the Scientific Committee in many aspects of its work, particularly in a future where relatively rapid changes in climate are already having an unknown impact on processes which drive ocean dynamics, and the distribution and abundance of marine organisms.

THE BROADER CONTEXT PROGRAMME

The IWC has limited capacity for research funding, yet the SWG on Environmental Concerns has been set the task, in a series of Resolutions from the Commission, of developing and implementing collaborations with other international organisations and research collaboratives which are necessarily large in scope, scale and therefore funding requirements. In order to maximise the potential of the IWC's collaboration in the major marine science programmes in this region, funds will need to be obtained outside the IWC.

A core group has been formed from the coordinators of the Steering Groups for IWC-CCAMLR, IWC-SO-GLOBEC and Scripps Institute of Oceanography to develop funding proposals that will cover the majority of costs of cetacean research under the national initiatives, whilst maintaining IWC presence (Moore, NOAA; Hildebrand, SIO; Thiele, IWC SC). This group have some approved programmes in

place, and are developing proposals with national governments for berths and ship time, with the aim of integrating the latest cetacean research methods into these programmes within the context of a much broader scale initiative on ecosystem research in the Antarctic.

This group has submitted proposals to a wide range of sources (national government programmes, trusts etc.) to obtain funding for the majority of the costs of placing observers, sonobuoys and ARP's on a suite of cruises to areas of the Antarctic where moorings can be deployed, and to fund associated fine-scale multidisciplinary cetacean ecological research on an annual basis at two sites (US SO-GLOBEC Amundsen/Belingshausen Sea and Mawson at sea CCAMLR Ecosystem Monitoring Program (CEMP)). An outline of this approach is given in Adjunct 1.

BUDGET REQUEST FROM IWC

To maintain IWC involvement in this long-term research effort we require a commitment to an annual amount of £25,000 for at least five years. This funding would support a co-ordinator for planning, logistics, input to research design, development of long-term research strategy for the whale component, development of funding proposals, reports, some components of analysis and collaborative workshop participation. We have conservatively estimated the funds and level of support from national programmes and other funding sources to support involvement in the research structure outlined above. This figure is in the order of a billion dollars a year, and it is important that the IWC consider this context when determining funding priorities. We consider that this is a unique opportunity towards resolving issues identified by the Commission and the SC as critical to conservation and management of cetaceans.

The request for £25,000 from the IWC is a minor contribution to what will be an enormous multidisciplinary research effort by many nations and these funds will ensure the continued involvement of the IWC in field and analysis work, and provide it with a leading role in the utilisation of significant new tools/techniques applied at a scale which is unprecedented.

The budget breakdown based on last year's costs is given in Table 1.

REFERENCES

- Hedley, S., Reilly, S., Borberg, J., Holland, R., Hewitt, R., Watkins, J., Naganobu, M. and Sushin, V. 2001. Modelling whale distribution: a preliminary analysis of data collected on the CCAMLR-IWC krill synoptic survey, 2000. Paper SC/53/E9 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal.]
- International Whaling Commission. 1997. Report of the IWC Workshop on Climate Change and Cetaceans. *Rep. int. Whal. Commn* 47:293-319.
- Thiele, D., Hofmann, E., Friedlaender, A., Moore, S. and McDonald, M. 2001. Preliminary report on IWC-SO-GLOBEC collaborative research in the western Antarctic peninsula study area, March-June 2001. Paper SC/53/E8 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal.]

Adjunct 1. Outline of Broader Programme

Until only two decades ago, baleen whales (e.g. blue, fin, humpback) were commercially harvested worldwide. While commercial hunting has been curtailed, there remain strong threats to recovery and conservation of these species. Basic information on population size, geographic range and habitat requirements are essential to promote the recovery and conservation of baleen whales.

Baleen whales migrate over vast areas of the world's oceans, so estimating their number and finding concentrations of animals for ecological studies is extremely difficult. The questions are very broad in scale, yet until very recently the available research techniques (visual survey and genetics) were narrow in scope. However, passive acoustics has now proven its capability for monitoring broad areas of the ocean under adverse conditions.

The Scripps Institution of Oceanography (SIO) in collaboration with the US Navy (USN) and the National Oceanic and Atmospheric Association (NOAA) have pioneered the development and deployment of autonomous acoustic recording packages (ARPs) for detection of baleen whales in the eastern Pacific Ocean and in Alaskan and Antarctic seas.

Provisional analysis of ARP data provides a hypothetical model, based on species-specific and/or population-specific call type, which, if applied across ocean basins, provides a means to identify areas in the world ocean where baleen whales concentrate. Broad-scale deployment of ARPs in the southern ocean would provide, in collaboration with

Table 1
Budget breakdown based on last year's costs.

Item	Fund allocation	Description
Observer costs*	£10,000	Travel and salary for IWC observers.
Co-coordinator costs	£10,000	Salary for Thiele (3 months) to coordinate surveys, logistics, planning with international organisations and individual nations and science teams in developing programmes, maximising IWC presence and likelihood of obtaining ship time, data handling, permitting, preparation of presentations and publications in the SO-GLOBEC timetable.
Travel and minor equipment	£5,000	Travel (£4,000): for workshops and meetings for analysis and planning, conferences etc. attendance to make presentations in the SO-GLOBEC/CCAMLR timetable. Minor equipment (£1,000): film for camera and video photo-id, processing costs, scanning and archive.

*Costs presented here will only support a small proportion of observer costs on the US SO-GLOBEC and CCAMLR surveys planned.

international-based visual and biopsy surveys, a non-invasive means to develop effective international conservation plans for these endangered species.

Hemisphere-scale acoustic sampling is proposed via ARP deployments in the Antarctic and (initially) one southern ocean basin, the Indian Ocean (Fig. 1). Recordings from these instruments, in combination with visual/genetic sampling and fine scale ecological investigations conducted via international collaborations will provide a novel dataset for assessment of baleen whale population status and conservation requirements. A plan of this type has never before been addressed for lack of a means to carry it out.

Scripps Institution of Oceanography (SIO) is a pre-eminent oceanographic institution (<http://www.sio.ucsd.edu>). The SIO Marine Physical Laboratory has designed, fabricated and field-tested ARPs throughout the world ocean (www-mpl.ucsd.edu and at www.whaleacoustic.com). SIO experience and collaborations with international research programmes in the Antarctic, (i.e. SO-GLOBEC, IWC, CCAMLR, Australia's SOCEP programme) and individual research efforts place it in a unique position to access a variety of research platforms suitable for deployment and retrieval of moorings and complementary ecological studies.

The research group headed by SIO, includes collaborators affiliated with NOAA and the IWC/Scientific Committee. These affiliations provide direct links to national and international policy makers and resource managers. The team is in a unique position to develop and coordinate the proposed broad scale research effort as a follow-on to the successful study underway in the SO-GLOBEC Western Arctic Peninsula (WAP) area (Fig. 1). Further, team-members' personal involvement in the management of baleen whales through science and policy initiatives at

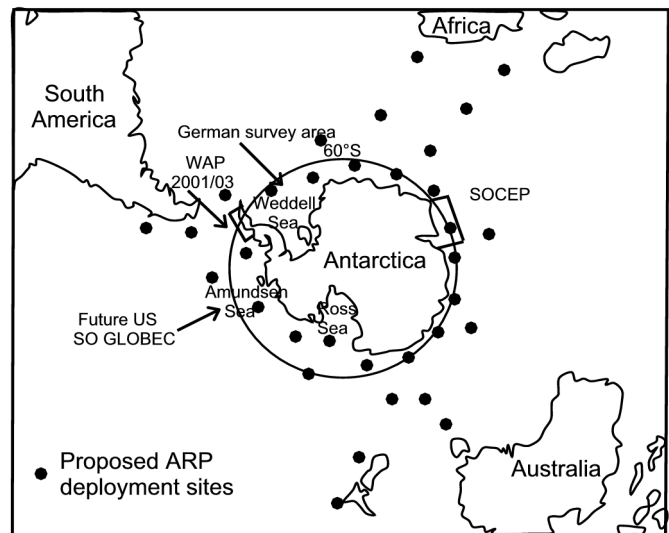


Fig. 1. Proposed deployment of Acoustic Recording Packages (ARPs) in the Southern Hemisphere.

international, regional and national levels will ensure a targeted flow of information.

The initial deployment of 12 (of 36) ARPs is proposed for 2004/05. The remaining 24 instruments will be deployed in sets of 4-12 in years 2006/07, as survey platforms permit. Yearly rotation of instruments is anticipated, working westward from the WAP study area. Visual survey, biopsy and fine scale ecological studies are planned for 2002/03 to 20012/13 via collaborations with the Australian SOCEP programme, under the Antarctic Marine Living Resources Program (AMLR).

Annex K

Report of the Sub-Committee on Small Cetaceans

Members: Read (Chair), Aguilar, Allison, Atkins, Baker, Baldwin, Berggren, Bjørge, Borodin, Brownell, Childerhouse, Cipriano, Clark, E., Collins, Corkeron, Deimer, DeMaster, Diake, Donahue, Donovan, Etylina, Fulford-Gardiner, Funahashi, Gales, Garrigue, Guissamulo, Gunnlaugsson, Hedley, Hung, Iniguez, Jefferson, Karczmarski, Kasuya, Kell, Kim, Kock, Krahn, Larsen, Lens, Manzanilla Naim, Melnikov, Mikhalev, Minton, Northridge, Oosthuizen, Palka, Parra, Parsons, Peddemors, Perrin, Porter, Rambally, Read, Reeves, Reijnders, Ridoux, Rogan, Rojas-Bracho, Rosenbaum, Rowles, Sadler, Senn, Simmonds, M., Sohn, Stachowitsch, Sutaria, Suydam, Swartz, Thiele, Tregenza, Urban-Ramirez, Van Waerebeek, Vikingsson, Wade, Williams, Wilson, Zeh, Zerbini.

1. ELECTION OF CHAIR

Read was elected Chair.

2. ADOPTION OF AGENDA

The adopted Agenda is given as Appendix 1.

3. APPOINTMENT OF RAPPORTEURS

Rogan and Wilson acted as rapporteurs.

4. REVIEW OF AVAILABLE DOCUMENTS

Documents relevant to the work of the sub-committee were: SC/54/SM2-37, SC/54/O4 and SC/54/O22.

5. REVIEW OF STATUS OF HUMPBACK DOLPHINS

On several occasions in the past, the Scientific Committee has expressed concern regarding the status of humpback dolphins (genus *Sousa*). This concern has arisen from the existence of potentially unsustainable bycatches in gillnet fisheries, as well as in shark control nets in South Africa and Australia (Perrin *et al.*, 1994), high levels of contaminants, and extensive habitat degradation in many areas of its range (e.g. IWC, 1999, pp.211-215). Humpback dolphins are obligate shallow water animals (Ross *et al.*, 1994; Jefferson and Karczmarski, 2001) that may be particularly vulnerable to the effects of anthropogenic activities, such as commercial fisheries and habitat modification in near-shore waters. At this year's meeting, the sub-committee examined the status of this genus throughout its range.

5.1 Systematics

The taxonomy of humpback dolphins (genus *Sousa*) is confused. Recent reports have suggested the existence of from one to five species within the genus. The classification proposed by Rice (1998) identifies three species: *S. teuszii*, *S. plumbea* and *S. chinensis* in the Atlantic, Indian and Indo-Pacific Oceans, respectively. In contrast, the IWC has preferred to be conservative in the face of uncertainty and currently recognises only two species: *S. teuszii* (the Atlantic humpback dolphin) and *S. chinensis* (the Indo-Pacific humpback dolphin) (IWC, 2001b).

SC/54/SM8 addressed the taxonomy of *Sousa* in an analysis of cranial morphometrics, measured from 181 skulls from throughout most of the range of the genus. Condylbasal length varied greatly, perhaps reflecting concomitant geographical variation in body size. Tooth counts were more conservative, although specimens from West Africa had lower tooth counts than animals from other areas. A Principal Components Analysis (PCA), performed using morphometric and meristic characters from adult skulls, resulted in the calculation of three principal components. A scatterplot of the first two components did not reveal clear-cut separation of geographical forms. When polygons were drawn around specimens from West Africa, western Indian Ocean and eastern Indian/Pacific Ocean, however, it was possible to discern some evidence of separation of samples from the three areas. Specimens from West Africa did not overlap with those from the western Indian Ocean, but showed strong overlap with those from the eastern Indian and western Pacific Oceans.

This finding is in contrast to geographical variation in gross external morphology and colouration. Humpback dolphins from West Africa and the western Indian Ocean exhibit a prominent dorsal hump and are uniformly grey in colour, while those from the eastern Indian Ocean and western Pacific lack the dorsal hump and are light grey to white as adults, often with prominent darker spots. Colouration changes in early post-natal development from dark grey to light in the eastern Indian Ocean, but not in western Indian Ocean and Atlantic *Sousa*. Parra informed the sub-committee that Graham Ross was currently revising the taxonomy of this genus based on morphology and colouration patterns. The sub-committee looks forward to receiving this update.

The preliminary analysis of cranial morphology underscored the variability of this genus and emphasised the need for additional research with larger samples, but no revisions of the IWC's current taxonomy were proposed.

Peddemors presented a synopsis of a thesis on geographical variation in skull morphometrics of *Sousa* (Limpers, 1998). The analysis was based on 16 morphological features, measured from 54 specimens in the

collection of the Zoological Museum of Amsterdam. The authors suggested that a cluster analysis showed clear separation of *S. teuszii* from *S. chinensis*, which was comprised of more than one group. However, it was not possible to fully evaluate this analysis, because the entire dataset was not available for examination.

SC/54/SM34 reviewed phylogenetic relationships and population structure of this genus, primarily from Southeast Asia, the coast of Oman and South Africa. A total of 110 samples were sequenced for 501bp of mtDNA control region. Additionally, a 358bp fragment of the Cytochrome B gene was amplified from a subset of samples. A maximum of 25 variable nucleotide positions, defining 27 unique haplotypes, were detected among the 110 mtDNA control region sequences. An AMOVA showed statistically significant variance among groups (southeast Asia, northern Indian Ocean, southern Indian Ocean; $\Phi_{ST} = 0.879$, $P = 0.000$). Variance among sites was also statistically significant when haplotype frequencies alone were analysed ($F_{ST} = 0.394$, $P = 0.000$). All pairwise comparisons using molecular information (Φ_{ST}) and haplotype information (F_{ST}) were highly significant ($p < 0.001$) for populations with sample sizes greater than or equal to 10 (Hong Kong, Xiamen, South Africa and Oman). Maternal lineages were only shared across Hong Kong, Pearl River estuary, Taiwan and Xiamen groups. The Pearl River lineage was found in the samples from Hong Kong, Taiwan and Xiamen; three other lineages (one for each pairwise comparison) were shared between Hong Kong, Taiwan and Xiamen.

Population aggregation analysis revealed four fixed, diagnostic nucleotide characters that distinguish humpback dolphins in the Indian Ocean (Oman, South Africa, Madagascar) from those in the Pacific Ocean (southeast Asia). Two diagnostic nucleotide characters and one private maternal lineage were found among the samples from Madagascar and South Africa. There were no diagnostic characters for samples from Oman. To examine the relationships of all unique haplotypes, a phylogenetic analysis of the mtDNA control region sequences was performed. Preliminary phylogenetic analysis suggested three principal clades among the sampled populations of humpback dolphins: a monophyletic clade containing all humpback dolphins from the Pacific (southeast Asia); a clade containing only Oman humpback dolphins; and a clade containing humpback dolphins from Madagascar, South Africa and a single lineage with two individuals from Oman. Indian Ocean maternal lineages were polyphyletic with respect to the overall topology. The clade containing only Oman lineages is sister to the clade containing all lineages from southeast Asia.

The results obtained from mitochondrial DNA control region analysis of humpback dolphin populations is intriguing, but preliminary and must be interpreted with caution. Both the population genetic and phylogenetic approaches reveal strong regional structuring among the populations examined. No maternal lineage haplotypes were shared between humpback dolphins in the southern Indian Ocean, northern Indian Ocean, or Pacific Ocean. The results from population genetic analyses suggest that strong population structuring occurs in this genus, both within and across ocean basins.

Applying a phylogenetic approach to analysing the mtDNA data is complicated because it is not known if the variation observed among humpback dolphins represents inter- or intra-specific variation. However, the finding of well-supported regional clades provide operational populations for testing hypotheses about species

designations. The phylogenetic results are less straightforward. Four fixed nucleotide characters differentiate all lineages sampled in the Indian Ocean from lineages in the Pacific Ocean. Yet the phylogeny shows that Indian Ocean lineages are polyphyletic, with one clade of lineages from Oman more closely related to humpback dolphins from southeast Asia, and a second lineage from Oman more closely related to lineages from the southern Indian Ocean than they are to other lineages from Oman. Therefore, the relationship between humpback dolphins in the Indian and Pacific Oceans cannot be further resolved until additional character data are included. An initial combined analysis, using both the mtDNA control region and a 358bp fragment of Cytochrome B resulted in topology identical to the mtDNA control region phylogeny. Given the ancestral polymorphism that could exist within the mtDNA sequences for analysis at the population-species level, the relationship between Pacific and Indian Ocean clades needs to be examined with additional character data from nuclear gene regions and morphology.

The lineage from Oman that forms a clade with samples from Madagascar and South Africa is comprised of two animals found stranded near Mughsayl. These are the only two samples from this region, and were obtained well south-west of the locations of other samples from Oman. The grouping of this lineage with the southern Indian Ocean lineages is well supported. Further sampling in this region of Oman, as well as in the Gulf of Aden, Horn of Africa/Somalia and the Red Sea should yield new insight into the population affiliation of these two specimens, which may be distinct from the populations of humpback dolphins in eastern Oman. With additional samples from this region and others from areas further to the east (e.g. India, Malaysia), it will be interesting to examine whether:

- (1) there is continued support for an African/western Arabia clade that unites the southern Indian Ocean and some parts of the northern Indian Ocean that is separate from populations to the east;
- (2) a more close evolutionary relationship exists between humpback dolphins from Oman with those from the Pacific Ocean.

The sub-committee agreed with the conclusion of the report that it would be premature to draw any firm conclusions concerning the taxonomy or systematics of humpback dolphins from these preliminary analyses. Therefore, the sub-committee recommends that the current IWC classification of two species be maintained for the time being, but recognises that this classification may require future revision. The sub-committee also recommends the use of the common name 'humpback' instead of 'hump-backed' for dolphins of this genus.

To provide a more complete systematic analysis of this genus, the sub-committee recommends the following:

- (1) Expanded morphological and molecular sampling throughout the range of the genus.
- (2) Representative sampling of humpback dolphins from areas in which samples have not yet been included in molecular analyses, such as Australia, India, Malaysia, Mozambique, Tanzania, the Persian Gulf, Gulf of Aden, Red Sea and West Africa.

In certain areas, such as southeast Asia, southern Africa, and the northern Indian Ocean, it may be possible to test hypotheses concerning the regional population structure of humpback dolphins. The sub-committee recommends that

this work continue to be conducted, so that gene flow within and between populations can be evaluated using molecular data.

5.2 Distribution and stock structure

Humpback dolphins occur in coastal waters of the eastern Atlantic, Indian and western Pacific Oceans (Jefferson and Karczmarski, 2001). Current knowledge regarding the distribution of this genus is given in Fig. 1. The distribution presented in Fig. 1 is derived from known and verified sightings or stranding records. Therefore, gaps in the distribution should be interpreted with caution, as they may represent real distribution gaps or gaps in our current knowledge due to a lack of research effort. SC/54/SM9 reviewed the distribution of humpback dolphins in western Africa. In this region, humpback dolphins have a discontinuous distribution from Dakhla Bay (Morocco), through Banc d'Arguin (Mauritania), Saloum-Niumi (Senegal – N. Gambia), Canal do Geba-Bijagos (Guinea-Bissau) and southern Guinea. Despite ongoing research, there have been no reports of humpback dolphins along a 720km length of coastline from eastern Benin to the Ivory coast. This area appears to be unsuitable habitat. There is no information on humpback dolphins in Liberia or Sierra Leone but records exist from Cameroon and Gabon. Rosenbaum noted that *Sousa* has not been recorded during systematic surveys of the waters of Gabon in recent years. Anecdotal records suggest that the genus may also be present in northern Angola. There are no records of humpback dolphins from northern Angola to South Africa and it is believed that this represents a real distributional gap.

In South Africa, *Sousa* have been recorded as far west as False Bay, Western Cape and are distributed along the coast into the Indian Ocean, with areas of high density apparently

spatially separated (SC/54/SM22, 25, 37). Humpback dolphins are present in some locations in Mozambique (SC/54/SM15, 28), Kenya (Weru, 2001) and Tanzania. *Sousa* have also been recorded along the western coast of Madagascar (SC/54/SM33), Mayotte (SC/54/H9) and from Zanzibar.

In the Arabian region, the range of humpback dolphins includes much of the Arabian Gulf, Arabian Sea, Gulf of Aden and Red Sea (SC/54/SM6, 26). There are records of *Sousa* from Somalia, the Gulf of Suez, Saudi Arabia and Yemen, but the distribution of humpback dolphins in this region is poorly known. *Sousa* form a large proportion of small cetacean strandings in Oman (SC/54/O4), but their range extends only as far north as Ra's Al Hadd. A hiatus in distribution extends as far north as Musandam. Humpback dolphins are present in the Arabian (Persian) Gulf, with records from the United Arab Emirates, Qatar, Bahrain, Saudi Arabia, Kuwait, Iraq and Iran.

Pilleri and Gahr (1972) documented the occurrence of *Sousa* in Pakistan and recent sightings confirm that humpback dolphins occur in this area (SC/54/SM35). Information on the distribution of humpback dolphins in India was derived from sightings, strandings and incidental catches (SC/54/SM35). In western India, *Sousa* is distributed more or less continuously from the Gulf of Kachchh to Kanyakumari. There are no records of humpback dolphins from Sri Lanka. There is limited information from Kanyakumari to Tamil Nadu and Andhra Pradesh, but the distribution is more or less continuous from there to the Bay of Bengal and Bangladesh.

Jefferson presented information on the distribution of humpback dolphins in southeast Asia from a number of sources, including strandings, live captures, sightings and skulls found at museums and whale temples. There are

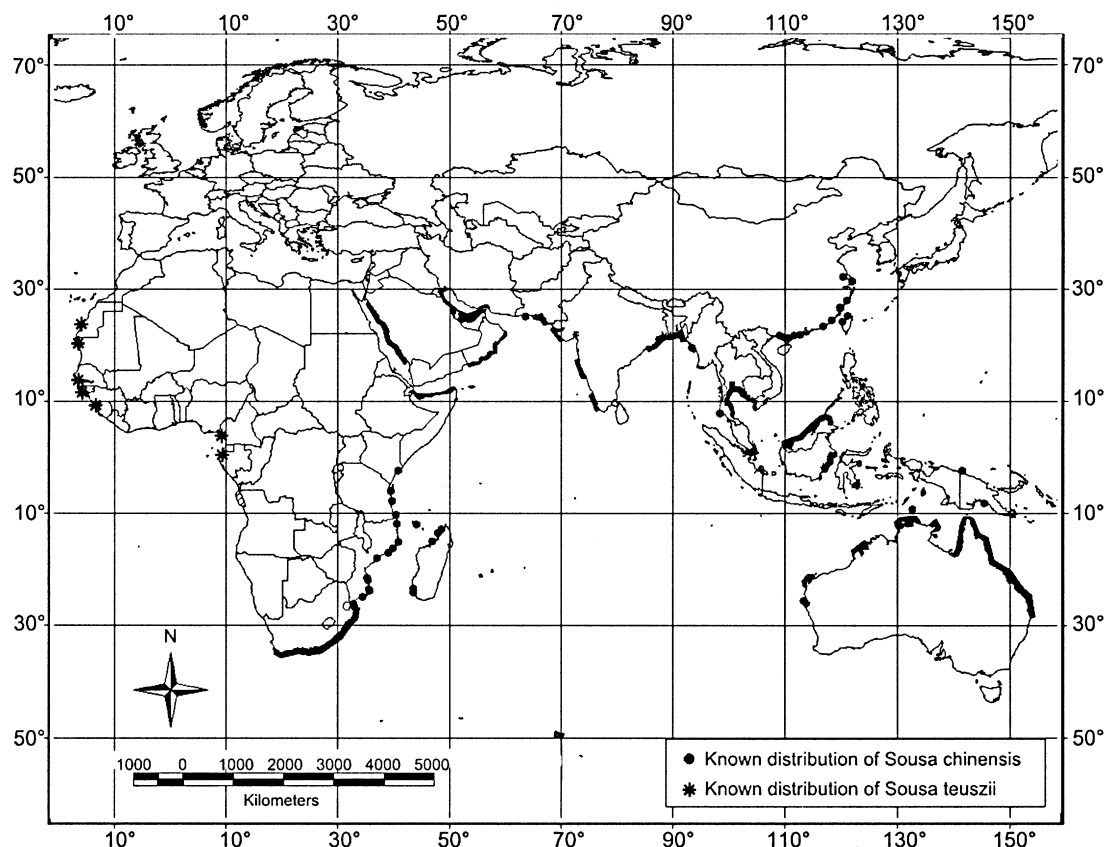


Fig. 1. Known distribution of *Sousa chinensis* and *S. teuszii*. The map depicts known occurrences only; gaps may represent a true hiatus in distribution or merely a lack of knowledge. Knowledge of the distribution of these species is fragmentary and some records may be outdated.

reports of *Sousa* from Myanmar, the Gulf of Thailand, Vietnam, Malaysia, Indonesia, Brunnei, Singapore and Papua New Guinea (Jefferson and Karczmarski, 2001). There are no records from the Maldives, Solomon Islands or East Timor. Perrin reported an absence of *Sousa* in most of the Philippines, despite many surveys. There is a record of a single stranding in the western Philippines, part of the Bornean faunal region.

SC/54/SM7 provided detailed information on the distribution of *Sousa* in China. Humpback dolphins are apparently discontinuously distributed and range from the border with Vietnam north to the mouth of the Yangtze River, and are found frequently at the mouths of major estuaries. Of these, Hong Kong and the Pearl River Estuary are the best studied. In Taiwan, there are sightings records from the west coast, but humpback dolphins are apparently absent from the east coast, where the continental shelf is narrow and habitat is unsuitable.

In Australia, humpback dolphins are distributed discontinuously from Ningaloo Reef in Western Australia to Brisbane in Queensland (SC/54/SM27). Gales reported a confirmed sighting from Shark Bay, but Berggren noted that humpback dolphins are very rare in this well-studied area. An apparent gap in distribution in the Gulf of Carpentaria and Ningaloo Reef is probably the result of a lack of survey effort. Perrin reminded the sub-committee of bycatches of humpback dolphins in a Taiwanese shark gillnet fishery, which operated in the northern Australian Exclusive Economic Zone in the 1980s (Harwood and Hembree, 1987). This fishery now operates in Indonesian waters of the Timor and Arafura Seas.

5.3 Abundance

There are few estimates of the abundance of humpback dolphins in any parts of their range. Estimates derived from line transect surveys or photographic capture-recapture methods are presented in Table 1.

Corkeron described the early stages of development of an acoustic approach to estimate density of humpback dolphins (SC/54/SM29). This approach uses a simple hydrophone and recording device to monitor the number of vocalisations. Humpback dolphin repertoires were easily distinguishable and regression equations indicate that the mean number of calls increases with school size (usually <9 individuals). Such an approach might complement traditional visual surveys to provide information on habitat utilisation and relative density, particularly in areas where such visual surveys are not feasible. The sub-committee welcomed this approach and encouraged its future development.

There was discussion about the most appropriate methods (e.g. photographic capture-recapture or line transect) to estimate abundance of humpback dolphins. A combination

of methods, as employed in Hong Kong and the Pearl River Estuary (SC/54/SM7), provides information on the potential biases of each method. This may not always be possible however, due to limitations imposed by habitat, animal behaviour, or logistical reasons. As noted by Wilson, the most appropriate method to estimate abundance of this species is the one most suited for the region, population characteristics and research objectives.

In summary, there are very few estimates of abundance for humpback dolphins in any part of their range and trend data exist at only one site, Hong Kong. However, in comparison with many other small cetaceans, humpback dolphins are not very abundant in any part of their range. The discontinuous distribution of the species likely reflects the existence of pockets of suitable and available habitat, and possibly local extirpations and range reductions. The sub-committee **recommends** that abundance estimates be derived for other areas.

5.4 Seasonal movements

Seasonal movements of humpback dolphins occur in many, but not all areas of the range. These movements appear to be rather diffuse, rather than co-ordinated migrations. In Richards Bay, South Africa, a small group of dolphins appear to be resident (Durham, 1994), while others range over larger areas (SC/54/SM25). At least one photographic match has been made between individuals in Richards Bay and those in Durban, 150km away. Seasonal movements have been found in Hong Kong (SC/54/SM7); Algoa Bay, South Africa (SC/54/SM14); and in Maputo Bay, Mozambique (SC/54/SM28). In some areas, including Hong Kong and Pearl River Estuary (SC/54/SM4; Jefferson, 2000), these movements may be associated with an increase in freshwater input into estuaries during the rainy season, possibly associated with seasonal variation in food availability. Parsons summarised other information on seasonal movements of humpback dolphins from other areas (SC/54/SM4). In Kwa-Zulu Natal, there is an increase in humpback dolphin bycatch in shark control nets in summer and autumn (Cockcroft, 1990) and in Hong Kong, seasonal movements and changes in abundance are linked to the hydrography of the Pearl River (SC/54/SM4; Jefferson, 2000).

5.5 Life history

There is very little information on the life history of this genus, existing data come almost exclusively from South Africa and Hong Kong (SC/54/SM22; Jefferson, 2000). Gestation lasts for approximately 12 months and calves are born at lengths of between 90-115cm. In South Africa, age at sexual maturation was estimated to be approximately 10 years in females and 13-14 years in males; limited

Table 1
Abundance estimates of humpback dolphins throughout their range.

Area	Abundance (95% CI)	Method	Reference
Kwa-Zulu Natal, S. Africa	160 – 165 (134-229)	Capture-recapture	Durham (1994)
Richard's Bay, S. Africa ¹	170 (112 – 230) 244	Capture-recapture	SC/54/SM25
Richard's Bay, S. Africa ¹	(217 – 287)	Capture-recapture	SC/54/SM25
Algoa Bay, S. Africa	466 (447 – 485)	Capture-recapture	Karczmarski <i>et al.</i> (1999)
Maputo Bay, Mozambique	105 (30 – 151)	Capture-recapture	SC/54/SM28
Hong Kong/Pearl River estuary, PRC	1,028	Line transect	Jefferson (2000)
Xiamen, PRC	80 (CV = 1.08)	Line transect	SC/54/SM7
Moreton Bay, Australia ²	119 (81 – 166)	Capture-recapture	Corkeron <i>et al.</i> (1997)
Moreton Bay, Australia ²	163 (108 – 251)	Capture-recapture	Corkeron <i>et al.</i> (1997)

¹ Estimated using different models; ² Calculated in two different periods.

observations suggest a similar range for humpback dolphins in Hong Kong. There is evidence of sexual dimorphism in South Africa, with males reaching an asymptotic length of 269cm, while females reach an asymptotic length of 242cm. The oldest animals aged to date were 34 years of age in Hong Kong and 46 years in South Africa. The calving interval in South Africa was estimated to be three years. Reproduction is diffusely seasonal in both areas, with a peak of births occurring during spring and summer. In many ways, these life history parameters, although derived from limited information, are similar to those of bottlenose dolphins from the Gulf of Mexico (e.g. Wells and Scott, 1990). These similarities should allow parameterisation of demographic models for *Sousa* using surrogate data from *Tursiops*.

The sub-committee **recommended** that more work on the life history of this species be carried out in the different regions, particularly in areas where samples of stranded or bycaught specimens are available. In other areas, some of this information can be derived from longitudinal studies using photographic identification techniques. A longitudinal approach offers particular promise to improve understanding of fecundity, mortality and immigration/emigration rates, but requires a substantial (decadal) time investment by individual researchers.

5.6 Ecology

Humpback dolphins are essentially coastal animals, inhabiting estuaries, river mouths and near-shore waters where mangroves, sandbars, rocky outcroppings or reefs harbour prey (Jefferson and Karczmarski, 2001). Most sightings have been made in water depths less than 25m, although the existence of populations in adjacent areas separated by deep water suggests that individual dolphins may traverse deeper waters on occasion.

Data on feeding ecology are also limited, with most data from the stomach contents of stranded or bycaught animals from Hong Kong, Xiamen and South Africa (SC/54/SM22; Jefferson, 2000). Most prey items are small estuarine or reef fish (SC/54/SM4) and some prey species are also commercially important. In Hong Kong, very few cephalopods, holothurians or crustaceans occur in the diet, but Baldwin noted that cephalopods and crustaceans were consumed in the Arabian Sea. In Hong Kong, humpback dolphins often associate with fishing vessels, primarily demersal pair trawlers (SC/54/SM4; Jefferson, 2000). Some individual dolphins are seen repeatedly behind trawlers, but other animals rarely associate with these fishing vessels.

As noted above, there is evidence of site fidelity in some areas. Along open coastlines, site fidelity is weak, and seasonal movements may be more pronounced. In the Algoa Bay region the majority of animals are involved in long-range movement, probably approximately a few hundred kilometers along the shore (Karczmarski *et al.*, 1999). Females show increased site fidelity before parturition and during the nursing period. In sheltered areas or areas protected by lagoons (for example, Maputo Bay, Mozambique; SC/54/SM14), there can be a higher degree of site fidelity, on a population/group level.

Sousa exhibit a fission–fusion society, structured to some degree by sex and age, with few long-term associations except for mother–calf pairs (SC/54/SM14). Solitary animals (perhaps males) have been seen frequently in the Eastern Cape, and may be engaged in mate searching (Karczmarski *et al.*, 1999). Group size varies among sites, but in general, humpback dolphins are found in small groups of less than fifteen animals. The sub-committee agreed that the social structure may vary from region to region.

5.7 Habitat

Hung presented a detailed analysis of humpback dolphin habitat use in Hong Kong (SC/54/SM36), based on 2,460 sightings made up to March 2002. The survey area was divided into 1km grids to examine patterns of habitat use and the effect of anthropogenic activities on humpback dolphins. The sighting data have not yet been standardised for effort, but a preliminary analysis suggests that dolphins are found most frequently near Lantau Island, in an area influenced by freshwater input from the Pearl River. This shallow, estuarine area supports abundant fisheries resources that are important prey for humpback dolphins. The sub-committee welcomed this approach and encouraged further development of the habitat analysis. Future work will examine diurnal, seasonal, and inter-annual variation in the distribution of humpback dolphins, as well as the effects of other factors such as water quality and depth. In addition, overlap in the distribution of finless porpoises will be examined and a critical habitat index derived to help describe preferred habitat of these two species.

Throughout its range, *Sousa* appears to be tolerant of variation in salinity. Humpback dolphins occur predominately in high salinity areas in Mauritania and Senegal, whereas in most other areas, such as Hong Kong, they are associated with relatively low salinities and large freshwater inputs.

Mangroves, reefs and coastal lagoons are important habitat in many areas of the range of this genus, such as Mozambique (SC/54/SM15). In other areas, rocky outcrops are important habitat, such as in western Madagascar (SC/54/SM33) and Eastern Cape, South Africa (SC/54/SM15; Karczmarski *et al.*, 1999). In Hong Kong, one of the most modified coastal habitats in the world, the bottom substrate is relatively uniform, but humpback dolphins often occur in shipping channels (SC/54/SM36). Although humpback dolphins are able to exist, to some degree, in the face of heavy shipping traffic, dredging, land reclamation and coastal development, the sub-committee noted that the continued presence of humpback dolphins in highly degraded habitats, such as the waters around Hong Kong, does not rule out adverse effects of habitat degradation. There is no long-term time series of relative abundance for this genus in any area of its range with which to measure the effect of such environmental degradation. In areas with patchy distribution of inshore suitable habitats (for example, west and southern/east Africa) habitat degradation can be a serious threat to *Sousa*.

5.8 Directed takes

With the exception of Madagascar, there is little evidence for intensive direct exploitation of humpback dolphins. In some areas, however, it is difficult to differentiate direct from incidental takes. In other areas, directed takes are illegal and estimation of their magnitude is difficult to quantify. For example, in Senegal and the Gambia, areas of rapid human population growth and, therefore, a high potential for cetacean consumption, Van Waerebeek noted that it is likely that some dolphins are killed regularly. This practice is illegal, however, and carcasses are often butchered at sea, or their remains buried on shore. A similar situation may exist in Mozambique. Berggren noted that dolphins used to be hunted in Menai Bay, Zanzibar, for human consumption and for bait in the long-line shark fishery. However, this hunt has in recent years (1997) been replaced by dolphin tourism.

SC/54/SM33 presented information on directed takes of humpback dolphins in Madagascar. Interviews and surveys at fishing camps made in 1999 in southern Madagascar

revealed that humpback dolphins have been hunted with harpoons and taken directly in gillnets. Since gillnets were introduced in 1985, fishermen have been using nets rather than harpoons. The fishing period typically occurs between August and December and, in general, dolphin meat is sold or consumed locally. There is also some evidence of a drive fishery for small cetaceans in this region. Twenty-two humpback dolphins were reported taken in Anakao between 1985 and 1999. No bycatch was reported from this area, but 30 stranding events were reported, which may or may not have been human induced. When few dolphins are caught, the meat is shared among family members or sold to local villages. Trade into larger urban areas occurs with larger harvests. The actual magnitude of this fishery is unknown and there is insufficient information to evaluate the impact of these directed takes on affected stocks.

Small numbers of humpback dolphins have also been hunted in the Arabian Sea and Red Sea (SC/54/SM6). Recent evidence, based on observations of butchered animals in Oman and interviews with fishermen from parts of Oman suggests that this practice still occurs to some extent. Anecdotal and photographic evidence indicates that dolphins are still hunted in Oman from small, motorised boats, using hand-held harpoons. The magnitude of this directed take is unknown.

Gales and Jefferson informed the sub-committee that there are reports of live captures of humpback dolphins from the Gulf of Thailand for the oceanarium trade. At least forty-five dolphins, including *Orcaella* and *Sousa* have been captured from this region. Additional mortality post-capture is of concern.

There was also a deliberate capture of 36 humpback dolphins from Xiamen Harbour, China, from 1960-1962, by the Fisheries Research Institute, with the goal of reducing competition with fisheries, together with an attempt to determine if leather could be made from skin (SC/54/SM7). There is no evidence of any large-scale fishery for this species in Chinese waters in the past, nor is there any recent evidence of directed takes.

There have been no recent directed takes of humpback dolphins in Australia, but live captures for the Australian aquarium trade from the Queensland coast were reported from the 1960s, with one of these captured dolphins still surviving today (SC/54/SM27).

5.9 Incidental takes

Incidental takes have been recorded from almost all areas of the range of this genus. With the exception of some shark control programmes, there have been no observer programmes from which bycatch estimates could be generated. Consequently, it is difficult to evaluate the magnitude of this threat in most areas. Most evidence for bycatch comes from observations of strandings, interviews with fishermen and personal observations. In some areas, where it is illegal to possess products from small cetaceans, detection of bycatch is particularly difficult (e.g. SC/54/SM9).

Van Waerebeek presented historical references and recent observations of bycatches of humpback dolphins from West Africa (SC/54/SM9), with takes reported from a number of gear types, including octopus lines, gillnets and beach seines. Mortality from gillnets may be substantial in many areas of West Africa, although quantitative data are lacking, as elsewhere (Perrin *et al.*, 1994). Fishing effort in Guinea-Bissau and Senegal have increased rapidly in recent decades (SC/54/SM9).

Humpback dolphins are taken as bycatch in shark control nets in South Africa (SC/54/SM37). A minimum of 149 dolphins have been recorded entangled in these nets, with 52% of this bycatch reported in Richards Bay, north of Durban. Current mitigation measures include the use of acoustic alarms and reduction of fishing effort. A second trial, using air-filled floats to increase the reflectivity of the net to echolocating dolphins, is to commence in May 2002.

In northern Mozambique, some humpback dolphins are taken in beach seine nets (SC/54/SM28). Humpback dolphins are used by fishermen to indicate the presence of fish in Maputo Bay. No information is available on dolphin bycatches from industrial fisheries in Mozambique. Humpback dolphins are also caught in a gillnet fishery for sharks in Madagascar (SC/54/SM34) and Berggren noted that they are also taken in drift and bottom-set gillnets in Zanzibar. Karczmarski reported that occasional incidental catches have been reported from Lamu, Kenya and bycatch is also known to occur in the trawl fishery for shrimp in India (SC/54/SM35), although levels have not been quantified.

Observations of stranded dolphins in Oman shows that a high proportion of these strandings have net marks or other physical trauma consistent with net entanglement (SC/54/O4). In this area, it is difficult to discern whether these mortalities were deliberate or the result of entanglement in fishing gear. Portions of some of these carcasses are used as shark bait.

Skeletal remains found at whale temples and museums in Vietnam provide indirect evidence of bycatch in these waters, although it is possible that some of these skulls may have been obtained from stranded animals.

In Hong Kong, information on interactions between humpback dolphins and fisheries is derived from strandings and from observations of live animals (SC/54/SM7). Bycatches of dolphins in gillnets and trawl nets are known to occur, but the magnitude of this mortality has not been estimated. Within Hong Kong harbour, there is a small-scale gillnet fleet and a large number of pair trawls. Dolphins often feed behind trawlers and there is evidence of occasional capture in these nets. Ship strikes of humpback dolphins have also been recorded in Hong Kong (SC/54/SM4).

Parra and Corkeron noted that incidental mortality of *Sousa* in Australian waters occurs in inshore gillnets set across creeks, rivers and shallow estuaries for barramundi (*Lates calceifer*) and threadfin salmon (*Polynemus sheridani* and *Eleutheronema tetradactylum*) (SC/54/SM27). However, there are no estimates of the magnitude of these indirect takes. Regulations to reduce the incidental take of non-target species in the gillnet fishery (e.g. net attendance rules, gear modifications) have been introduced, but surveillance and enforcement is lacking in remote areas. New policies on bycatch are being developed in Australia, which may help to reduce the incidental mortality of humpback dolphins in gillnet fisheries.

In a recent analysis of the effects of shark control nets on non-target species (Gribble *et al.*, 1998), it was estimated that between 1962 and 1995, an average of 19.2 dolphins (of all species) were caught each year. This was reduced to 12.5 animals per year from 1992-1995. However, the species composition for most of the dolphins prior to 1992 is unknown. Data from the Queensland Shark Control Programme (QSCP) suggest that, on average, one humpback dolphin is taken annually in these nets. However, these incidental takes appear to be localised. Some mitigation measures are currently in place to reduce dolphin mortality in these nets and the response of humpback dolphins to

acoustic alarms is currently being evaluated. The sub-committee welcomed these initiatives and **recommended** that any dolphins captured in these nets be recovered for post-mortem examination to obtain information on life history and stock structure. It would be useful if information on the bycatch of dolphins in Australian shark control nets be reported on a finer geographical scale.

Interactions between humpback dolphins and trawlers have been reported from Moreton Bay, Australia (SC/54/SM27), but the effect of these interactions has not been quantified. In the past, humpback dolphins (together with spinner and bottlenose dolphins) were caught in a Taiwanese offshore drift net fishery that operated in the Arafura and Timor Seas (Harwood and Hembree, 1987). This fishery no longer operates in Australian waters, but may still be taking humpback dolphins in Indonesia.

5.10 Other

SC/54/SM5 reviewed published literature on the potential impacts of pollutants on Indo-Pacific humpback dolphins. Although data on contaminant levels are lacking through most of the species range, such information exists for dolphins in Hong Kong. Studies on contaminant levels in sediments in Hong Kong and the Pearl River estuary have pointed to widespread organochlorine contamination in these waters, with elevated PCB and DDT concentrations. Other pollutants that may pose a risk to humpback dolphin populations include butyltins, Polynuclear Aromatic Hydrocarbons (PAHs) and sewage born pathogens (viruses and bacteria).

PCB concentrations of up to 125 parts per million (ppm) lipid weight and DDT levels of 381 ppm have been recorded from humpback dolphins in Hong Kong. The concentration of DDT to its metabolites (DDD and DDE) was high, suggesting that the animals are living close to a source of DDT. This is consistent with core sediment sample analysis which indicates the entry of organochlorines into the Pearl River system between 1992 and 1994.

The sub-committee discussed the possible health implications of these contaminants. Half of stranded animals examined in Hong Kong had PCB levels above which toxic effects might be expected (Kannan *et al.*, 2000), and 44% had PCB levels above which increased levels of infectious disease were reported in UK cetaceans (Jepson *et al.*, 1998). The TEQs (TCDD Toxic Equivalents) for dioxin-like PCBs from Hong Kong dolphins were nearly double the blubber TEQs recorded in seals exhibiting symptoms of organochlorine-induced immune suppression (Vos, 2000). An area of particular concern is the effect of organochlorines transferred to humpback dolphins calves from their mothers' milk. A high proportion of stranded cetaceans in Hong Kong are neonatal animals and it has been suggested that this may be linked to organochlorine contamination via lactation.

Studies of organochlorines in sediments of other areas of the habitat of humpback dolphins in China and west India demonstrate levels similar to those recorded in the Pearl River estuary. Therefore, organochlorine contamination could be an issue for the health of these populations. SC/54/SM22 reported DDT concentrations of 131 ppm and 50 ppm of PCB congener 1260 in South African humpback dolphins, the highest levels of any marine mammals sampled from that region.

Parsons suggested that the elevated concentrations of pollutants observed in tissues of humpback dolphins from Hong Kong indicate that pollution may pose a risk to the

health of dolphins in this area and by virtue of similar contamination in other habitat, possibly to *Sousa* populations in other regions.

SC/54/SM16 contained new information on the incidence of epimeletic behaviour in humpback dolphins in Hong Kong. Epimeletic behaviour has been reported in a number of cetacean species, including bottlenose dolphins and killer whales. Porter noted that the incidence of this behaviour is high relative to observations from well-studied bottlenose dolphin populations in Sarasota and Shark Bay and expressed concern these observations may reflect high rates of neonatal mortality.

The coastal habitats of this genus include sandy beaches, enclosed bays and coastal lagoons, mangrove areas, sea grass meadows, rocky and coral reefs and turbid estuaries, and a number of papers dealt with the issue of habitat degradation. In particular, Hong Kong exhibits rapid rates of coastal development, including the construction of a new 1,200 hectare airport in 1998, most of which was built on reclaimed land. Unfortunately, there is no baseline data on habitat use patterns of humpback dolphins prior to construction of this airport. In addition, a fuel depot was constructed nearby and studies during construction (which involved piling) showed differences in both behaviour and habitat use of humpback dolphins.

There are very few areas within the known range of humpback dolphins where anthropogenic alteration to habitat has not occurred. Habitat degradation has been used as a factor to assess the status of this taxon in South Africa following IUCN red list categories and criteria (SC/54/SM37). On the basis of limited coastal occurrence and occupancy, combined with incidental mortality in shark control nets, and reduction in habitat, humpback dolphins are listed as 'Vulnerable' in South Africa.

5.11 Consideration of status

Humpback dolphins are listed as 'Data Deficient' by the World Conservation Union (IUCN) and are listed in Appendix 1 of the Convention on Trade of Endangered Species (Klinowska, 1991; Baillie and Groombridge, 1996). The taxonomy of humpback dolphins remains unresolved and information on this genus is fragmentary throughout almost all of its range. Humpback dolphins are long-lived, but nowhere have research programmes on these animals been in place for longer than 10 years, a small fraction of their lifespan. Baseline data on abundance, population structure, rate of increase, recruitment and mortality levels are lacking.

The primary threats to humpback dolphins are incidental mortality in fisheries, including shark control nets, habitat degradation and, in a few areas (such as Madagascar), directed catches. Levels of contaminants in tissues of humpback dolphins are very high in some areas, fuelling concern regarding the effects of these pollutants. The sub-committee was able to recognise the existence of these threats, but it was not possible to evaluate them with current information. Therefore the sub-committee **concluded** that the status of humpback dolphins is unknown, however it recognises that this genus is adversely impacted by anthropogenic changes throughout its known range.

The sub-committee **recommends** the following.

- (1) Wide collaboration among *Sousa* researchers to allow resolution of the systematics and population structure within the genus.
- (2) Studies over long time-scales to obtain estimates of abundance, and rates of fecundity and mortality.

- (3) Surveys, and photo-identification and genetic sampling in areas where the distribution of humpback dolphins is patchy, to allow for more detailed information on distribution, ranging patterns, discontinuity or population fragmentation and stock structure.
- (4) Studies of the life history, behaviour and ecology of this genus, to better understand its conservation status, ecological requirements and social structure.
- (5) Further quantitative studies of habitat use, and of the degradation of habitat, especially where habitat modification has occurred.
- (6) Independent observer monitoring programmes to estimate incidental mortality from bycatch and to monitor the effects of mitigation measures when they have been introduced.
- (7) Evaluation of the magnitude and effects of the directed fishery for humpback dolphins in Madagascar.

6. PROGRESS ON PREVIOUS RECOMMENDATIONS

Read reminded the sub-committee of IWC Resolution 2001-13 (IWC, 2002b), which directs the Scientific Committee to continue to review progress on recommendations and resolutions relating to critically endangered stocks on a regular basis. This year, the sub-committee reviewed progress on several of these stocks.

6.1 Baiji

The baiji (*Lipotes vexillifer*) is the most endangered cetacean. Its range is restricted to the Yangtze River and its population size is probably only a few tens of animals (IWC, 2001a, p.275). Hung informed the sub-committee that recent sightings confirm the continued existence of this species in the Yangtze River. Given the critically endangered status of the baiji, in 2000 the Scientific Committee asked that the Secretary of the IWC request the Government of China to report progress on the conservation of this species to the Scientific Committee on an annual basis. Unfortunately for the second consecutive year, no new information was received from China. Therefore, the sub-committee **reiterated** its request for updated information on the status of this critically endangered species and on management efforts intended to conserve it. In particular, the sub-committee would welcome the report of a recent meeting on baiji, organised by the Government of China, for its consideration at next year's meeting.

6.2 Vaquita

The sub-committee received three papers describing research and conservation activities focused on the highly endangered vaquita (*Phocoena sinus*). SC/54/SM17 described the results of a study to investigate the distribution of the vaquita in the northern Gulf of California. Because of the potential for long-range responses of these animals to a moving survey vessel, a new method of detecting porpoises was employed. The research boat stopped at predetermined stations to listen for porpoise vocalisations, which resulted in a significantly higher rate of encounters. These investigations suggest that porpoises in the upper Gulf of California continue to inhabit a core area between Rocas Consag and San Felipe Bay. This distribution coincides with an area of intense fishing operations. Further cruises are planned and will include an oceanographic data collection component.

The upper Gulf of California is a Biosphere reserve, but also an important fishing ground for blue and brown shrimp (*Penaeus* spp.). Bycatch of vaquitas in this seasonal trawl fishery are known to occur at a low level. There are also concerns that this intense fishing effort might impact the porpoises in more subtle ways. SC/54/SM19 described a study to investigate potential impacts on vaquita distribution, using data on the distribution of vaquitas and trawlers obtained during the 1997 survey. A positive relationship was found between the occurrence of trawlers and the level of aggregation of vaquita. As more trawlers were encountered, the average time interval between sightings fell and the mean size of groups became significantly larger. Whether this change is a direct consequence of the presence of trawlers is as yet unproven, but these findings raise concerns that such spatial aggregations might lead to higher vulnerability to a single large mortality event.

Since 2000, WWF, CIRVA and Conservation International (CI) have convened a series of inclusive meetings of parties interested in the recovery of the vaquita. The main outcome was the establishment of a Working Group whose mandate is to develop a general strategy for the recovery of the vaquita. SC/54/SM18 described this strategy and current progress. The strategy consists of four elements: (1) conservation; (2) socio-economic considerations; (3) education/awareness issues; and (4) a legal framework. Among the many activities that have been carried out are a search for, and evaluation of alternative fisheries and alternative economic opportunities in the Upper Gulf. A meeting of various government departments identified a legal route to expand the boundaries of the Biosphere Reserve and declare the entire range of vaquita as an 'Area de Refugio de Fauna Silvestre'. Further research has been carried out on the distribution and habitat use of vaquita (e.g. SC/54/SM17 and 19). Furthermore, Manzanilla-Naim noted that environmental legislation directed to marine protected areas in Mexico specifies a prohibition on the use of fishing gears for which the bycatch/target species ratio within any marine protected area should be no greater than 1:1. To enforce this provision the Environment Ministry (SEMARNAT) in conjunction with the navy (SEMAR) launched an enforcement operative directed to fishing trawlers from October to the end of the 2001-2002 shrimp season. This enforcement operative will continue within the upper Gulf of California Biosphere Reserve.

The small cetacean sub-committee **commends** the joint efforts of WWF, CIRVA, Conservation International and the Government of Mexico in their development and implementation of a general strategy for the recovery of the vaquita, based largely on recommendations from CIRVA. The sub-committee looks forward to an update on the implementation of this strategy at its next meeting.

Manzanilla-Naim described two datasets on marine mammal distribution in relation to oceanographic and biological conditions in the upper Gulf of California. The first of these datasets was collected during an inter-El Niño period (1994/95) while the second during an El Niño year (1998). Manzanilla-Naim asked the committee whether there was interest in funding further analysis of these datasets to improve our understanding of the role of estuarine productivity on the foraging ecology and status of the vaquita. The committee encouraged the development of a full proposal for consideration at its next meeting and highlighted the potential value of this work to other sub-committees. The sub-committee also cautioned that there was likely to be considerable complexity in the temporal coupling of El Niño events, river flow and

significant changes in prey populations of the vaquita. The sub-committee also reminded applicants that funds available for such research are extremely limited and tightly prioritised.

6.3 Harbour porpoise

The harbour porpoise (*Phocoena phocoena*) is widely distributed in shelf waters of the temperate North Atlantic and North Pacific Oceans. Although still abundant as a species, it has experienced major declines in parts of its range, including and perhaps most notably in the Baltic Sea (East of the Darss Sill). An aerial survey conducted in July 1995 estimated that 599 (CV = 0.57) porpoises were present in the Baltic Sea (Hiby and Lovell, 1996). This survey did not include Polish coastal waters, where porpoise bycatches are known to occur year-round, and where it has been suggested that an unknown, but significant part of the Baltic population might occur. To address this limitation, therefore, an acoustic and visual survey for porpoises was conducted in Polish waters during August and September 2001 and the results were reported in SC/54/SM3. A combined visual and acoustic transect survey was conducted from a sailboat travelling under power, covering a trackline of 3,300km of acoustic surveys and 377km of visual surveys. In addition, automatic recording devices (PODs) were moored in areas of suspected porpoise occurrence. Only two independent porpoise detections were made, both in the extreme western part of the survey area. These detection rates were two orders of magnitude lower than those documented in the English Channel and southern North Sea. Thus, the study confirms that harbour porpoises do occur in the Polish sector of the Baltic Sea but also that (during the study period) only low numbers were present.

At the request of the Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS), the sub-committee then considered a draft version of the ASCOBANS recovery plan for harbour porpoises in the Baltic Sea ('Jastarnia Plan'). The plan's intended purpose is to promote and facilitate population recovery, which in the ASCOBANS context means to at least 80% of its carrying capacity level. The draft plan was the culmination of a series of scientific initiatives and meetings over several years, in particular a workshop in Jastarnia, Poland, in January 2002 which included managers, scientists, representatives of the fishing sector and NGOs.

The sub-committee commended ASCOBANS for a valuable draft recovery plan that provides guidance for action to conserve harbour porpoises in the Baltic Sea. It strongly endorses the plan and concurs with its recommendations. Particularly with respect to the recommendation to implement a pinger programme on a short-term basis (i.e. two to three years), the sub-committee offered the following comments and suggestions:

- (1) Before introducing pingers to the Baltic environment, a simple modelling exercise should be conducted to confirm that they will function there essentially as they do elsewhere. Sound propagation measurements from a series of selected sites and water depths in the Baltic would be needed for this.
- (2) Cost-effectiveness and efficiency will be best served if pinger implementation is targeted on those areas/times considered most likely to have overlap between 'high' porpoise densities and intensive driftnet and/or bottom-set gillnet fishing (hotspots). A few of these can be identified based on available information on bycatches and fishing effort (e.g. the Swedish driftnet

fishery for salmon and bottom-set gillnet fishery for cod in ICES rectangles 3958, 4059, 4159 and 4160; the Polish driftnet fishery for salmon in Puck Bay) and short-term implementation in these areas should move ahead now.

- (3) To identify other hotspots will require that the recommended compilations of data on fishing effort, the timing and location of porpoise bycatches (both historical and recent) and porpoise distribution (sightings, strandings, etc.) be undertaken immediately. This work had been stressed by the ASCOBANS Baltic Discussion Group in 2001 and again in the draft recovery plan and must be given an extremely high priority.
- (4) As noted in the draft recovery plan, it is essential that any pinger implementation must be accompanied by an observer programme to verify that pingers are being used properly at sea.
- (5) The importance of independent on-board observation, at an appropriate sampling level, to obtain reliable data on cetacean bycatch is well documented. The sub-committee urged that despite the associated difficulties with high fishing effort and low bycatch rates, bycatch monitoring be made an integral part of any pinger implementation programme, especially in the hotspots identified above.
- (6) The concern expressed in the draft recovery plan that pingers might exclude porpoises from large areas of critical habitat should be addressed before pinger use becomes widespread in the Baltic. An analysis similar to that conducted previously for the North Sea should be conducted to estimate the potential extent of habitat exclusion for the Baltic.
- (7) The draft recovery plan recommended that implementation of pingers be *short-term* and therefore such implementation should be reconsidered within three years, with the expectation that pinger use will be replaced by longer-term mitigation measures at that time.
- (8) The requirement in the draft recovery plan for rapid development of medium- and long-term approaches to mitigation (e.g. reduced fishing effort in 'high-risk' areas, conversion to fishing gear and practices that are much less likely to result in porpoise bycatch) is crucial and should not be compromised. This work should be initiated immediately and be pursued in parallel with the hotspot analyses and targeted pinger implementation efforts.

In view of the critical status of harbour porpoises in the Baltic, it is important to review the progress of the recovery plan at frequent intervals and to incorporate new information. The first review should occur within three years of the implementation of the plan.

In some respects, for example their small population size, the conservation status of harbour porpoises in the Baltic Sea is similar to that of the vaquita in the Gulf of California, and the sub-committee recalled that it had recommended against the use of pingers to reduce bycatches of vaquitas at its meeting in Grenada (IWC, 2000, pp. 242-243). The sub-committee agreed, however, that the two situations are different, in the following respects: (1) the vaquita exists in a single population restricted to the Gulf of California, while harbour porpoises in the Baltic form only one of many populations of this species in the North Atlantic; (2) pingers have been demonstrated to be effective in reducing bycatches of harbour porpoises, but have not been tested

with the vaquita; (3) vaquitas are taken in a variety of artisanal fisheries, in which it would be difficult or impossible to implement pingers as an effective mitigation strategy; and (4) the vaquita exists only in Mexico, but the Baltic population of harbour porpoises occurs in the waters of seven countries. The sub-committee concluded that the two situations were indeed different and, therefore, distinct conservation approaches were called for.

On behalf of ASCOBANS, Reijnders thanked the sub-committee for its careful and constructive review of this plan.

SC/54/SM31 presented updated estimates of harbour porpoise bycatches in Danish North Sea bottom-set gillnet fisheries from 1987-2001. Two estimation methods were investigated, and each was applied to observed bycatch rates from 1992-2001. The first method used extrapolations from landings of target species and resulted in an estimated annual bycatch of from 2,867-7,566 harbour porpoises, with a mean of 5,817. This method was used by Vinther (1999) to estimate bycatches in this fishery from 1994-1998. The second, newer method used extrapolations from fleet fishing effort to address the effect of temporal changes in catch per unit effort. Estimated bycatches from this method were slightly lower, except for the years 1998-2001, and ranged from 3,887-7,366 porpoises per year, with a mean of 5,591. Both methods suggest that bycatches have been reduced in recent years due to decreases in both effort and landings, although the new method suggests a smaller reduction. Neither estimate accounted for the use of pingers in the wreck net fishery for cod, which may have reduced the bycatch in that fishery to near zero (SC/54/SM32). Larsen outlined the impacts of potential biases in these analyses, including the placement of observers on larger boats. The sub-committee welcomed these new analyses.

6.4 Survey methodology for freshwater cetaceans

At its meeting in 2000, the sub-committee recommended that scientists with appropriate analytical skills be directly involved in the design and implementation of surveys for freshwater cetaceans, so that these surveys might result in statistically robust estimates of abundance. It was also suggested that scientists familiar with quantitative techniques provide appropriate background training to field researchers on abundance estimation techniques (IWC, 2001a, p.277).

Hedley outlined the details of line-transect, strip transect and photo-identification surveys of boto (*Inia geoffrensis*) and tucuxi (*Sotalia fluviatilis*) in the Colombian Amazon. The study involved field collaboration among quantitative analysts and field researchers. The survey was carried out in March and April 2002 and presentation of results is expected at next year's meeting of the sub-committee. To facilitate wider consultation, an e-mail correspondence group has been established. The sub-committee thanked Hedley and Williams for their efforts and agreed that these activities will provide useful information to groups studying freshwater cetaceans and other species inhabiting complex environments, such as *Sousa*. The sub-committee **recommended** the continued development of these techniques.

6.5 Bycatch mitigation

An alternative to the use of pingers (acoustic alarms) is the development of alternative fishing gear that has a lower probability of entangling cetaceans. One such approach is the development of monofilament that would be more detectable to an echolocating odontocete. In SC/54/SM30,

Larsen described a study to test whether gillnets made from high density monofilament (impregnated with iron oxide) catch fewer harbour porpoises. The trial was conducted in the Danish North Sea bottom-set gillnet fishery in 2000 and recorded a 20% reduction in cod catch relative to nets made from conventional materials. Eight porpoises were caught in control nets and none were taken in high-density nets, a significant reduction in bycatch. Surprisingly, acoustic testing indicated that there were no significant differences in the acoustic target strength of modified and control nets, suggesting that the reduction in bycatch was not caused by an increase in acoustic reflectivity. Neither was net colour likely to be important in reducing bycatches of porpoises. Instead it is more likely that the modified nets caught fewer porpoises (and cod) because they were stiffer than conventional nets. If this is true, modification of net stiffness offers the potential for an inexpensive means of reducing bycatch, although this benefit may be tempered by reduced catch of target species and heavier and more bulky nets. The sub-committee welcomed the results of this research and encouraged further developing and testing of these modified nets.

Use of acoustic alarms became mandatory in Danish North Sea wreck cod gillnet fisheries in August 2000. SC/54/SM32 outlined the results of an independent observer programme monitoring harbour porpoise bycatch in this fishery before and after implementation of pingers (1993-2001). Before the introduction of pingers, porpoises were observed taken in 19 of 873 sets, while after their introduction, no porpoises were observed in 129 sets in nets equipped with pingers. Thus, the introduction of pingers significantly reduced the bycatch rate in this fishery. As with other studies of bycatch, these results should be viewed with caution. While bycatch has been reduced it is unlikely to have been eliminated and habituation to the pingers remains a possibility. In addition, compliance with regulation requiring use of pingers and their proper use need to be monitored. The sub-committee welcomed these encouraging results and **recommends** continued monitoring of this fishery, including pinger use and bycatch rates.

Some results from the 'EPIC' project report were brought to the sub-committee's attention and are summarised in SC/54/ProgRep Denmark. One of the most relevant findings of this research is that pingers are still aversive to harbour porpoises even when the duration of the sounds were reduced from 256 msec to 64 msec. This finding has important implications for the design of acoustic alarms, and should allow the conservation of battery life and prolong the longevity of pingers in the field.

A growing number of studies have demonstrated the ability of acoustic alarms to reduce harbour porpoise bycatch in fishing nets, but a variety of concerns remain regarding their use. The research outlined in SC/54/SM2 was conducted to investigate two of these concerns: (1) the devices might exclude porpoises from preferred habitat; and (2) porpoises might attempt to swim through nets where malfunctioning pingers create an acoustic window. The presence and behaviour of porpoises were monitored around a simulated net, equipped with functioning and non-functioning pingers, off the coast of western Scotland. When pingers were active, the frequency of porpoise sightings was reduced significantly in an area 375m from the net and significantly fewer vocalisations were recorded in an area 500m from the net. One porpoise passed through an acoustic gap of approximately 300m, indicating that it is possible that porpoises may occasionally become entangled in nets with malfunctioning or missing pingers. The results

of this work suggest that pingers may exclude porpoises from a larger area than was previously believed and warrant concern in areas with intense fishing effort. As noted previously by this sub-committee (IWC, 2000, p.240) the sound produced by many pingers might create large zones from which porpoises are excluded. It must be noted, however, that the reduction in acoustic detections within 500m of the net could represent a change in acoustic behaviour or orientation rather than exclusion.

6.6 Dall's porpoises

Read reminded the sub-committee of IWC Resolution 2001-12, which directed the Scientific Committee to complete a full assessment of the status of exploited Dall's porpoise stocks as soon as sufficient information becomes available (IWC, 2002a). In its review of the subject in 2001, the sub-committee was unable to complete this assessment, because information on takes in the Japanese hand harpoon fishery was not made available. The hand harpoon fishery for Dall's porpoises continues, but members of the Japanese delegation did not participate in the work of this sub-committee this year and no new information was made available on this topic. Therefore, the sub-committee was again unable to complete its assessment of the status of Dall's porpoise stocks.

The sub-committee noted the value of the information provided by the Government of Japan on the status of small cetaceans in previous years and was disappointed that members of the Japanese delegation did not participate in the work again this year. The sub-committee requests that the Government of Japan reconsider its position on this matter and resume the valuable contribution of Japanese scientists to the sub-committee's work on small cetaceans.

The sub-committee wished to thank the Government of the Republic of Korea for including observations of incidental takes of Dall's porpoises in its progress report (SC/54/ProgRep Korea). The sub-committee reiterated its request that the Government of Russia report bycatches of Dall's porpoises (and other small cetaceans) in its annual Progress Reports to the Scientific Committee, together with estimates of the magnitude of bycatches in other fisheries.

6.7 Other recommendations

No new information was submitted on other past recommendations.

7. OTHER

SC/54/SM10 provided the results of a monitoring project to investigate the takes of small cetaceans in coastal fisheries in Peru. Port monitoring is now hampered by recent conservation legislation outlawing the commercial use of bycaught small cetaceans. As a result, fishers now often butcher carcasses at sea and land concealed meat. Van Waerebeek and others initiated a boat-based observer scheme to document the bycatch of sea turtles, in which they observed three Burmeister's porpoises (*Phocoena spinipinnis*) taken in 10 overnight sets in artisanal bottom gillnets. In addition, evidence for a minimum of 471 small cetacean captures was documented from 1999-2001. Most striking was a continuation in the reduction of the relative proportion of dusky dolphins (*Lagenorhynchus obsurus*) taken in these fisheries (Van Waerebeek, 1994). Over a period of 15 years, dusky dolphins have fallen from 78% of the total recorded catches to only 40% on the central coast. The reasons for this significant decline are unknown.

The sub-committee **commended** the group for instituting this observer programme. This largely opportunistic port monitoring study revealed remarkably high levels of bycatch and the sub-committee **requests** that the Government of Peru submit these catch statistics of small cetaceans in their next progress report to the Commission.

The sub-committee then considered a proposal for funding from the IWC Voluntary Fund for Small Cetaceans. This proposal was to augment an application previously approved by the Commission at its 53rd Annual meeting: 'Comprehensive study of the distribution, taxonomy, genetic, natural history, pathology of common dolphins *Delphinus capensis* and *Delphinus delphis* in coastal waters of Pacific South America' (SC/52/RP1). Initiation of the study has been hampered by the need for stipends for researchers in South America. The proposal submitted to the sub-committee was to cover these costs at a level of USD \$4,000. The sub-committee recognised the timely nature of this initiative given studies of this genus in other geographic areas and the potential synergy with the objectives of the Scientific Committee's Standing Working Group on Environmental Concerns. The sub-committee **supported** this proposal and requested that Van Waerebeek report initial findings to the sub-committee next year.

SC/54/O22 reported that the conservation status of 42 cetacean populations in South Africa were recently assessed, using the IUCN 2001 Red Data List criteria. Eleven populations of delphinids were considered to be 'Data Deficient' and six were classified as being of 'Least Concern'. The Indo-Pacific humpbacked dolphin (*Sousa chinensis*) was classified as 'Vulnerable' (SC/54/SM37) and the resident stock of Indian Ocean bottlenose dolphins (*Tursiops aduncus*) was considered to be 'Vulnerable' due to its limited area of occupancy, limited occurrence, nearshore habitat degradation, bycatch in the shark control nets, and existence of a single sub-population. The migratory stock of Indian Ocean bottlenose dolphins was classified as 'Endangered' due to its small population size, single population and continuing decline caused by incidental capture in shark control nets. Concern was expressed that the only cetacean endemic to the region (Heaviside's dolphin, *Cephalorhynchus heavisidii*) was classified as 'Data Deficient' and that this should be rectified as a matter of urgency, particularly given the existence of bycatches in set nets. Other identified threats to small cetaceans in South Africa included fishery interactions, and possible reduced prey base for Risso's dolphins (*Grampus griseus*) caused by fishing activities. As part of the CAMP process, recommendations included monitoring of all species, primarily through collection of stranded and bycaught animals, compilation of life history data, and population surveys. This assessment highlighted the urgent requirement for population surveys and genetic studies in South African waters.

Iñiguez briefly informed the sub-committee of progress on research and conservation of small cetaceans in Argentina. There are several groups actively working on small cetaceans in Argentinean waters. The main species studied include franciscana, Peale's dolphins, dusky dolphins, Commerson's dolphins and killer whales. In Ria Gallegos between 1999 and 2000 almost 80 Commerson's dolphins were caught in gillnets. A report of research on these catches will be submitted to the next meeting of the sub-committee.

Brownell noted that a permit for catch quotas of white whales and killer whales had been issued recently by the Russian Central Committee of Fisheries. The quotas

included 1,000 white whales (for harvest) and 10 killer whales (for live capture). As in the past (IWC, 1992; 2000) the sub-committee expressed concern over such takes of small cetaceans when there is insufficient information to adequately assess the impact on the target populations. The sub-committee **recommended** that such captures be preceded by an assessment of the size of affected populations and of the impact of these removals.

Information on bycatches of small cetaceans in California drift and set gillnet fisheries in 2001 were submitted to the committee (SC/54/SM12 and SC/54/SM13). Observers accompanied approximately 25% of all trips in the drift net fishery and documented 14 takes of cetacean species. The species composition, gender and size of the bycatches in 2001 were comparable to those of previous years. The bottom-set gillnet fishery that operates in Monterey Bay was not observed during 2001 but reports of stranded animals with evidence of entanglement indicated that there is still cause for concern about the impact of this fishery on harbour porpoises.

SC/54/SM11 provided the report of a study of the potential use of pingers to reduce depredation of catches and damage to gear caused by bottlenose dolphins in a trammel net fishery in the Balearic Islands. This work was prompted in an effort to obviate the use of Acoustic Harassment Devices (AHDs) with quieter and potentially less damaging sound sources. The study did not directly compare the efficacy of these two devices, but concluded that pingers could significantly reduce dolphin depredation to catches in trammel nets.

8. TAKES OF SMALL CETACEANS

The sub-committee was not able to review its table of recent catches (Appendix 2) of small cetaceans at this year's meeting. Nevertheless, the sub-committee agreed that it was highly likely that this table would be incomplete, as it has been in previous years. To assist the sub-committee in identifying data gaps in this table, Atkins, Parra and Sutaria compiled a summary of which member countries had contributed data over the past six years. Read agreed to ask the Secretariat to request data on directed and incidental takes of small cetaceans from other contracting governments, preferably on a stock-by-stock basis.

9. WORK PLAN

The sub-committee reviewed its schedule of priority topics. Those currently held by the sub-committee (IWC, 2002c, p.332) are as follows:

- (1) Systematics and population structure of *Tursiops*;
- (2) Status of ziphiids in the Southern Ocean;
- (3) Status of small cetaceans in the Caribbean Sea;
- (4) Status of small cetaceans (*Phocoena*, *Delphinus* and *Tursiops*) in the Black Sea;
- (5) Review of the status of *Pontoporia*.

The sub-committee considered the location of its meeting in 2003 (Berlin) and the current formative status of the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS). As a result the sub-committee agreed that it should review the status of small cetaceans in the Black Sea as it's priority topic for the next meeting. Read will consult with the Secretariat of ACCOBAMS to ensure that the relevant scientists from Black Sea range states are invited to

attend this meeting. The committee also agreed that while it was going to restrict its review to the status of small cetaceans in the Black Sea, it would consider material from adjacent waters if it was informative to the review.

10. OTHER BUSINESS

There was no other business.

11. ADOPTION OF REPORT

The report was adopted as amended on 5 May 2001. Read thanked the rapporteurs for their hard work. On behalf of the sub-committee, Read thanked Kasuya for organising a highly successful field trip to observe finless porpoises in the Inland Sea.

REFERENCES

- Baillie, J. and Groombridge, B. (eds.). 1996. *IUCN Red List of Threatened Animals*. World Conservation Union, Gland, Switzerland. 368pp.
- Cockcroft, V.G. 1990. Dolphin catches in the Natal shark nets, 1980-1988. *S. Afr. J. Wildl. Res.* 20(2):44-51.
- Corkeron, P., Morissette, N.M., Porter, L. and Marsh, H. 1997. Distribution and status of humpback dolphins, *Sousa chinensis*, in Australian waters. *Asian Mar. Biol.* 14:49-57.
- Durham, B. 1994. The distribution and abundance of the humpback dolphin (*Sousa chinensis*) along the Natal coast, South Africa. M.Sc Thesis, University of Natal. 84pp.
- Gribble, N.A., McPherson, G. and Lane, B. 1998. Effect of the Queensland Shark Control Program on non-target species. Whale, dugong and dolphin: a review. *Mar. Freshw. Res.* 49:645-51.
- Harwood, M.B. and Hembree, D. 1987. Incidental catch of small cetaceans in the offshore gillnet fishery in northern Australian waters: 1981-1985. *Rep. int. Whal. Commn* 37:363-7.
- Hiby, L. and Lovell, P. 1996. Baltic/North Sea aerial surveys. (Unpublished final report). 11pp. [Available from: lex@conres.demon.co.uk].
- International Whaling Commission. 1992. Report of the Scientific Committee. Annex G. Report of the sub-committee on small cetaceans. *Rep. int. Whal. Commn* 42:178-234.
- International Whaling Commission. 1999. Report of the Scientific Committee. Annex I. Report of the Standing Sub-Committee on Small Cetaceans. *J. Cetacean Res. Manage. (Suppl.)* 1:211-25.
- International Whaling Commission. 2000. Report of the Scientific Committee. Annex I. Report of the Sub-Committee on Small Cetaceans. *J. Cetacean Res. Manage. (Suppl.)* 2:235-57.
- International Whaling Commission. 2001a. Report of the Scientific Committee. Annex K. Report of the Standing Sub-Committee on Small Cetaceans. *J. Cetacean Res. Manage. (Suppl.)* 3:263-91.
- International Whaling Commission. 2001b. Report of the Scientific Committee. Annex U. Report of the Working Group on Nomenclature. Appendix 2. Proposed nomenclature changes to IWC list of recognised species of cetaceans. *J. Cetacean Res. Manage. (Suppl.)* 3:365-7.
- International Whaling Commission. 2002a. Chair's Report of the 53rd Annual Meeting. Annex C. Resolutions Adopted During the 53rd Annual Meeting. Resolution 2001-12. Resolution on Dall's porpoise. *Ann. Rep. Int. Whaling Comm.* 2001:59.
- International Whaling Commission. 2002b. Chair's Report of the 53rd Annual Meeting. Annex C. Resolutions Adopted During the 53rd Annual Meeting. Resolution 2001-13. Resolution on small cetaceans. *Ann. Rep. Int. Whaling Comm.* 2001:60.
- International Whaling Commission. 2002c. Report of the Scientific Committee. Annex K. Report of the Standing Sub-Committee. *J. Cetacean Res. Manage. (Suppl.)* 4:325-38.
- Jefferson, T.A. 2000. Population biology of the Indo-Pacific humpbacked dolphin in Hong Kong waters. *Wildl. Monogr.* 144:1-65.
- Jefferson, T.A. and Karczmarski, L. 2001. *Sousa chinensis*. *Mamm. Species* 655:1-9.
- Jepson, P.D., Bennett, P.M., Allchin, C.R., Baker, J.R., Kuiken, T., Rogan, E., Lockyer, C., Law, R.J., Walton, M.J. and Kirkwood, J.K. 1998. Chronic PCB exposure is associated with infectious disease mortality in harbour porpoises stranded in England and Wales, 1990-1996. *Eur. Res. Cetaceans [Abstracts]* 12:352.
- Kannan, K., Blankenship, A.L., Jones, P.D. and Giesy, J.P. 2000. Toxicity reference values for the toxic effects of polychlorinated

- biphenyls to aquatic mammals. *Hum. Ecol. Risk Assess.* 6(1):181-201.
- Karczmarski, L., Winter, P.E.D., Cockcroft, V.G. and McLachlan, A. 1999. Population analyses of Indo-Pacific humpback dolphins *Sousa chinensis* in Algoa Bay, Eastern Cape, South Africa. *Mar. Mammal Sci.* 15(4):1115-23.
- Klinowska, M. (ed.). 1991. *Dolphins, Porpoises and Whales of the World. The IUCN Red Data Book.* IUCN, Gland, Switzerland and Cambridge, UK. viii + 429pp.
- Limpers, J.W. 1998. Clustering and incomplete multidimensional data. MSc Thesis, Technical University of Delft, Netherlands. pp.
- Perrin, W.F., Donovan, G.P. and Barlow, J. (eds.). 1994. *Report of the International Whaling Commission (Special Issue 15). Gillnets and Cetaceans.* International Whaling Commission, Cambridge, UK. 629pp.
- Pilleri, G. and Gehr, M. 1972. Contribution to the knowledge of cetaceans of Pakistan with particular reference to the genera *Neomeris*, *Sousa*, *Delphinus*, and *Tursiops* and description of a new Chinese porpoise (*Neomeris asiaorientalis*). *Invest. Cetacea* 4:107-62.
- Rice, D.W. 1998. *Marine Mammals of the World. Systematics and Distribution.* Special Publication No. 4. The Society for Marine Mammology, Lawrence, Kansas. 231pp.
- Ross, G.J.B., Heinsohn, G.E. and Cockcroft, V.G. 1994. Humpback dolphins — *Sousa chinensis* (Osbeck, 1765), *Sousa plumbea* (G. Cuvier, 1829) and *Sousa teuszii* (Kükenthal, 1892). pp. 23-42. In: S.H. Ridgway and R. Harrison (eds.) *Handbook of Marine Mammals.* Vol. 5. *The First Book of Dolphins.* Academic Press, London and San Diego. 416pp.
- Van Waerebeek, K. 1994. A note on the status of the Dusky dolphins (*Lagenorhynchus obscurus*) off Peru. *Rep. int. Whal. Commn* (special issue) 15:525-7.
- Vinther, M. 1999. Bycatches of harbour porpoises (*Phocoena phocoena*, L.) in Danish set-net fisheries. *J. Cetacean Res. Manage.* 1(2):123-35.
- Vos, J.G. 2000. Immunotoxicity of dioxins in seal and flounder. Proceedings of a Symposium on Dioxin and Dioxin-like Chemicals, University of Zurich, Zurich, Switzerland, 3 March 2000. pp. 50-59. [Abstract]
- Wells, R.S. and Scott, M.D. 1990. Estimating bottlenose dolphin population parameters from individual identification and capture-release techniques. *Rep. int. Whal. Commn* (special issue) 12:407-15.
- Weru, S. 2001. Rapid baseline survey of large marine animals, with special emphasis on humpback whales, in Kenya. *KWS Technical Series* [Available from: werus@africaonline.co.ke].

Appendix 1

AGENDA

1. Election of Chair 2. Adoption of agenda 3. Appointment of rapporteurs 4. Review of available documents 5. Review of status of humpback dolphins 5.1 Systematics 5.2 Distribution and stock structure 5.3 Abundance 5.4 Seasonal movements 5.5 Life history 5.6 Ecology 5.7 Habitat 5.8 Directed takes 5.9 Incidental takes 5.10 Other 5.11 Consideration of status	6. Progress on previous recommendations 6.1 Baiji 6.2 Vaquita 6.3 Harbour porpoise 6.4 Survey methods for freshwater cetaceans 6.5 By-catch mitigation 6.6 Dall's porpoise 6.7 Other recommendations 7. Other 8. Takes of small cetaceans 9. Work plan 10. Other business 11. Adoption of report
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Appendix 2

SMALL CETACEAN CATCHES 1998-2001

All information was taken from National Progress reports unless otherwise stated. Catches are presented by nation, rather than ocean area, except in the case of the data submitted by the IATTC for the eastern tropical Pacific (ETP). In this case, the submitted estimated catches are not broken down by country and a summed total incidental catch for the participating countries is given. The reported catch columns include catches reported by observer programmes, from interviews with fishermen and incidental reports (e.g. stranded whales determined to have died in nets).

Please note that catches should be tabled according to the calendar year in which they were taken. All direct and incidental removals (including live captures) should be recorded but not stranded animals.

	1998					1999					2000					2001				
Species	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live
	Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total	
Argentina																				
Dusky dolphin	-	-	15 ^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Franciscana	-	-	-	-	-	-	-	-	-	-	-	-	49 ^b	272-570 ^b	-	-	-	-	-	-
Peale's dolphin	-	-	-	-	-	-	-	-	-	-	-	-	1 ^c	5 ^c	-	-	-	-	-	-
Commerson's dolphin	-	-	-	-	-	-	-	-	-	-	-	-	37 ^d	<168 ^d	-	-	-	6 ^e	-	-
Australia																				
False killer whale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 ^h	-	-
Bottlenose dolphin	-	-	9	-	-	-	-	9	-	-	-	-	2 ^a	4 ^a	-	-	-	3 ^d	6 ^d	-
Bottlenose dolphin sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3 ^g	-
Common dol. (?sp.)	-	-	7	-	-	-	-	8	-	-	-	-	-	-	-	-	-	2 ^e	5 ^e	-
Irrawaddy dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
Indo-pacific humpback	-	-	2	-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	2 ^f	-
Spinner dolphin	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-
Short beaked comm. d.	-	-	5	-	-	-	-	8	-	-	-	-	6 ^b	3 ^b	-	-	-	-	-	-
Pantropical spotted d.	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Unidentified dolphin	-	-	27	-	-	-	-	12	2	-	-	-	1 ^c	3 ^c	-	-	-	-	-	-
Unidentified cetacean	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brazil																				
Bottlenose dolphin	-	-	-	-	-	-	-	-	-	-	-	-	1 ^j	-	-	-	-	-	-	-
Franciscana	-	-	101 ^b	25 ^c	3 ^f	-	-	17 ^g	202 ^g	-	-	-	55 ^k	>850 ^k	-	-	-	19 ^o	-	-
Tucuxi	-	-	7 ^e	3 ^d	-	-	-	17 ^h	141 ^h	-	3	-	8 ^l	-	-	-	-	4 ^p	-	-
Atlantic spotted dol.	-	-	5 ⁱ	-	-	-	-	-	-	-	-	-	2 ^m	-	-	-	-	-	-	-
Rough-toothed dol.	-	-	-	-	-	-	-	7	150	-	-	-	-	-	-	-	-	-	-	-
Striped dolphin	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
<i>Inia geoffrensis</i>	-	-	1	-	-	-	-	-	-	-	-	-	-	-	78 ⁿ	-	-	-	-	-
Unidentified dolphins	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified species	-	-	9 ^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canada																				
Narwhal	a	-	-	-	-	a	-	-	-	-	a	-	-	-	-	559 ^b	-	-	-	-
White whale	a	-	-	-	-	a	-	-	-	-	a	-	-	-	-	375 ^c	-	-	-	-
Chile																				
Burmeister's porpoise	-	-	1 ^a	-	-	-	-	1 ^c	-	-	-	-	-	-	-	-	-	-	-	-
Long-finned pilot w.	-	-	-	-	-	1 ^b	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Species	1998				Live Rep.	1999				Live Rep.	2000				Live Rep.	2001				Live Rep.	
	Direct		Indirect			Direct		Indirect			Direct		Indirect			Direct		Indirect			
	Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est.		
Denmark																					
Harbour porpoise	-	-	-	5,206 ^a	-	-	-	-	4,227 ^a	-	-	-	-	4,149 ^a	-	-	-	-	3,887 ^a	-	
Unidentified species	-	-	-	+	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-	
ETP																					
Bottlenose dolphin	-	-	29	29	-	-	-	9	9	-	-	-	4	4	-	-	-	-	-	-	
Pantropical spotted d.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Northeastern	-	-	298	298	-	-	-	358	358	-	-	-	303	303	-	-	-	-	-	-	
Western-southern	-	-	341	341	-	-	-	253	253	-	-	-	428	428	-	-	-	-	-	-	
Coastal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Spinner dol. (? stock)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Eastern	-	-	422	422	-	-	-	363	363	-	-	-	272	272	-	-	-	-	-	-	
Whitebelly	-	-	249	249	-	-	-	192	192	-	-	-	262	262	-	-	-	-	-	-	
Central	-	-	12	12	-	-	-	13	13	-	-	-	2	2	-	-	-	-	-	-	
Striped dolphin	-	-	24	24	-	-	-	5	5	-	-	-	11	11	-	-	-	-	-	-	
Common dol. (?sp.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Northern	-	-	261	261	-	-	-	85	85	-	-	-	56	56	-	-	-	-	-	-	
Central	-	-	172	172	-	-	-	34	34	-	-	-	222	222	-	-	-	-	-	-	
Southern	-	-	33	33	-	-	-	1	1	-	-	-	9	9	-	-	-	-	-	-	
Rough-toothed dolphin	-	-	-	-	-	-	-	-	-	-	-	-	27	27	-	-	-	-	-	-	
Risso's dolphin	-	-	-	-	-	-	-	3	3	-	-	-	-	-	-	-	-	-	-	-	
Short finned pilot w.	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	
Pygmy sperm whale	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Unspecified dolphins	-	-	35	35	-	-	-	32	32	-	-	-	39	39	-	-	-	-	-	-	
Faroes																					
Long-finned pilot w.	815 ^a	-	-	-	-	608 ^b	-	-	-	-	588 ^b	-	-	-	-	-	-	-	-	-	
Atlantic white-sided d.	438 ^a	-	-	-	-	0 ^b	-	-	-	-	255 ^b	-	-	-	-	-	-	-	-	-	
France																					
Long-finned pilot w.	-	-	1 ^a	-	-	-	-	5 ^a	-	-	-	-	1 ^a	-	-	-	-	-	2 ^{ab}	-	
Bottlenose dolphin	-	-	7 ^a	-	-	-	-	7 ^a	-	-	-	-	3 ^a	-	-	-	-	-	10 ^{ac}	-	
Striped dolphin	-	-	17 ^a	-	-	-	-	14 ^a	-	-	-	-	7 ^a	-	-	-	-	-	11 ^{ad}	-	
Common dol. (?sp.)	-	-	19 ^a	-	-	-	-	140 ^a	-	-	-	-	193 ^a	-	-	-	-	-	118 ^{ac}	-	
Risso's dolphin	-	-	2 ^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Harbour porpoise	-	-	1 ^a	-	-	-	-	8 ^a	-	-	-	-	11 ^a	-	-	-	-	-	12 ^{af}	-	
Spotted dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1 ^{ag}	-	
Unidentified dolphin	-	-	2 ^a	-	-	-	-	18 ^a	-	-	-	-	9 ^a	-	-	-	-	-	-	-	
Unid./other cetacean	-	-	-	-	-	-	-	1 ^a	-	-	-	-	-	-	-	-	-	-	-	-	
Germany																					
Harbour porpoise	-	-	5	-	-	-	-	3	-	-	-	-	5 ^a	5 ^a	-	-	-	-	8 ^b	8 ^b	
White-beaked dolphin	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Greenland																					
Narwhal	822	-	-	-	-	912 ^b	-	-	-	-	a	-	-	-	-	a	-	-	-	-	
White whale	746	-	-	-	-	493 ^b	-	-	-	-	a	-	-	-	-	a	-	-	-	-	
Harbour porpoise	2,131	-	-	-	-	1,830 ^b	-	-	-	-	a	-	-	-	-	a	-	-	-	-	
Long-finned pilot w.	365	-	-	-	-	115 ^b	-	-	-	-	a	-	-	-	-	a	-	-	-	-	

cont...

Species	1998					1999					2000					2001				
	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live
	Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est.	
Ireland																				
Common dolphin	-	-	14 ^b	-	-	-	-	8 ^c	-	-	-	-	3	-	-	-	-	1 ^d	-	-
Harbour porpoise	-	-	2 ^a	-	-	-	-	4	-	-	-	-	-	-	-	-	-	1 ^d	-	-
White-sided dolphin	-	-	1 ^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Striped dolphin	-	-	14	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Risso's dolphin	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Italy																				
Striped dolphins	a	-	a	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bottlenose dolphins	a	-	a	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common dolphins	a	-	a	-	-	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Japan																				
Baird's beaked whale	54	-	-	-	-	62	-	-	-	-	62	-	-	-	-	-	-	-	-	-
Killer whale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
False killer whale	45	-	-	-	3	5	-	-	-	-	8	-	-	-	-	-	-	-	-	-
Short-finned pilot	229	-	-	-	-	394	-	-	-	2	304	-	-	-	-	-	-	-	-	-
Pacific white-sided d.	-	-	1	-	-	-	-	-	-	11	1	-	-	-	-	-	-	-	-	-
Bottlenose dolphin	245	-	-	-	21	658	-	-	-	91	1,426	-	-	-	-	-	-	-	-	-
Pantropical spotted d.	460	-	-	-	-	38	-	-	-	-	39	-	-	-	-	-	-	-	-	-
Striped dolphin	449	-	2	-	-	596	-	1	-	-	300	-	-	-	-	-	-	-	-	-
Short-beaked comm.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Risso's dolphin	442	-	-	-	3	489	-	-	-	-	506	-	-	-	-	-	-	-	-	-
Dall's porpoise	11,385	-	2	-	-	14,807	-	169	-	-	16,171	-	-	-	-	-	-	-	-	-
Finless porpoise	-	-	6	-	1	-	-	1	-	-	-	-	20	-	-	-	-	-	-	-
Stejneger's beaked	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Unidentified dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified species	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Korea																				
Baird's beaked whale	-	-	-	-	-	-	-	1 ^{ab}	-	-	-	-	-	-	-	-	-	1 ^b	-	-
Pacific white-sided d.	-	-	7 ^{bc}	-	-	-	-	3 ^{bg}	-	-	-	-	4 ^{bg}	-	-	-	-	41 ^{bp}	-	-
Common dolphin	-	-	17 ^{bd}	-	-	-	-	25 ^{bh}	-	-	-	-	29 ^k	-	-	-	-	62 ^{br}	-	-
Risso's dolphin	-	-	7 ^{ef}	-	-	-	-	2 ^{bc}	-	-	-	-	20 ^l	-	-	-	-	25 ^{bs}	-	-
Harbour porpoise	-	-	-	-	-	-	-	1 ^{bg}	-	-	-	-	-	-	-	-	-	87 ^{bt}	-	-
Finless porpoise	-	-	2 ^{bc}	-	-	-	-	14 ⁱ	-	-	-	-	-	-	-	-	-	7 ^{bu}	-	-
Stejneger beaked whale	-	-	-	-	-	-	-	2 ^j	-	-	-	-	1 ^m	-	-	-	-	-	-	-
Killer whale	-	-	-	-	-	-	-	-	-	-	-	-	1 ^{bg}	-	-	-	-	-	-	-
False killer whale	-	-	-	-	-	-	-	-	-	-	-	-	1 ^{bg}	-	-	-	-	-	-	-
Bottlenose dolphin	-	-	-	-	-	-	-	-	-	-	-	-	12 ⁿ	-	-	-	-	3 ^{bv}	-	-
Dall's porpoise	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2 ^{bw}	-	-
Unidentified dolphin	-	-	-	-	-	-	-	-	-	-	-	-	27 ^o	-	-	-	-	--	-	-
Mexico^a																				
Vaquita	-	-	-	-	-	-	-	-	-	-	-	-	5 ^{bd}	-	-	-	-	-	-	-
Gulf of California	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2 ^d	-	-

	1998					1999					2000					2001				
Species	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live
	Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est.	
Mexico cont.																				
Bottlenose dolphin																				
Baja California	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7 ^c	-	-	-	-	-
Gulf of California	-	-	-	-	4 ^c	-	-	-	-	4 ^c	-	-	-	-	8 ^c	-	-	1	-	15
Gulf of Mexico	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15 ^c	-	-	-	-	-
Risso's dolphin	-	-	-	-	-	-	-	-	-	-	-	-	1 ^c	-	-	-	-	-	-	-
Netherlands																				
Atlantic white-sided d.	-	-	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Harbour porpoise	-	-	4	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
New Zealand																				
Long-finned pilot w.	-	-	1 ^a	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Bottlenose dolphin	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Common dolphin	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3 ^d	-	-
Hector's dolphin	-	-	14 ^b	-	-	-	-	5 ^c	-	-	-	-	10 ^c	-	-	-	-	13 ^e	-	-
Dusky dolphin	-	-	1	-	-	-	-	-	-	-	-	-	2	-	1	-	-	3 ^f	-	-
Peru																				
Dusky dolphin	-	-	-	-	-	-	-	50 ^a	-	-	-	-	12 ^a	-	-	-	-	2 ^a	-	-
Long-beaked comm. d.	-	-	-	-	-	-	-	48 ^a	-	-	-	-	20 ^a	-	-	-	-	7 ^a	-	-
Bottlenose dolphin	-	-	-	-	-	-	-	32 ^a	-	-	-	-	6 ^a	-	-	-	-	1 ^a	-	-
Burmeister's porpoise	-	-	-	-	-	-	-	79 ^a	-	-	-	-	39 ^a	-	-	-	-	14 ^a	-	-
Unspecified species	-	-	-	-	-	-	-	67 ^{ab}	-	-	-	-	79 ^{ab}	-	-	-	-	12 ^{ab}	-	-
South Africa																				
Indian Ocean	-	-	28	-	-	-	-	41 ^a	-	-	-	-	-	-	-	-	-	22	-	-
Common dolphin	-	-	7	-	-	-	-	11 ^a	-	-	-	-	-	-	-	-	-	-	-	-
Long-beaked comm. d.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	-	-
Indo-Pacific	-	-	8	-	-	-	-	8 ^a	-	-	-	-	-	-	-	-	-	2	-	-
Spinner dolphin	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified dolphins	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spain																				
Common dolphin	-	-	-	-	-	-	-	2	-	-	-	-	3	-	-	-	-	4	-	-
Cuvier's beaked whale	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
False killer whale	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Harbour porpoise	-	-	-	-	-	-	-	1	-	-	-	-	2	-	-	-	-	1	-	-
Bottlenose dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Clymene dolphin	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Spinner dolphin	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Long-finned pilot	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Short-finned pilot	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
Pilot whale(?)	-	-	-	-	-	-	-	-	-	-	-	-	2 ^a	-	-	-	-	-	-	-
Peale's dolphin	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-

cont...

	1998					1999					2000					2001				
Species	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live
	Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est.	
Spain cont.																				
Atlantic spotted	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-
Striped dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Pygmy sperm whale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
White sided dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Unidentified dolphin	-	-	5	-	-	-	-	4	-	-	-	-	12	-	-	-	-	1	-	-
St Lucia																				
Short-finned pilot	-	-	-	-	-	8 ^a	35 ^a	-	-	-	-	-	-	-	-	-	-	-	-	-
Pygmy killer whale	-	-	-	-	-	2 ^a	18 ^a	-	-	-	-	-	-	-	-	-	-	-	-	-
False killer whale	-	-	-	-	-	3 ^a	12 ^a	-	-	-	-	-	-	-	-	-	-	-	-	-
Melon head whale	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bottlenose dolphin	-	-	-	-	-	2 ^b	20 ^b	-	-	-	-	-	-	-	-	-	-	-	-	-
Atlantic spotted	-	-	-	-	-	12 ^b	60 ^b	-	-	-	-	-	-	-	-	-	-	-	-	-
Short-snouted Spinner	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fraser's dolphin	-	-	-	-	-	1 ^b	6 ^b	-	-	-	-	-	-	-	-	-	-	-	-	-
Common dolphin	-	-	-	-	-	1 ^b	10 ^b	-	-	-	-	-	-	-	-	-	-	-	-	-
Striped dolphin	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sweden																				
Harbour porpoise	-	-	14	-	-	-	-	2	-	-	-	-	3 ^a	-	-	-	-	-	-	-
UK																				
Striped dolphin	-	-	1 ^a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common dolphin(?sp.)	-	-	5 ^a	-	-	-	-	4 ^c	-	-	-	-	12 ^g	-	-	-	-	52 ⁱ	-	-
Harbour porpoise	-	-	33 ^b	-	-	-	-	19 ^d	-	-	-	-	34 ^h	-	-	-	-	-	-	-
Bottlenose dolphin	-	-	-	-	-	-	-	1 ^e	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified Delphinid	-	-	-	-	-	-	-	1 ^f	-	-	-	-	-	-	-	-	-	-	-	-
USA																				
White whale	-	366 ^a	-	-	-	238 ^p	-	-	-	-	240	-	-	-	-	463 ^t	-	-	-	-
Killer whale	-	-	0	0	-	-	-	2 ^u	4 ^u	-	-	-	-	-	-	-	-	-	-	-
Atl. pilot whale	-	-	14 ^b	104 ^b	-	-	-	3 ^v	371 ^v	-	-	-	-	-	-	-	-	-	-	-
Pac. pilot w.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atl white-sided dol.	-	-	1 ^c	34 ^c	-	-	-	4 ^w	69 ^w	-	-	-	-	-	-	-	-	-	-	-
Pac. white-sided dol.	-	-	1 ^d	1 ^d	-	-	-	0	0	-	-	-	2 ^r	5 ^r	-	-	-	-	-	-
Atl. Bottlenose dol.	-	-	6 ^e	66 ^e	-	-	-	7 ^x	115 ^x	-	-	-	-	-	-	-	-	-	-	-
Pac. Bottlenose dol.	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	-
Striped dolphin	-	-	4 ^f	4 ^f	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pac. short-beak com d.	-	-	11 ^g	53 ^g	-	-	-	34 ^y	191 ^y	-	-	-	23 ^r	75 ^r	-	-	-	-	-	-
Pac. long-beak com d.	-	-	2 ^h	2 ^h	-	-	-	1 ^z	8 ^z	-	-	-	2 ^r	9 ^r	-	-	-	-	-	-
Atl. Com dolphin (sp.)	-	-	272 ⁱ	272 ⁱ	-	-	-	3 ^A	195 ^A	-	-	-	-	-	-	-	-	-	-	-
Pac Com dolphin (sp.)	-	-	-	-	-	-	-	2 ^y	2 ^y	-	-	-	3 ^s	-	-	-	-	-	-	-

cont.

Species	1998					1999					2000					2001				
	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live
	Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est. total		Rep.	Est. total	Rep.	Est.	
USA cont.																				
Spottd d. (<i>Stenella</i> sp.) -	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northern right whale d -	-	-	-	-	-	-	-	3 ^y	17 ^y	-	-	-	11 ^r	47 ^r	-	-	-	-	-	-
Atl Risso's dolphin -	-	-	10 ^j	44 ^j	-	-	-	1 ^B	22 ^B	-	-	-	-	-	-	-	-	-	-	-
Pacific Risso's dolphin -	-	-	-	-	-	-	-	0	0	-	-	-	2 ^r	7 ^r	-	-	-	-	-	-
Atlantic harp porpoise -	-	-	65 ^k	778 ^k	-	-	-	36 ^C	342 ^C	-	-	-	-	-	-	-	-	-	-	-
Pacific harp porpoise -	-	-	1 ^l	>64 ^l	-	-	-	28 ^D	133 ^D	-	-	-	7 ^r	26 ^r	-	-	-	-	-	-
Dall's porpoise -	-	-	7 ^m	14 ^m	-	-	-	4 ^o	5 ^o	-	-	-	-	-	-	-	-	-	-	-
Beaked whales -	-	-	11 ⁿ	11 ⁿ	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	-
Unidentified species -	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	-

Argentina: In the following notes the estimated catch is given, followed by observed catch in brackets: (a) 5 caught by FV Humpback and 10 caught by FV Harengus between 2/4/98 to 13/4/98 (SC/51/SM45); (b) Buenos Aires coast - gillnet; (c) Tierra del Fuego - gillnet; (d) Figure composed as follows: <100 (34) Tierra del Fuego - gillnet + 68 (3) Ria Gallegos - gillnet; (e) pers. comm. M. Iniguez.

Australia: In the following notes the estimated catch is given, followed by observed catch in brackets: (a) Figure composed as follows: 3 (0) Gold Coast, Queensland + 0 (1) Shark net, SE Australia, New South Wales + 1 (1) gillnet, SE Australia, New South Wales; (b) Figure composed as follows: 3 (0) Gold Coast, Queensland + ? (6) SE Australia, New South Wales; (c) Figure composed as follows: 2 (0) Gold Coast, Queensland + 1 (1) SE Australia, New South Wales; (d) Figure composed as follows: 1 (0) Sunshine Coast, Queensland + 2 (0) Gold Coast, Queensland + 1 (0) Gillnet fishery, Gulf of Carpentaria, Queensland + 1 (0) Mackay, Queensland + 0 (2) Probable entanglement SA Coastline + 0 (1) Euthanasied, SA Coastline + 1 (0) Salmon farm net, Southern Australia; (e) Figure composed as follows: 3 (0) Sunshine Coast, Queensland + 2 (0) Gold Coast, Queensland + 0 (2) SE Australia (f) Figure composed as follows: 0 (1) Sunshine Coast, Queensland + 0 (1) Cairns, Queensland; (g) Gulf of Carpentaria, Queensland; (h) SE Australia (NSW) Net entanglement.

Brazil: Note: All the information for the 1997 and 1998 catches was taken from the revised Prog. Rep. Brazil except for the 12 franciscana and 4 tucuxi caught on Northern RJ State (pers. comm. A.P. Di Benedetto and R. Ramos) 1998. The catches in 1999 and 2000 are pers. comm. Salvatore Siciliano. In the following notes the estimated catch is given, followed by the observed catch in brackets: (a) Caught in Rio de Janeiro (pers. comm. A.P. Di Benedetto and R. Ramos - UENF). (b) 17 from Southern (north RS) + 61 from Southern (south RS) + 6 from SW Atlantic + 4 from Praia Grande - S.P. State + 12 from North of RJ State. (pers. comm. A.P. Di Benedetto and R. Ramos) + 1 from northern Rio de Janeiro (pers. comm. S. Siciliano). (c) 4 from Praia Grande - S.P. State + 6 from SW Atlantic + 15 from Northern Rio Grande do Sul (d) 3 from SW Atlantic. (e) 3 from SW Atlantic + 4 from Northern RJ State (pers. comm. A.P. Di Benedetto and R. Ramos). (f) From Praia Grande - S.P. State. (g) 178 [1986-1999] (1) from Northern Rio de Janeiro + 24 [Aug. 1998 - May 2000] (10) from Central São Paulo + (3) from Northern Rio Grande do Sul + (3) from Northern Rio de Janeiro (pers. comm. A.P. Di Benedetto and R. Ramos). (h) 141 (4) from Northern Rio de Janeiro + (4) from Northern Espírito Santo + (2) from Paraíba + (7) from Northern Rio de Janeiro State (pers. comm. A.P. Di Benedetto and R. Ramos). (i) Caught in Rio de Janeiro (pers. comm. Salvatore Siciliano). (j) Caught in Central São Paulo - Gillnet (k) Caught in Southern Brazil - Gillnet. It is only a rough estimate based on extrapolation. For the whole fleet. Data from only nine boats from a fleet of about 140-150 (see Sechi *et al.*, 1997) (l) Figure composed as follows: 3 Direct and 3 Indirect from Cananea Estuary, SP - Gillnet + 2 from Northern Rio de Janeiro - Gillnet (pers. comm. A.P. Di Benedetto and R. Ramos) + 3 from NE Brazil - Gillnet (m) Caught from Central São Paulo. (n) Caught from Central Amazon. (o) Figure composed as follows: 1 Northern Rio Grande do Sul, gillnets + 18 Northern, gillnets. (p) Northern

Canada: (a) No information; (b) Figure composed as follows: 451 High Arctic + 108 Hudson; (c) Figure from Nunavut. Figures from Northwest Territories - Beaufort Sea not available at time of report.

Chile: Figures are taken from SC/51/SM17 and are a mixture of direct and incidental catches. (a) Port Punta de Choros IV R - Carcass (II) with net marks butchered openly on wharf; meat reportedly used for human consumption. (b) Stranded (III), harpoon wounds; + witness evidence directed take; parts muscle and blubber removed. (c) Stranded with multiple cut marks and flukes severed.

Denmark: (a) SC/54/SM31 - Bycatch is overestimated, as the effect of the use of pingers has not been taken into account.

Faroese: (a) NAMMCO Annual Report 1999; Faroe Islands Progress Report 1998; (b) pers. comm. Daniel Pike, Scientific Secretary, NAMMCO; (c) no Information.

France: (a) Includes those found stranded with marks indicating that they had been most probably caught in fishing gear. Data are provided by the CRMM-La Rochelle, France; (b) Figure composed as follows: 1 Atlantic + 1 Mediterranean; (c) Figure composed as follows: 2 English Channel + 7 Atlantic + 1 Mediterranean; (d) Figure composed as follows: 7 Atlantic + 4 Mediterranean; (e) Figure composed as follows: 1 English Channel + 117 Atlantic.; (f) Figure composed as follows: 3 English Channel + 9 Atlantic; (g) Caribbean.

Germany: (a) Figure composed as follows: 3 from Schleswig-Holstein, Baltic Sea - Gillnet + 2 from Mecklenburg-Prepommern, Baltic Sea - Gillnet; (b) Figure composed as follows: 5 from Schleswig-Holstein, Baltic Sea - Gillnet + 3 from Mecklenburg-Prepommern, Baltic Sea - Gillnet.

Greenland: (a) No information; (b) pers. comm. Daniel Pike, Scientific Secretary, NAMMCO.

Ireland: (a) Bycatch determined from post-mortems; (b) Bycatch of 1 determined from post-mortem + 13 incidentally caught in surface gillnet; (c) Bycatch of 1 determined from post-mortem + 7 incidentally caught in surface gillnet; (d) Bycatch determined from post-mortems.

Italy: (a) Centro Studi Cetacei della Società Italiana di Scienze Naturali 1998 and 1999 report in preparation.

Japan: (a) Northern & Southern forms.

Korea: (a) Drift gillnet; (b) East Sea; (c) Figure composed as follows: 4 set net, 2 gillnet, 1 drift gillnet; (d) Figure composed as follows: 9 set net, 7 gillnet, 1 drift gillnet; (e) Set net; (f) South Sea; (g) Gillnet; (h) Figures composed as follows: 20 Set net, 5 gillnet; (i) Figures composed as follows: 1 East Sea gillnet, 13 Yellow Sea stow net; (j) Figure composed as follows: 1 Gillnet + 1 drift gillnet; (k) Figure composed as follows: East Sea - 2 trap net + 8 purse seine + 7 gillnet + 12 set net; (l) Figure composed as follows: East Sea - 2 gillnet + 17 Set net + 1 trap net. (m) East Sea - Set net; (n) Figure composed as follows: East Sea - 1 gillnet + 1 set net + South Sea - 10 Purse seine; (o) Figure composed as follows: East Sea - 1 purse seine + 18 gillnet + 3 set net + 4 trap net + South Sea - 1 set net; (p) Figure composed as follows: 21 gillnet + 14 set net + 3 trap net + 3 unidentified; (r) Figure composed as follows: 18 purse seine + 1 long line + 8 gillnet + 32 set net + 3 trap net; (s) Figure composed as follows: 4 purse seine + 5 gillnet + 4 set net + 1 long line + 2 trap net + 9 unidentified; (t) Figure composed as follows: 1 long line + 57 gillnet + 29 set net; (u) Figures composed as follows: 5 gillnet + 2 set net; (v) Figures compose as follows: 1 gillnet + 1 set net + 1 trawl; (w) Figures composed as follows: 1 gillnet + 1 set net.

Mexico: (a) See the ETP table for catches taken in the Eastern Tropical Pacific. They are not included here. (b) Captured in the Gulf of California. (c) Permits issued by SEMARNAP. The animals are being kept in captivity at recreational facilities. (d) Gillnet. (e) Pacific - Long line.

New Zealand: (a) pers. comm. R.G. Johnston; (b) South Island. From Govt observer program (covering about 10% of range of Hector's dolphin); (c) South Island # beachcast; (d) Gillnet/Trawl; (e) Figure composed as follows: Gillnet - 3 North Island, West Coast + 6 South Island, West Coast + 4 South Island, East Coast; (f) Trawl.

Peru: (a) Figures are taken from SC/54/SM10 and are a mixture of direct and incidental catches. All catches taken from Table 1 have been tabled as incidental because it is not clear which were direct and which were incidental; (b) Mostly meat samples.

South Africa: (a) pers. comm. P. Best; (b) Shark nets.

Spain: (a) Probable pilot whale – ship strike.

St Lucia: All caught in the Caribbean Sea. (a) Harpoon gun; (b) Harpoon gun/hand harpoon.

Sweden: Figure composed as follows: 1 Baltic Sea Gillnet + 2 Swedish Skagerrak Sea (1 Gillnet + 1 Trawl).

UK: (a) Bycatch diagnosed at necropsy (England and Wales); (b) Figure composed of: 20 from gillnets, 12 unknown but diagnosed at necropsy, 1 reported to SWF in Shetland (2 from Scotland, 30 from England and Wales + 1 from Shetland); (c) Bycatch diagnosed at necropsy (England) (d) Figure composed as follows: 9 diagnosed at necropsy (England and Wales), 4 Gillnet fisheries (England), 1 Gillnet (E. Scotland), 3 Trawl (W. Scotland), 2 diagnosed at necropsy (W. Scotland); (e) Illegal salmon net (Moray Firth); (f) Gillnet fishery (England); (g) Figure composed as follows: 10 England & Wales - Stranded/diagnosed at necropsy + 2 Celtic Sea – Observed bycatch in set net fisheries; (h) Figure composed as follows: 8 England & Wales - Stranded/diagnosed at necropsy + 12 North Sea - Observed bycatch in set net fisheries + 14 Celtic Sea - Observed bycatch in set net fisheries; (i) Pelagic trawling.

USA: The reported catch columns include catches reported by observer programs, from interviews with fishermen and incidental reports (e.g. stranded animals determined to have died in nets). There are no live captures to report. All information is taken from published USA National Marine Fisheries Service Annual Marine Mammal Stock Assessment Reports (SAR) unless otherwise indicated. Stranded animals are not included.

In the following notes the estimated catch is given, followed by observed catch in brackets. (a) K.J. Frost 1999. Harvest report: statewide summary for western Alaska beluga stocks, 1994/98. Report 99-1, Alaska Beluga Whale Committee; Cook Inlet figures - pers. comm. DeMaster. Includes 39 struck and lost (except Cook Inlet, where no data were available); (b) Figure composed as follows: 12(12) Pelagic drift gillnet + squid, mackerel, butterfish fishery 85(1) + Mid-Atlantic coastal sink gillnet 7(1); (c) Figures composed as follows: 34(1) NE multispecies sink gillnet (US Atlantic and Gulf of Mexico SAR - 2000); (d) Figures composed as follows: for 1998 1(1) WA/CA/OR groundfish trawl (US Pacific SAR - 2000); (e) Figures composed as follows: 63(3) Mid-Atlantic coastal sink gillnet(coastal bottlenose) + 3(3) pelagic drift gillnet (offshore bottlenose); (f) 4(4) Pelagic drift gillnet; (g) Figures composed as follows: 51(9) CA/OR drift gillnet + ≥ 2 (2) CA large mesh set gillnet (US Pacific SAR - 2000); (h) Figures composed as follows: ≥ 2 (2) CA large mesh set gillnet (US Pacific SAR - 2000); (i) Figures composed as follows: 255(255) Pelagic drift gillnet + 17(17) mackerel joint venture (US Atlantic and Gulf of Mexico SAR - 2000); (j) Figures composed as follows: 9(9) Pelagic drift gillnet + 35(1) Pelagic longline (US Atlantic and Gulf of Mexico SAR - 2000); (k) Figures composed as follows: 332(12) NE multispecies sink gillnet + 446(53) Mid-Atlantic coastal gillnet + 0(0) Pelagic drift gillnet (US Atlantic and Gulf of Mexico SAR - 2000); (l) Figures composed as follows: ≥ 1 (1) Klamath River tribal salmon fishery + 63 (n/a) CA large mesh sink gillnet (as described for 1997) (US Pacific SAR - 2000); (m) Figures composed as follows: 3(2) WA/OR/CA groundfish trawl + 4(3) BSAI groundfish trawl + 3(1) Gulf of Alaska trawl + 4(1) BSAI groundfish longline (US Pacific SAR - 2000 and Alaska SAR - 2000); (n) Pelagic drift gillnet fishery (US Atlantic and Gulf of Mexico SAR - 2000); (o) SC/54/ProgRep USA – Figure composed as follows: 4(3) Alaska groundfish fisheries(trawl, longline and pot) + 1(1) Washington, Oregon and California at-sea processing groundfish trawl fishery.; (p) pers. comm. D.P. DeMaster – does not include figures for Cook Inlet; (q) Halibut/angel shark set gillnet fishery – Monterey Bay (SC/53/SM9); (r) Swordfish/thresher shark drift gillnet fishery (SC/53/SM9); (s) Set gillnet fishery – non-Monterey strata: Southern California, Ventura, Channel Is., and Morro Bay) (SC/53/SM9); (t) SC/54/ProgRep USA - Figure includes 51 struck and lost – does not include figures for Cook Inlet; (u) SC/54/ProgRep USA - Alaska groundfish fisheries (trawl, longline and pot); (v) SC/54/ProgRep USA - Figures composed as follows: 228(1) NW Atlantic – N. Atlantic bottom trawl + 49(1) NW and Mid-Atlantic – Squid, mack., butt. trawl + 94(1) Mid-Atlantic – Pelagic longline; (w) SC/54/ProgRep USA - NW Atlantic – NE multispecies sink gillnet; (x) SC/54/ProgRep USA - Figures composed as follows: 63(3) Mid-Atlantic coastal sink gillnet + 52(4) Central Florida shark gillnet; (y) SC/54/ProgRep USA - California/Oregon/Washington swordfish/thresher shark drift gillnet fishery; (z) SC/54/ProgRep USA - California swordfish/thresher shark drift gillnet fishery; (A) SC/54/ProgRep USA - Figures composed as follows: 146(2) NW Atlantic, NE multispecies sink gillnet + 49(1) NW and Mid-Atlantic, squid, mack, butt., trawl; (B) SC/54/ProgRep USA - NW and Mid –Atlantic pelagic longline (serious injury); (C) SC/54/ProgRep USA - Figures composed as follows: 270(14) NW Atlantic, NE multispecies sink gillnet + 53(3) Mid-Atlantic coastal sink gillnet + 19(19) NW and Mid-Atlantic, NMFS/NER records (gillnet); (d) SC/54/ProgRep USA - Central California angel shark/halibut and other species large mesh (>3.5") set gillnet fishery.

References:

- Ferrero, R.C., D.P. DeMaster, P.S. Hill, M.M. Muto and A.L. Lopez. 2000. Alaska Marine Mammal Stock Assessments, 2000. NOAA, NMFS. NOAA Tech. Memo. NMFS-AFSC-119. 191p.
- Forney, K. A., J. Barlow, M.M. Muto, M. Lowry, J. Baker, G. Cameron, J. Mobley, C. Stinchcomb and J.V. Carretta. 2000. U.S. Pacific Marine Mammal Stock Assessments: 2000. NOAA, NMFS. NOAA Tech. Memo. NMFS-SWFSC-300. 276 p.
- Secchi, E.R., Zerbini, A.N., Bassoi, M., Dalla Rosa, L., Moller, L.M., Rocho-Campos, C.C. 1997. Mortality of franciscanas (*Pontoporia blainvillei*) in coastal gillnetting in southern Brazil: 1995-1995. *Rep. Int. Whal. Comm* 47: 653-658.
- Waring, G.T., J.M. Quintal and S.L. Swartz. 2000. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2000. NOAA, NMFS. NOAA Tech. Memo. NMFS-NE-162. 197 p. +app.

U.S. Marine Mammal Stock Assessment Reports are available at the following web site: http://www.nmfs.noaa.gov/prot_res/PR2/Stock_Assessment_Program/sars.html

Annex L

Report of the Sub-Committee on Whalewatching

Members: Kato (Chair), Berggren, Carlson, Clapham, Clark, C., Collins, Corkeron, Fulford-Gardiner, Gales, Garrigue, Guiste, Haug, Iniguez, Lawrence, Lens, Manzanilla, Mattila, Minton, Murase, Nagatomo, Nishiwaki, Oosthuizen, Otani, Palazzo, Parsons, Peddemors, Rambally, Reijnders, Robbins, Rose, Sakamoto, Simmonds, M., Stachowitsch, Swartz, Urban, Walters, Weinrich, Williams, Wilson, Yoshida.

1. OPENING REMARKS AND TERMS OF REFERENCE

Kato welcomed the participants and noted the priority items identified by the Scientific Committee:

- (1) Review the work of the Intersessional Correspondence Groups:
 - (a) Data Collection Correspondence Group; and
 - (b) Whalewatching Management Correspondence Group.
- (2) Review information on the significance of noise production from vessels and aircraft in a joint session with the Standing Working Group on Environmental Concerns.
- (3) Review of the research on the effectiveness of and compliance with national whalewatching guidelines and regulations.

Additional work would be to review new information on: (1) dolphin feeding programmes; (2) 'swim-with' whale and dolphin programmes; and (3) national guidelines and regulations.

2. ELECTION OF CHAIR AND RAPPORTEURS

Kato was elected Chair. Carlson acted as rapporteur, assisted by Rose, Weinrich and Williams.

3. ADOPTION OF AGENDA

The adopted agenda is given as Appendix 1.

Sakamoto stated that it is the Government of Japan's position that whalewatching is outside the competence of the IWC. Japan does not deny that studying the effects of whalewatching on whale stocks is beneficial in order to obtain better understanding of the stocks. However, the IWC has limited financial and human resources and should be focusing its efforts on important matters such as stock assessment.

Clapham responded that, in contrast to the views expressed by Sakamoto, it should be noted that in many locations, whalewatching has provided a free or low-cost platform for data collection that has proved of considerable importance to the assessment and understanding of local cetacean populations. In the Gulf of Maine, for example,

numerous studies have been published that are based in part or entirely upon data collected from whalewatching vessels. Indeed, from this region alone, whalewatching-based studies have resulted in at least 30 peer-reviewed publications in international journals. These papers concern several species of large whales, and many topics of importance to management such as abundance, distribution, population characteristics, reproductive rates, population structure and composition, social structure, age at sexual maturity, migratory movements, mating systems, sex ratio, and changes in distribution in relation to the abundance of prey. Because of the free access provided by whalewatching vessels, these studies have been conducted at essentially no survey cost. Consequently, to state that the IWC should ignore whalewatching and instead concentrate its scarce resources on 'assessments' ignores the considerable contribution to the latter that can be made by whalewatching data.

4. REVIEW OF AVAILABLE DOCUMENTS AND REPORTS

The following documents were considered: SC/54/WW1-4; SC/54/E7-8; SC/54/O7; SC/54/SM24; Bain (2001; 2002); Constantine (2001); Erbe (2000; 2001); Heckel *et al.* (2001); McCarthy (2001); McCauley and Cato (2002); Morton and Symonds (2002); Richardson and Würsig (1997); Williams *et al.* (2002a; b).

5. REPORT OF INTERSESSIONAL WORKING GROUPS

5.1 Data Collection Correspondence Group

SC/54/WW2 reported on the further development of the Data Recording System (DRS) initiated at the two previous meetings of the Whalewatching sub-committee. The paper provided two brief reviews: (1) the history of research associated with whalewatching operations (as background to those who may be new to this issue); and (2) the kinds of reactions that cetaceans can show to vessels (providing illustrations of what kinds of behaviour can be observed and measured). It was noted that SC/54/E7 is also helpful in this respect in that it provides a list of reported interactions between vessels and cetaceans. Based on consultations conducted intersessionally, and a review of comments made at the previous sub-committee meeting, SC/54/WW2 provided a revised version of the DRS and preliminary instructions for its use. One correspondent noted that, for some time, a comprehensive and global approach has been required for the collection of scientific data on board whalewatching vessels. Not only because the collection of such data, even in its simplest form, can yield important information relating to research and conservation; but also,

and of equal importance, such studies provide whalewatching operators with a stake in the learning process.

Data collectors would enter appropriate figures (e.g. times or distances) or just a 'Y' for yes or 'N' for no in the relevant data fields. Where possible, they could add the number of animals in the boxes relating to the described behaviours or group formations. For example, if mother and calf are seen in tight formation and six animals are tightly grouped around them, the response would be 'Y/6'. The collection of some data (i.e. the Interaction Record, Boat Record and Behavioural and Group Composition Record) can be at regular intervals and the data fields are designed to facilitate this.

In the development of the form and subsequent data collection, it is strongly recommended that the advice of an experienced field researcher be sought. Training, for example in the recognition of species and behaviours, is also recommended. Consideration also needs to be given as to who will analyse the data. Collecting the data is only part of any research project and provision should be made for appropriate analyses.

Quality control is very important and if, for example, there is a dedicated and trained researcher on board, she/he can be expected to collect high quality data such as a continuous record of behaviour during sightings. However, if the observer doubles as the skipper, tour guide and data collector, she/he should probably aim for a simpler level of data collection; for example, species identity combined with precise location information. Even simpler levels of data collection can prove valuable over time if data are collected systematically.

Bearing the above points in mind, anyone interested in using the DRS in the field is recommended to follow these steps:

- (1) Consider what is practical to collect according to the circumstances in which the whalewatching platform is operating.
- (2) Choose from the DRS those data fields that are identified as appropriate and modify into a 'daughter form' (always including the critical information highlighted for each data field).
- (3) Test the 'daughter form' in the field – i.e. in the conditions in which it is intended to be used – to ensure that in practice it can be filled in with reasonable ease and accuracy.

The DRS is not intended to be exhaustive but to provide an indication of what data may be collected by whalewatching platforms; which data should be regarded as having priority; and how data may be recorded. It does not facilitate the collection of acoustic or photographic material other than allowing notes to be made of where and when such data were recorded, although both types of research are recommended. The DRS would benefit from further development and, in particular, testing in the field.

It is apparent that the full DRS has been misunderstood repeatedly as being a single form which would-be data collectors have found daunting. It was suggested that it might be possible to produce an interactive computer program based on the DRS that would facilitate the production of site-specific forms to be used in the field. The DRS could also be developed as an interactive web-based or lap-top/palm top system (with the potential for collecting data in real time in a manner similar to the *LOGGER* program).

Noting that the greater part of the DRS data fields had already been published and that further modification would benefit from field trials, M. Simmonds suggested that further work on the DRS should be conducted interessionally.

M. Simmonds then demonstrated a simple computer program that allowed would-be researchers to generate simple date-collection forms based on the DRS. The program allowed the researchers to identify the types of data that they wished to collect (or had been advised to collect) by responding to questions and then produced a 'daughter form' as a product which could be printed.

Parsons presented the results of a whalewatching DRS form survey that he and his colleagues conducted in West Scotland. Due to this year's short interseasonal period, field tests were not possible. However, the master form and derived 'daughter form' were sent to 21 marine wildlife tour operators in West Scotland for comment. The operations ranged from 'one-man' operations to large vessels with several crew members capable of carrying more than 60 passengers. Most vessels, however, were less than 40 feet in length and carried less than 12 passengers.

Eighteen (out of 21 contacted) tour operators commented on the data forms. Two of the more established operators already had a data-collection system in place. Only two of the remaining 16 operators sent sighting data to scientists for analysis. They did not feel that an onboard computer could be used as a way of recording data due to logistic constraints (e.g. lack of space available or weather-proof facilities), but supported the idea of waterproof logbooks for recording data.

None of the operators had the equipment or training to record more than basic sighting information (i.e. sighting position, species, sea state). However, several were willing to collect more detailed information if equipment and training were provided.

Although the operators considered the master forms to be complicated, 80% considered use of a 'daughter form' feasible. Most thought that check boxes, 'delete where applicable' sections and tables were easier to use than diagrams. They were unwilling to draw a map of their route, as they did not wish to alert other whalewatching operations to their favoured sites. None were prepared to fill in a form several pages long or record environmental data every five minutes during a sighting; recording such data once an hour or several times during the day, however, was considered feasible.

The 16 operators that did not have onboard guides were asked if they were willing to have a dedicated data collector. Thirty-eight percent were agreeable; those that declined did so for practical reasons, e.g. the operation/vessel was too small and a researcher would displace a paying customer.

In summary, there is great potential for data collection in the region and marine wildlife tourism operators represent a potential source of scientific data collection that is largely untapped. There is a high degree of support for a derived 'daughter form' and the critical criterion for data form design is ease of use, as many operators run 'one-man' businesses that operate from small vessels and have to pilot while recording data.

The data that operators collect should initially be limited with minimal time required for completion. The complexity and amount of data recorded can be increased through time. Moreover, a suite of forms should be developed to accommodate various classes of operations and ideally be tailored for individual operators. Finally, DRS forms need not be limited to whalewatching operations but could be applicable to a variety of other marine-user groups.

There was a productive discussion on the development of the DRS and the 'daughter form' used in Parsons' study (developed last year in the sub-committee) and the utility of collecting scientific data from whalewatching vessels. Comments included the need to: simplify data forms for some operations; laminate forms for open boats; include a way to report areas where there was effort but no sightings; provide feedback to operators and tourists; relate other variables to cetacean behaviour; and extend information on vessel behaviour. It was suggested that the scientific question the forms attempt to address should be noted. The group was reminded that the DRS allows the creation of a myriad of daughter forms, and that this process in developing an appropriate daughter form should be driven by the research questions being asked.

Carlson suggested that data forms from whalewatching operations and research groups around the world, as well as the scientific question(s) the forms attempt to address, be gathered and collated. The sub-committee **agreed** with this suggestion and tasked Carlson to collate the information for presentation next year.

Some members noted that there were serious limitations for whalewatching operations to collect data that can be used for the management of whales, but rather dedicated sighting surveys and other research are necessary. Others noted that, in some areas, such data are the only available information on species distribution and that long-term data collected on whalewatching vessels has been used in discussions on the RMP and the Comprehensive Assessment of the North Atlantic humpback whale. It was noted that the sub-committee had discussed this issue in detail at the 2000 and 2001 meetings.

A small group, chaired by M. Simmonds, prepared a document on the terms of reference for an intersessional Correspondence Group to review and further develop the DRS. The sub-committee agreed that an intersessional group be formed to continue the work as described in Appendix 2. Members of the group include: Fulford-Gardiner, Iniguez, Nishiwaki, Oosthuizen, Palazzo, Parsons, Rose, Weinrich, Williams and Yoshida. M. Simmonds will Chair the Correspondence Group.

5.2 Whalewatching Management Correspondence Group

Oosthuizen presented the report of the group regarding planning for a workshop on the development of whale- and dolphin-watching management. He noted that the rationale and need for such a workshop was discussed in detail at the Scientific Committee last year and that instructions to the intersessional correspondence group were to develop the terms of reference and agenda. He further noted that the management framework should be based on the best available scientific evidence.

Sakamoto stated that it is not appropriate for the sub-committee to discuss management of whalewatching as it is outside of the competence of the IWC. He further noted that the Scientific Committee mandate is to deal with scientific issues and therefore Japan could not support the proposal as written. Palazzo commented that Brazil supports the concept of the workshop as whalewatching is an important use of whale resources in Brazil and other developing countries. Furthermore, the workshop would bridge the gap between scientific assessment and management. Rose and M. Simmonds noted that the workshop was not intended to be an official IWC workshop but that information from the recent deliberations of the sub-committee were expected to be helpful. It was

emphasised that funds for the workshop will not be requested from the IWC. Nagatomo commented that the expertise of the Scientific Committee might be useful in providing advice on the scientific aspects of managing whalewatching, but not management *per se*. Kato suggested that members of the sub-committee could comment on the proposal and that a revised proposal be submitted for discussion.

Noting the ongoing proliferation of whalewatching activities worldwide, and concerns about possible impacts of whalewatching activities on cetacean populations, the sub-committee **agreed** that an intersessional workshop would benefit future whalewatching management.

The meeting agenda might include:

- (1) a review of available scientific information on cetacean watching;
- (2) scientific information needed to develop and manage cetacean watching;
- (3) consideration, where feasible, of total allowable effort of specific cetacean watching industries (e.g. boat numbers and size, noise levels, number of trips);
- (4) geographical allocation for vessels;
- (5) review of current regulations, permit conditions, codes of conduct; and
- (6) the role of marine protected areas.

Data required include: existing cetacean watching management plans; specified case studies; Carlson's compendium of whalewatching regulations and codes of conduct on the IWC website; review of relevant scientific literature; and invited papers on specific topics.

The format of the workshop will be a two-day symposium followed by a 3-4 day invitational workshop. As this will not be an official IWC workshop, funds will not be sought from the IWC, but from member nations and other potential sponsors. The workshop will be scheduled before next year's meeting.

The sub-committee **recommended** that:

- (1) An Intersessional Advisory Group be established to advise Oosthuizen on the scientific parameters which would be discussed during the proposed workshop; members to include: Carlson (Chair), Iniguez, Palazzo, Parsons, Rose, M. Simmonds and Williams.
- (2) The Committee endorse the Workshop and encourage participation by members of the Scientific Committee and IWC member states.

6. WHALEWATCHING ACTIVITIES AND NOISE IMPACTS

This was a joint session with the Standing Working Group on Environmental Concerns

SC/54/E7 considered recent knowledge concerning noise pollution and its implications for cetaceans, with particular reference to vessel noise. It was primarily intended as an update to earlier submissions to the Scientific Committee and considered:

- (1) Developments in the theoretical framework (including recent recommendations that seismic surveys avoid areas where densities of marine mammals are known to be high; that initial surveys for marine mammals should

be conducted in the vicinity of deployment; and the recent use of computer models to estimate noise impacts, including in the context of whalewatching).

- (2) Technological mitigation (for example using low intensity seismic sources).
- (3) Vessel design (including machinery noise reduction).

SC/54/E7 also identified some novel marine noise sources, such as the re-launch of the Acoustic Thermometry of Ocean Climate (ATOC) project (now named the North Pacific Acoustic Laboratory) and the ongoing expansion worldwide of marine wind farms. The authors also provided some new information about established sources including: military activities; vessel noise; acoustically-based anti-predator devices; and seismic exploration, noting that McCauley and Duncan (2001) had commented that, of man-made noises, seismic airgun noises present the greatest environmental threat.

M. Simmonds concluded that, despite increasing concerns about noise pollution, it still receives little attention from policy makers. The need for the regulation of boat traffic when in the vicinity of cetaceans, including in particular (but not limited to) whalewatching vessels, is also indicated. The legal underpinning of mitigation measures in response to all sources of noise is strongly indicated, although it needs to be flexible enough to address the fact that the implications of noise for marine wildlife is still only poorly understood and that knowledge will improve with time. The need to study the implications of changing the marine acoustic environment has never been greater.

SC/54/E7 contained information on avoidance behaviour as well as changes in behaviour and habitat use by cetaceans as a result of vessel traffic. A total of 104 scientific studies involving 22 species of small cetaceans, sperm whales and nine species of baleen whales were presented. Parsons noted that there are additional, published studies on vessel impacts on cetaceans and several more in unpublished governmental reports and scientific literature. Examples of these studies are noted and appear in Appendix 3.

In response to a request for references as to what constitutes 'loud' vessels, M. Simmonds identified Bain (2001), Erbe (2000; 2001), McCauley and Cato (2002), Richardson and Würsig (1997) and Williams *et al.* (2002a).

In regard to the mass stranding of beaked whales in the Bahamas in March 2000 (IWC, 2001, p.255), DeMaster inquired if any beaked whales had been observed after the event or if only photo-identified individuals were not resighted. Rowles replied that few to no *Ziphius* were sighted in the summer of 2000, but some *Ziphius* were sighted the following year. Sighting rates are apparently still depressed. She further noted that *Mesoplodon* were sighted during both years. Rose clarified that even when *Ziphius* individuals were resighted, none of them were animals photo-identified before the stranding. Rowles elaborated that annual sightings of photo-identified individuals were not common before the stranding and long intervals between sightings had been previously known. She commented that it was premature to conclude that all animals present in the area at the time of the stranding had been killed or displaced.

Tregenza noted that the increase in the number of high-speed ferries, whalewatching vessels and other ships may lead to high rates of vessel/whale collisions and pose a serious threat to cetaceans that do not show avoidance to their noises. M. Simmonds agreed and added that in some areas jet skis may be a problem as they may produce insufficient noise in the water to cause animals to avoid

them. He further noted the problem in the Canary Islands with the increase of large, high-speed ferries and whalewatching vessels. It was noted that within the next few decades, freighters and super tankers would have the capability of travelling at 60mph.

Dizon reported on an increase in average low frequency ambient noise of 10dB off the central California coast in the last two decades. This increase could significantly lower a whale's communication range by several orders of magnitude. Tregenza commented that there is a problem in assuming that disturbance is always negative and that avoidance responses by whales are clearly positive if they avert a ship strike. Fast ferries may in fact be a bigger problem (e.g. in the Ligurian Sea) through direct kills. There is also an assumption that sound is directional and whales will move away; this is not always the case and does not help to avoid collisions. Therefore, further research is needed to determine whether making vessels quiet necessarily confers a net benefit to whale populations.

In the context of mitigation of noise impacts on cetaceans, SC/54/E8 reported on an investigation of the relevance of international law to marine noise. Two types of legal instrument are relevant: (1) instruments where there is provision for the control of pollution that includes noise or energy; and (2) instruments where the disturbance of marine wildlife is specifically addressed. It may be assumed that disturbance primarily relates to noise (for example, vessel noise), but it should also be noted that it may relate to other properties of the source of disturbance (for example, the physical presence of a vessel).

The 1982 United Nations Convention on the Law of the Sea (UNCLOS) establishes duties on its contracting parties in respect to pollution of the marine environment 'from any source' (e.g. see Art 194(1) UNCLOS). Art 1(1)(4)UNCLOS states that:

'[P]ollution of the marine environment' means the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities.

It may be argued that the term 'energy' in UNCLOS includes noise and that the term 'pollution of the marine environment' includes human-induced noise.

MARPOL addresses pollution from ships but focuses solely on substances. There may be scope for defining the term 'substance' such that it includes energy or at least ocean noise. Though this has not been done in MARPOL, such an approach does appear to have been taken by the International Maritime Organisation in its *Guidelines for the Identification and Designation of Particularly Sensitive Sea Areas* ('the PSSA Guidelines'; see Resolution A.927(22), Annex 2). These refer to noise as a substance (see para 2.2).

M. Simmonds briefly considered some instruments that focus on the protection of marine wildlife (i.e. the provisions of the Ligurian Sea Sanctuary; the EU Habitats and Species Directive; ASCOBANS and ACCOBAMS; and the US Marine Mammal Protection Act). He noted that there was a growing recognition of disturbance in international law, especially relating to cetaceans. There seemed to be a need for 'generally accepted international rules and standards' with respect to noise pollution (although coastal states may still establish and manage 'particularly sensitive sea areas' in response to ocean noise concerns). Finally, he recommended that scientifically supported definitions of what constitutes

unacceptable or dangerous noise pollution, disturbance or harassment would help to inform the development and interpretation of existing and future law.

M. Simmonds drew attention to another legal review recently published by McCarthy (2001). This review came to very similar conclusions to those presented in SC/54/E8. McCarthy reported that 'the [necessary international] legal framework exists but has not yet specifically been applied to underwater noise pollution. The problems of underwater noise pollution are significant and its international regulation is complicated by the transboundary nature of sound in the ocean...[which] effectively necessitates a system of controls on a global scale'.

In her review, McCarthy had also included comment on the work on noise conducted to date under the auspices of the Standing Working Group on Environmental Concerns, noting that 'to date, no scientific research on the effects of noise on marine mammals has been promulgated by the IWC'.

DeMaster pointed out that legal opinions need to come from appropriate authorities. Further, DeMaster noted the need to establish links between noise and demographics (e.g. the Bahamian beaked whale strandings). He commented on the difficulty of defining unacceptable noise levels, as it would have to be species- and frequency-specific.

C. Clark noted that one approach on potential impacts from anthropogenic noise separates impacts into physical harm and behavioural responses. Physical harm, often due to chronic exposure to noise, is evident as a permanent threshold shift (PTS) in hearing ability caused by damage to inner ear sensory receptors, while temporary threshold shift (TTS) is a modification of these receptors that, although not damaging, does serve as an indicator that further exposure is likely to lead to PTS. He further noted that important progress has been made in the ability to estimate levels of noise exposure for individual animals or populations of animals and that this might provide a way forward to better evaluate the potential for noise impacts. This approach combines known characteristics of noise sources with site-specific physical models of sound propagation, and integrates these physical descriptions of noise levels with the distribution, densities and movement patterns of animals over space and time. The output from this type of model provides a quantitative and reasonable estimate of noise exposure for each animal within a hypothetical population (analogous to dosage exposure level), with most uncertainty in exposure as a result of uncertainty in biological variables (i.e. spatial and temporal distributions and the percent of time spent at different depths). One benefit of this approach is to move discussion away from generalised statements on noise impacts into a domain where quantified measures of exposure are available as a function of noise source, ocean environment, and animal movement and distribution. The challenge for biologists is to provide scientifically based information on animal responses to noise exposures as a function of biological context and to develop plausible mechanisms for how such responses impact individual survivorship and fitness, and populations.

C. Clark also commented that noise pollution may have an analogue with anthropogenic light pollution and its reported impact on birds, frogs and sea turtles. He asked if there was any legal reference or legal mechanism enacted to mitigate the effect of light pollution. Swartz stated that in the southern US, there are state and local regulations on coastal lighting to protect turtle hatchlings on nesting beaches. Rose stated that the US Endangered Species Act might make reference to this and suggested that it be investigated.

Two workshops, relevant to the discussion were announced: a NMFS workshop on shipping noise, impacts on marine mammals and mitigation; and a workshop on resonance effects.

Williams *et al.* (2002a) reported results from a shore-based experimental study of behavioural responses of killer whales to a vessel operating in western Canadian waters at two operating speeds. Killer whales responded to high-speed experimental approach by adopting paths that were significantly less predictable than those observed during preceding no-boat conditions. The tendency for whales to swim further along a circuitous route during experimental treatment appears to be an attempt to evade the boat. Short-term behavioural responses such as these may carry energetic costs to whales. It was noted that the source level of the experimental boat noise was 14dB higher when speeding up than when operating at slow speed. Using a reasonable model of transmission loss, the boat would need to be 700m away for the whales' received noise level to equal the noise level received by the same boat operating at slow speed at 100m from the whale.

Kato commented that studies such as these are valuable as they demonstrate that noise level can be used to determine biologically relevant approach distances for vessels watching whales.

Williams presented attempts to model the cumulative effects of such short-term energetic costs (Bain, 2002). This study considered the increased energy expenditure due to avoidance responses and reduced energy acquisition due to acoustic impairment of foraging efficiency. The models synthesised a variety of experimental and observational studies on wild and captive killer whales, to link real-world data on energetic costs of whalewatching, the extent of whalewatching day and season, and masking effects of boat noise, with real-world data on resident killer whale population dynamics. The models considered energetic costs in competition with growth in a food-limited population, and allowed prey acquisition to be impaired to a range of extents as a function of search pattern. The models suggest that population-level effects are negligible for killer whale populations well below carrying capacity. This indicates that population growth in the presence of disturbance cannot be used to conclude that disturbance will not affect the population at other densities as it approaches carrying capacity. The models suggested that missed prey due to noise was a more prominent mechanism than excess energy expenditure. The authors cautioned that these findings are linked to a unique aspect of resident killer whale population dynamics, a high-shape parameter ($z = 11.3$). But they warned that if they had not known the stock-specific parameter, the default shape parameter of $z = 1$ would underestimate maximum net productivity level and overestimate potential biological removal. The authors reported continuing efforts to verify that some of the assumptions made in the model are valid. However, they cited the precautionary principle as impetus for enacting management procedures that mitigate potential impacts until data become available to indicate that the regulations are unnecessary.

Weinrich noted that the effects reported by Bain (2002) may or may not be related to noise exposure. However, increased exposure to vessel noise could lead to a series of temporary threshold shifts, which can eventually result in a permanent threshold shift. A model of this work was published by Erbe (2001). He further noted that combined with the work reported by Morton and Symonds (2002), there is an indication that killer whale populations appear to

be susceptible to noise-generated disturbance. Williams noted that the models indicated that missing prey was a greater contributor to population dynamics than avoidance, which suggests that noise is the link.

It was noted that the study demonstrates how physical acoustic and biological information can be merged and serves as an excellent model of how to integrate the two fields.

7. REVIEW OF RESEARCH ON EFFECTIVENESS AND COMPLIANCE WITH WHALEWATCHING GUIDELINES AND REGULATIONS

SC/54/WW1 investigated short-term impacts on Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) in Menai Bay, Zanzibar. Observations were made from tourist boats and from a research boat in order to evaluate the impact of violating guidelines. Changes in group activity (resting, travelling, socialising and foraging) during boat approaches, and the occurrences of stress-related behaviours (leaps, tail-slaps and coughing) during 30 minute follows were studied using scan sampling. The results showed that the dolphins were more likely to change their group activity when guidelines were violated during boat approaches compared to when they were followed. Further stress-related behaviours were significantly more frequent during group follows when guidelines were violated. Results indicate that the behaviour of the Indo-Pacific bottlenose dolphins in Menai Bay is significantly affected by dolphin tourism in its present form. The adoption, implementation and enforcement of suggested guidelines could be an important step towards the sustainable development of dolphin tourism in Menai Bay. Dolphins were hunted in Menai Bay (for human consumption and for bait in the long-line shark fishery) until 1997 when this activity was replaced by the dolphin tourism as a long-term economic alternative. Careful monitoring of the development of the tourism in Menai Bay will be crucial in years to come in order to protect this valuable resource for the local community.

Weinrich asked whether violating the spatial or temporal component of the guidelines elicited a stronger response from the dolphins. Berggren responded that although the dataset was limited, the more important factor was how the vessel was operated during approach and while following groups of dolphins. Robbins asked if whalewatching operators were more likely to make aggressive approaches to dolphins when certain behaviours were exhibited. Berggren replied that more aggressive approaches occurred when the dolphins were travelling away from the vessel. He added that some tourists tip the operators to encourage closer approaches to the animals.

In discussions on identifying 'negative' impacts, Peddemors suggested that the research be conducted in selected areas. He noted that in South Africa, *Tursiops* appear to use specific locations for specific activities. When asked if researchers will separately examine both sets of violations, boat-based and in-water, Berggren replied that they will do so in the future, and ideally would like the swimming activities to be terminated. However, if in-water encounters are allowed, swimmers should be 'attached' to the vessel as this may elicit less of a response from the dolphins.

There was a brief discussion on the impact of the research on local operators and the importance of feedback. Berggren informed the sub-committee that the dolphin-watching occurs in two neighbouring villages in Menai Bay. In this area, local scientists and operators meet to discuss research

results in relation to guidelines and how the dolphin watching is conducted. The intent is to develop dolphin-watching activities that are conducted in a sustainable manner with a minimal impact on dolphins to ensure that this valuable resource will be available in the future.

The sub-committee welcomed the type of research represented by SC/54/WW1, noting that it was the kind of systematic examination of the impact of whalewatching on cetaceans and the effectiveness of whalewatching guidelines that falls within the terms of reference of this sub-committee. The sub-committee **agreed** that research such as that described in SC/54/WW1 should be encouraged.

8. NEW INFORMATION ON PREVIOUSLY DISCUSSED TOPICS

8.1 Dolphin feeding programmes

Corkeron presented an update on the feeding programme at Tin Can Bay, southeast Queensland, focusing on Indo-Pacific humpback dolphins. Details are discussed in SC/54/SM27. To date, no management programme, such as those in place at Monkey Mia or Tangalooma, has been established.

Gales noted that a book, in the process of publication, contains a chapter on the effects of provisioning dolphins; the study spans 15 years. Other chapters in the book may be relevant to the discussions of the sub-committee. Gales expects that the book will be available for next year's meeting.

8.2 'Swim-with' whale and dolphin programmes

Rose presented information on three 'swim-with' whale programmes discovered during a search of whalewatching operation websites. The number of commercial operations promoting swimming with large whales appears to be increasing. She reported on operations in Tonga and the Caribbean, while one in Australia was reported at the 2000 meeting in Adelaide. In some cases, the activity is tightly controlled with swimmers tethered to a boat by a rope; in others, the swimmers are allowed to approach and even touch the whales. Rose suggested that a thorough review of these proliferating programmes be conducted for discussion next year.

Some members expressed concern over the swim-with programmes, particularly those that are not regulated, which allow free swimming and encourage swimming with mothers with small calves.

The sub-committee **agreed** that research on the impacts of swim-with-whale programmes should be encouraged and **recommended** that a review of these programmes be a priority next year.

8.3 National guidelines and regulations

SC/54/WW3 provided a review of whalewatching guidelines from six areas in Japan. The paper detailed target species, safety zones, minimal approach distances, and general codes of conduct for each area. There are no laws or ordinances in Japan that directly regulate whalewatching activities. There are however, several areas where voluntary codes of conduct have been established by operators, scientists or associations. Since there is no law to regulate whalewatching activities, only operators in the area or members of local associations are affected by the voluntary codes of conduct; self-imposed regulation may be difficult to attain. Furthermore, not all areas have developed voluntary codes

of conduct. In the future, general rules for whalewatching may be established. These general rules would then be tailored to suit specific areas, species and operations.

Rose noted that the situation in Japan is ideal for studying and comparing whale behaviour in whalewatching areas with, and without, written codes of conduct and inquired if such research was planned. Kato explained that the level of scientific expertise varies greatly between these areas: in the Bonin Islands, researchers are conducting scientific studies and the development of codes of conduct is driven by science, while in other areas, local operators have little knowledge of whales. However, meetings between operators in different areas of Japan have been held to exchange information and views.

C. Clark asked if whalewatching boats in Japan used sonar systems for navigation. He noted that for some species, such as *Tursiops*, active sonar is in the best hearing range of the animals and caution needs to be taken into consideration. Kato did not think that active sonar was used to find whales, but in some cases, sonar may be used for other purposes; in some areas, small fishing boats serve as whalewatching platforms, but sonar is used only when fishing.

There was a brief discussion of whalewatching codes of conduct for multiple boats and diving with whales. While there are codes of conduct for both multiple boats and maximum viewing time in Zamami Islands, Okinawa, these codes of conduct are not detailed in many areas. Codes of conduct for SCUBA diving or swimming with cetaceans also vary between areas. For example, SCUBA diving is not allowed in Tosa Bay and Kochi on Bryde's whales, but may be allowed in other areas with other target species.

There was a brief discussion of the development of national whalewatching regulations. Some members felt that it would be difficult to standardise regulations due to several variable factors. Therefore, rules should be overarching with specifics tailored to suit target species, area use (i.e. feeding, breeding, resting and migrating areas) and vessel and operation types. It was noted that the variability of voluntary regulation in Japan was similar to that in the UK and USA where there is a range of guidelines and local approaches to whalewatching management. In the USA, there are few places where whalewatching is regulated. Furthermore, the US Marine Mammal Protection Act facilitates context-specific federal laws although they may be superseded by more restrictive state laws. Recently, the US government requested comment on the development of rules for all human/marine mammal interactions. Iniguez reported that in Argentina, the Province of Chubut regulates the watching of southern right whales by provincial law or regulation. In the Province of Santa Cruz there are two main areas where Commerson's dolphin watching activities are conducted. Although the activity is not regulated, in July 2001, Commerson's dolphins were declared a Provincial Natural Heritage, protecting the species in the waters of Santa Cruz. At St. Julian, studies on dive times, mother/calf pairs and Commerson's dolphin reactions near vessels have been initiated by Fundacion Cetus researchers to provide baseline data to help facilitate the development of regulations, in conjunction with the provincial government, tour operators and researchers. Oosthuizen noted that a co-management system in South Africa, with dialogue between government and operators, has been effective in improving whalewatching management.

M. Simmonds made reference to SC/54/E8 that contains the text of resolution 1.11 from the recent meeting of the Parties to the Agreement for the Conservation of Cetaceans of the Black and Mediterranean Seas (ACCOBAMS). The

resolution provides a detailed set of 'Guidelines for Commercial Cetacean Watching Activities'. The resolution recommended that the Contracting Parties should take these Guidelines into consideration when drafting or updating their domestic legislation on cetacean watching and that the ACCOBAMS' Scientific Committee should further develop these guidelines. M. Simmonds noted that this was an unusual example of a set of guidelines being provided to a large region and noted that the Ligurian Sea Sanctuary also had a set of guidelines for watching cetaceans. The latter contains a provision that ships should not approach animals from the rear. The group briefly discussed this recommendation. It was noted that a similar limited approach had been recommended in other areas, but that experts recommend approaching sperm whales from the rear. This seems to be specific for only this species. Weinrich stated that work in the US on manatees, expanded to right whales, showed that in vessels with propellers higher than the hull, there is an area immediately in front of the vessel that is very quiet. This may minimise the impact of noise, but could lead to startle reactions.

Carlson announced that a compendium on whalewatching guidelines and regulations around the world can be found on the IWC website, thanks to the work of the IWC Secretariat. She requested that any new or changed guidelines or regulations be sent to her so that the site can be updated.

M. Simmonds suggested consideration might be given to the meaning of the term 'harassment' and/or what constitutes unacceptable disturbance. Some members were of the opinion that this was an extremely difficult task as there are several confounding variables that may affect whale behaviour. In addition, the term harassment has legal implications and the discussion should be science-based. The sub-committee concluded that:

- (1) In order to minimise the risk of negatively impacting a cetacean population, whalewatching operations should take into account the risk of their long-term impact on cetaceans, based on science.
- (2) In particular, persistent changes in cetacean behaviour associated with the presence of whalewatching platforms may indicate a negative effect.
- (3) Further research is encouraged.

8.4 Other

Morton and Symonds (2002) reported on a natural experiment investigating the deliberate introduction of high-amplitude noise into a portion of the core habitat of resident and transient killer whales in British Columbia, Canada. The killer whales of the Johnstone Strait/Broughton Archipelago region were monitored year-round by two researchers between 1985 and 2000. When open-net Atlantic salmon fish farms began using anti-predator Acoustic Harassment Devices (AHDs) in 1993, sightings of killer whales in that portion of the range declined to near zero. After six years, usage of the devices was terminated, and killer whale usage of that portion of the range returned to baseline levels. In the adjacent (control) area, killer whale presence remained stable across the 15-year study. Careful consideration of alternative explanations for the findings, including changes in prey distribution, led the authors to conclude that acoustic harassment must have displaced killer whales from one part of their range, while usage of the habitat immediately adjacent remained consistent. When asked what impact AHDs have on wild salmon, Williams replied that since both resident (salmon-feeding) and transient (marine mammal-feeding) left the area, prey

distribution was not a factor. The study is an example of a large-scale natural experiment that is applicable to the work of the sub-committee.

SC/54/WW4 discussed behavioural responses of wintering humpback whales to vessels in Ecuador. These vessels focused on natural history tours of a national park, which stopped to watch whales opportunistically. The study aimed to identify components of whale behaviour that changed consistently when boats approached, to provide concrete signs that boat operators could look for to determine when they might be too close, or staying around whales too long. The land-based study compared whale behaviour when no boats were present to the behaviour of the same group as vessels approached, and found that whales increased swimming speed significantly. Park managers were advised to caution boat operators that if they had to increase their boat speed to keep up with whales, this might be a sign that they should end their whalewatching encounter.

Heckel *et al.* (2001) described a study on the influence of whalewatching on the behaviour of migrating gray whales in Todos Santos Bay on the Northwest coast of the Baja California Peninsula. The study showed that during the southbound migration of gray whales, there were no significant differences in swimming direction between whale groups with and without whalewatching boats. By contrast, during the northbound migration, the differences were statistically significant. Although Mexican whalewatching law is explicit concerning manoeuvres around whale groups, an additional suggestion is made to prevent disturbances.

The sub-committee welcomed these papers and noted that the whalewatching management-related research presented represents the type of studies necessary for the development of science-based regulation.

9. OTHER

SC/54/O7 described a novel DNA-based method for identifying krill species present in the faeces of baleen whales. The technique has been applied to blue whale faeces, and has successfully identified the krill species in the diet. Based on the success of this group-specific approach, he and his colleagues are developing similar techniques for identifying species from other key prey groups to enable identification of all prey items in cetacean (and other predator) diet. Gales believes the continued development of this technique will provide a widely applicable, non-invasive method capable of measuring the components of cetacean diet. It was noted that whalewatching vessels offer an ideal platform of opportunity for the collection of cetacean faecal samples, and broad collaboration with researchers who work in targeted parts of this industry is sought. Several researchers expressed interest in collaborating on this work, and discussions were to continue outside the meeting.

Some discussion about the application of this technique to dolphin feeding studies occurred, and it was noted that it may have application to these studies.

Gales made reference to a workshop that occurred on Philip Island, Australia in 2001, during which several papers on the issues of whalewatching, scientific studies of measuring impacts from tourist activities and dolphin feeding programmes were presented. These papers will appear in a proceedings of the conference. Gales undertook to encourage the authors to present these papers for information at the next IWC meeting.

Weinrich noted that the sub-committee might consider the proliferation of high-speed whalewatching vessels around

the world, because they target areas where whales are found, and their speed minimises the ability of either the whales or the operators to avoid collisions. Since the sub-committee is charged with assessing the impact of whalewatching on whale populations, this seems relevant. He further commented that he had been tasked, through an intersessional working group of the Standing sub-committee on the Estimation of Bycatch and Other Human-induced Mortality, to review impacts to cetaceans from high-speed ferries. He suggested that this could be expanded to review where high-speed whalewatching vessels operate and what collisions have occurred.

The sub-committee **agreed** that this should be a priority for next years' work plan, relevant information should be sent to Weinrich for collation and that a joint session with the Standing sub-committee on the Estimation of Bycatch and Other Human-induced Mortality should be held next year to discuss this issue.

Palazzo suggested that a directory of whalewatching researchers be compiled. There was some discussion of the suitability of collecting information from whalewatching researchers concerning their studies. This exercise would include brief details of their methodologies. Palazzo agreed to compile this information for presentation at next year's meeting.

10. WORK PLAN

The sub-committee **agreed** on the following work plan, which is not prioritised:

- (1) Review the report of the Intersessional Whalewatching Data Collection Correspondence Group, and the report of the Intersessional Whalewatching Management Correspondence Group (or a report of a meeting if one is held intersessionally).
- (2) Review information on the significance of noise produced from vessels and aircraft with respect to cetaceans.
- (3) Review information on 'swim-with' whale programmes.
- (4) Review information on high speed vessels and whale/vessel collisions in a joint session with the Standing sub-committee on the Estimation of Bycatch and Other Human-induced Mortality.
- (5) Review a compendium of data forms used on whalewatching platforms.
- (6) Review a directory of researchers using whalewatching vessels as platforms of opportunity or who are engaged in studies on the impacts of whalewatching, including reference to the research they are conducting.

Other work:

- (1) Review of research on the effectiveness of and compliance with national whalewatching guidelines and regulations;
- (2) Review of national whalewatching guidelines and regulations;
- (3) Review of new information on dolphin feeding programmes; and
- (4) Review of new information on 'swim-with' dolphin programmes.

11. ADOPTION OF THE REPORT

The report was adopted on 5 May 2002 at 12:45pm. The sub-committee expressed its appreciation to Kato (in Japanese) for his leadership and to Carlson for rapporteuring.

REFERENCES

- Bain, D.E. 2001. Noise-based guidelines for killer whale watching. Paper presented at the 14th Biennial Conference on the Biology of Marine Mammals, Vancouver, BC, Canada (unpublished). [Available from the Society of Marine Mammalogy at <http://pegasus.cc.ucf.edu/smm>.]
- Bain, D.E. 2002. A model linking energetic effects of whale watching to killer whale (*Orcinus orca*) population dynamics. *Mar. Mammal Sci.*:Submitted.
- Constantine, R. 2001. Increased avoidance of swimmers by wild bottlenose dolphins (*Tursiops truncatus*) due to long-term exposure to swim-with-dolphin tourism. *Mar. Mammal Sci.* 17(4):689-702.
- Erbe, C. 2000. Underwater noise of whale watching boats and its effects on marine mammals. Paper SC/52/WW11 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- Erbe, C. 2001. Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. Report for Fisheries and Oceans, Canada, 16 April 2001. 27pp. [Available from the author: erbe.c@yahoo.com].
- Heckel, G., Reilly, S.B., Sumich, J.L. and Espejel, I. 2001. The influence of whalewatching on the behaviour of migrating gray whales (*Eschrichtius robustus*) in Todos Santos Bay and surrounding waters, Baja California, Mexico. *J. Cetacean Res. Manage.* 3(3):227-37.
- International Whaling Commission. 2001. Report of the Scientific Committee. Annex J. Report of the Standing Working Group on Environmental Concerns. *J. Cetacean Res. Manage. (Suppl.)* 3:239-62.
- McCarthy, E.M. 2001. International regulation of transboundary pollutants: the emerging challenge of ocean noise. *J. Wildl. Law Policy* 6:257-92.
- McCauley, R.D. and Cato, D.H. 2002. The underwater noise of vessels in the Hervey Bay (Queensland) whale watch fleet and its impacts on humpback whales. *J. Acoust. Soc. Am.* 109(5):24-55.
- McCauley, R.D. and Duncan, A.J. 2001. Marine acoustic effects study, blue whale feeding aggregations, Otway Basin, Bass Strait Victoria. Project CMST 319. Report R2001-7 prepared for Ecos Consulting of South Australia. 46pp. [Available from the Centre for Marine Science and Technology, Curtin University of Technology, Perth, Western Australia].
- Morton, A.B. and Symonds, H.K. 2002. Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia, Canada. *ICES J. Mar. Sci.* 59:71-80.
- Richardson, W.J. and Würsig, B. 1997. Influences of man-made noise and other human actions on cetacean behaviour. *Mar. Freshwater Behav. and Physio.* 29:183-209.
- Williams, R., Bain, D.E., Ford, J.K.B. and Trites, A.W. 2002a. Behavioural responses of male killer whales to a 'leapfrogging' vessel. *J. Cetacean Res. Manage.* 4(3):305-10.
- Williams, R., Trites, A.W. and Bain, D.E. 2002b. Behavioural responses of killer whales to whale-watching traffic: opportunistic observations and experimental approaches. *J. Zool., London.* 256:255-70.

Appendix 1

AGENDA

1. Opening remarks and terms of reference
2. Election of chair and rapporteurs
3. Adoption of agenda
4. Review of available documents
5. Report of intersessional working groups
 - 5.1 Data Collection Correspondence Group
 - 5.2 Whalewatching Management Correspondence Group
6. Whalewatching activities and noise impacts
7. Review of research on effectiveness and compliance with whalewatching guidelines and regulations
8. New information on previously discussed topics
 - 8.1 Dolphin feeding programmes
 - 8.2 'Swim-with' whale and dolphin programmes
 - 8.3 National guidelines and regulations
 - 8.4 Other
9. Other
10. Work plan
11. Adoption of report

Appendix 2

WORKPLAN FOR INTERSESSIONAL REVIEW AND DEVELOPMENT OF THE DATA RECORDING SYSTEM (DRS)

Each type of data will be reviewed such that it can be given a priority rating, i.e. essential information; information of lesser importance; information of low importance. There may be a fourth category that relates to information only collected under certain circumstances and/or to address certain questions, or specific to certain geographical areas. The data levels 1-3 and the Critical Response Parameters previously established by the sub-committee will be used in this respect (IWC, 2002, pp.339-340). The review would also encompass consideration of which issues each data-type

will help to investigate and would be used to create a matrix of qualifications relating to each data-type. This would then be used to:

- (1) improve the DRS;
- (2) help to provide further instructions for its application; and
- (3) help to design an interactive computer program that would assist whalewatching researchers in designing data-collection forms (similar to the program

demonstrated by Simmonds). This may include the development of pre-set 'daughter forms' for particular investigations.

This review will also be used to provide would-be researchers with an outline of which data might be used to help to investigate certain questions.

This process will also be informed by field-testing of forms derived from the DRS intersessionally with further consultation with field workers and whalewatching operators. Colleagues are invited to take part in this and

provide feedback to an intersessional correspondence group.

In addition, consideration will be given to adding information to the DRS to help facilitate the collection of appropriate photo-identification data for a variety of taxa using both standard 35mm photography and digital photography.

REFERENCE

International Whaling Commission. 2002. Report of the Scientific Committee. Annex L. Report of the Sub-Committee on Whalewatching. *J. Cetacean Res. Manage. (Suppl.)* 4:339-60.

Appendix 3

EXAMPLES OF SCIENTIFIC STUDIES SHOWING CHANGES IN CETACEAN BEHAVIOUR AND HABITAT USE AS THE RESULT OF THE PRESENCE OF WHALEWATCHING VESSELS

Table 1 is by no means comprehensive, and many more publications exist on the effects of whalewatching vessels on cetacean behaviour and habitat use. This summary table simply serves to illustrate some examples of scientific studies that have addressed this issue.

Species	Reference
Bottlenose dolphin, <i>Tursiops truncatus</i>	Gregory and Rowden (2001) Scarpaci <i>et al.</i> (2000) Janik and Thompson (1996)
Indo-Pacific bottlenose dolphin, <i>T. aduncus</i>	SC/54/WW1
Rough-toothed dolphins, <i>Steno bredanensis</i>	Ritter (2002)
Hector's dolphin, <i>Cephalorhynchus hectori</i>	Bejder <i>et al.</i> (1999)
Beluga whale, <i>Delphinapterus leucas</i>	Blane and Jaakson (1994)
Sperm whale, <i>Physeter macrocephalus</i>	Richter <i>et al.</i> (2002) Gordon <i>et al.</i> (1992)
Killer whale, <i>Orcinus orca</i>	Williams <i>et al.</i> (2002) Williams <i>et al.</i> (2002) Kruse (1991)
Humpback whales, <i>Megaptera novaeangliae</i>	SC/54/WW4 McCauley and Cato (2001) Au and Green (2001) Schilling <i>et al.</i> (1989) Corkeron (1995)
Gray whale, <i>Eschrichtius robustus</i>	Heckel <i>et al.</i> (2001)
Southern right whale, <i>Eubalaena australis</i>	SC/51/WW8
Fin whale, <i>Balaenoptera physalus</i>	Stone <i>et al.</i> (1992)

REFERENCES

Au, W.W.L. and Green, M. 2001. Acoustic interaction of humpback whales and whalewatching boats. *Mar. Environ. Res.* 49:469-81.
Bejder, L., Dawson, S. and Harraway, J.A. 1999. Responses by Hector's dolphins to boats and swimmers in Porpoise Bay, New Zealand. *Mar. Mammal Sci.* 15(3):738-50.
Blane, J.M. and Jaakson, R. 1994. The impact of ecotourism boats on the St Lawrence beluga whales. *Environ. Conserv.* 21(3):267-9.
Corkeron, P.J. 1995. Humpback whales (*Megaptera novaeangliae*) in Hervey Bay, Queensland: Behaviour and responses to whale-watching vessels. *Can. J. Zool.* 73:1290-9.
Gordon, J., Leaper, R., Hartley, F.G. and Chappell, O. (eds.). 1992. *Effects of Whale-Watching Vessels on the Surface and Underwater*

Acoustic Behaviour of Sperm Whales off Kaikoura, New Zealand. Department of Conservation, Wellington. 63pp.
Gregory, P.R. and Rowden, A.A. 2001. Behaviour patterns of bottlenose dolphins (*Tursiops truncatus*) relative to tidal state, time-of-day, and boat traffic in Cardigan Bay, West Wales. *Aquat. Mamm.* 27(2):105-13.
Heckel, G., Reilly, S.B., Sumich, J.L. and Espejel, I. 2001. The influence of whalewatching on the behaviour of migrating gray whales (*Eschrichtius robustus*) in Todos Santos Bay and surrounding waters, Baja California, Mexico. *J. Cetacean Res. Manage.* 3(3):227-37.
Janik, V.M. and Thompson, P.M. 1996. Changes in surfacing patterns of bottlenose dolphins in response to boat traffic. *Mar. Mammal Sci.* 12(4):597-602.
Kruse, S. 1991. The interactions between killer whales and boats in Johnstone Strait, B.C. pp. 149-59. In: K. Pryor and K.N. Norris (eds.) *Dolphin Societies, Discoveries and Puzzles*. University of California Press, Berkeley, California, USA. 397pp.
McCauley, R.D. and Cato, D.H. 2001. The underwater noise of vessels in the Hervey Bay (Queensland) whale watch fleet and its impact on humpback whales. *J. Acoust. Soc. Am.* 109:2455.
Richter, C.F., Dawson, S.M. and Slooten, E. 2002. Sperm whale watching off Kaikoura, New Zealand: effect of current activities on surfacing and vocalisation patterns (unpublished). [Available from: liz.slooten@stonebow.otago.ac.nz]
Ritter, F. 2002. Behavioural observations of rough-toothed dolphins (*Steno bredanensis*) off La Gomera, Canary Islands (1995-2000) with special reference to their interactions with humans. *Aquat. Mamm.* 28:46-59.
Scarpaci, C., Bigger, S.W., Corkeron, P.J. and Nugegoda, D. 2000. Bottlenose dolphins (*Tursiops truncatus*) increase whistling in the presence of 'swim-with-dolphin' tour operators. *J. Cetacean Res. Manage.* 2(3):183-6.
Schilling, M.R., Weinrich, M.T. and Ledder, T.L. 1989. Reaction of humpback whales to vessel approaches in New England. p.60. In: Abstracts of the 8th Biennial Conference on the Biology of Marine Mammals, December 1989, Pacific Grove, California. Society of Marine Mammalogy, Pacific Grove, California [Abstract].
Stone, G.S., Katona, S.K., Mainwaring, A., Allen, J.M. and Corbett, H.D. 1992. Respiration and surfacing rates of fin whales, *Balaenoptera physalus*, observed from a lighthouse tower. *Rep. int. Whal. Commn* 42:739-45.
Williams, R., Bain, D.E., Ford, J.K.B. and Trites, A.W. 2002a. Behavioural responses of male killer whales to a 'leapfrogging' vessel. *J. Cetacean Res. Manage.* 4(3):305-10.
Williams, R., Trites, A.W. and Bain, D.E. 2002b. Behavioural responses of killer whales to whale-watching traffic: opportunistic observations and experimental approaches. *J. Zool., London.* 256:255-70.

Annex M

Report of the Sub-Committee on Estimation of Bycatch and Other Human-Induced Mortality

Members: Berggren (Chair), Baba, Baker, Baldwin, Bando, Bjørge, Brownell, Carlson, Childerhouse, Cipriano, Clapham, Clark, E., Collins, Cooke, Dalebout, Deimer, Diake, Dizon, Donahue, Donovan, Etylina, Funahashi, Gales, Garrigue, Goodman, Goto, Guissamulo, Hammond, Hatanaka, Haug, Hester, Iniguez, Ishikawa, Kanda, Kasuya, Kawahara, Kell, Kim, Kock, Leaper, Lens, Manzanilla Naim, Martien, Mattila, Miyashita, Morishita, Murase, Nagahata, Nagatomo, Nishiwaki, Northridge, Ohsumi, Okamura, Oosthuizen, Park, Parsons, Pastene, Peddemors, Perrin, Pike, Rambally, Read, Reeves, Reijnders, Rennie, Ridoux, Robbins, Rogan, Rojas-Bracho, Rose, Rosenbaum, Rowles, Sadler, Sakamoto, Santamaria, Senn, Shimada, Simmonds, Sohn, Stachowitsch, Sutaria, Swartz, Tamura, Tanaka, Taylor, Thiele, Tomita, Tregenza, Urban-Ramirez, Van Waerebeek, Wade, Wakako, Walløe, Weinrich, Williams, Wilson, Yamamura, Yasunaga, Yoshida, Zeh, Zelensky, Zenitani, Zerbini.

1. CONVENER'S OPENING REMARKS AND TERMS OF REFERENCE

Berggren welcomed the members of the sub-committee and referred to the 52nd meeting of the Commission when the Scientific Committee (SC) was instructed that catch limits calculated under the Revised Management Procedure (RMP) shall be adjusted downwards to account for human-induced mortalities caused by aboriginal subsistence whaling, scientific whaling, whaling outside the IWC, bycatches and ship strikes. The Commission stated that each such adjustment shall be based on an estimate provided by the SC of the size of adjustment required to ensure that total removals over time from each population and area do not exceed the limits set by the RMP. In order to address this task the Terms of Reference given in Appendix 1 were developed for the sub-committee by the SC convener group. Berggren also reminded the sub-committee that the task primarily applies to areas where the RMP is likely to be implemented: the northeast Atlantic and the western North Pacific.

2. ELECTION OF CHAIR AND APPOINTMENT OF RAPORTEURS

Berggren was elected Chair. Leaper and Northridge agreed to act as rapporteurs.

3. ADOPTION OF AGENDA

The adopted Agenda is given as Appendix 2.

4. REVIEW OF DOCUMENTS

The following documents were relevant to the sub-committee: SC/54/BC1-6, SC/54/RMP8, 20, SC/54/SD2, SC/54/SM12 and Dalebout *et al.* (2002).

5. BYCATCH ESTIMATION METHODS

5.1 Report of the working group on the collation of information from fisheries

Last year the sub-committee reviewed a list of categories of information that might appear on a form that could be distributed to identify certain fisheries where bycatch is thought to take place, in order to assist in the future design of appropriate sampling schemes. Northridge chaired an intersessional group in order to design a suitable form to achieve this task. Northridge reported that during the intersessional period it became apparent that this exercise might either generate a vast amount of information, or very little, depending on how the first field of the query (fishery category) was interpreted. Moreover, it was recognised that an initial request for such a large amount of information, much of it difficult to collate, might be poorly received and result in a poor return of data. Each country is likely to categorise fisheries in an individual manner, based on some combination of target species, gear type and geographical area. Given this, the intersessional group thought the best way to approach the collection of data would be to ask each IWC member state to provide a list of fisheries and details of how fisheries are categorised. This would provide a first step that might assist in developing a sampling strategy for monitoring bycatch. The sub-committee **recommended** that the Secretary of the Commission write a letter to the relevant authorities in each member country requesting a list of fisheries, broken down by gear type, target species and geographical area, to the extent to which this is routinely done in each country. It was noted that in order to encourage cooperation, the objectives of collecting this information needed to be clearly specified. A small group (Kim, Morishita, Northridge, Perrin, Read and Rogan) agreed to develop suitable text to form the basis of a letter that might be sent out to member states (Appendix 3). Data would also be welcomed from non-member states that may be willing to volunteer information even if a formal request from the IWC is not appropriate.

This information gathering exercise could be used to identify fisheries for which there is little or no information on whale bycatch but which share common characteristics

with fisheries where bycatch has been monitored. The sub-committee **agreed** that it was important to consider such fisheries as well as fisheries where bycatch is known to occur. Consideration of these data might suggest the relative priority of monitoring programmes to assess incidental takes for different fisheries.

Data on bycatch by category of fishery are also needed. It was noted that information on the type of fishery involved in cetacean bycatch was not sufficiently detailed in the National Progress Reports. The sub-committee **recommended** that data in the Progress Reports should be amplified to include detail on the type of fishery involved in large whale bycatch. The level of detail should ideally include not only gear type, but the way in which this gear is being used and the target species. For example, the same gear might be used for either bottom or mid-water trawling, but the risk of bycatch might be different between the methods of operation. As a minimum the gear description should correspond to an item listed in the response to the request for information on fishery categories.

Kim questioned the need to consider estimation of bycatch given that he believed the mandatory bycatch reporting system in the Republic of Korea resulted in all bycatch being reported. He suggested that if there was reason to believe that bycatch was occurring in a particular fishery within a country then the Commission could ask that member government to establish a bycatch reporting system rather than ask for fisheries information. Other members noted examples of where independent observer schemes had been established for fisheries that already had reporting schemes. In several cases these revealed much greater levels of bycatch than had previously been reported.

The sub-committee **recommended** that modelling studies should be encouraged to try and estimate how much observer coverage of a particular fishery would be required to allow reliable estimates of large whale bycatch. These studies might assist in assessing how best to utilise data as it becomes available from the information gathering process discussed above. Taylor noted that modelling had been undertaken for gillnet fisheries in California and the sub-committee **agreed** to encourage papers on these types of statistical studies.

5.2 Independent observer programmes

The sub-committee briefly considered SC/54/SM12 but no further information was available as to methodology within this or other papers this year.

5.3 Mandatory or voluntary reporting schemes

Records of large whale bycatch were extracted from National Progress reports for the statistical year 2001. Several large whale species had been recorded as bycatch in fisheries during 2001 and in previous years, but not all such incidents had been fatal (see Table 1). Minke whales are by far the most often recorded bycatch species, with over 230 recorded in 2001.

Rose noted that records of minke whale bycatches were very clumped, notably in Japan and in eastern Korea, and wondered whether this could be due to better reporting in these areas, with under-reporting elsewhere, or whether there might be some aspect of fisheries in these two regions which made bycatch more likely than elsewhere.

Sohn replied that the relatively higher bycatch in Korean waters is related to cetacean distribution and to the distribution of fishing gear. The results of Korean whale sightings surveys, as presented in Cho *et al.* (2001) and Kim and Sohn (2001), demonstrate that cetaceans including minke whales are distributed along the coast of the East Sea. In the East Sea the migration corridor of minke whales is along the narrow continental shelf where coastal fishing gears are set. In the West Sea the distribution of minke whales is further offshore compared to where most fishing gears are set. There is little overlap between the two, and this results in lower bycatch rates. Minke whales are rare in the South Sea as demonstrated by previous whaling records.

The Japanese progress report for 2001 records that all minke whale bycatches were in trap nets (Kato, 2001). Similar nets in Newfoundland are also known to entrap large whales, and Lien (1994) reported 124 minke whales entrapped there over a 12-year period between 1979 and 1990.

Hester asked whether such nets might also be employed in North Korea or China. The sub-committee had no information regarding fishing gear types used in these countries, though it noted that the proposed request to the

Table 1
Large whale entanglements reported in Progress Reports, 2002.

Nation	Area	Year	Species	No.	Description
Australia	NSW	2001	Humpback	3	2 associated with beach protection shark nets; 1 'entangled'
	SA	2001	Southern right	1	Tuna long line
Canada	Gulf of St Lawrence	2001	Humpback	1	Danish seine
Denmark	West Greenland	2001	Humpback	2	'Fishing gear'
Japan		2001	Minke	79	Trap nets
		2001	Fin	1	Other coastal fishery
		2001	Baleen whale sp.	1	Trap net
Korea	East Sea	2001	Minke	132	Entangled
	South Sea	2001	Minke	11	Entangled
	Yellow Sea	2001	Minke	5	Entangled
New Zealand		2001	Humpback	2	Crayfish pot lines – released alive
Oman		2001	Balaenoptera sp.	1	Entangled
		1999 - 2000	Humpback	8+	Entangled alive in gillnets, 'most' released; 'some' stranded animals with evidence of bycatch
Spain		2000	Minke	1	Entangled
UK	England	2001	Minke	1	Entangled
USA	WN Atlantic	1999	N Atlantic right	1	Entangled
	WN Atlantic	1999	Humpback	1	Entangled
	WN Atlantic	1999	Minke	5	Entangled
	Alaska	2001	Humpback	1	Trawl
	Alaska	2001	Fin	1	Trawl
	Alaska	2001	Sperm	1	Longline (injured)

Commission to send a letter asking for details of fishery categories to member states and other states might help elucidate this point.

The issue of reporting efficiency, and how current reporting schemes are implemented, were discussed in detail, as such matters are crucial to providing advice to the Commission on how best to estimate total large whale mortalities in fishing gear.

Sohn pointed out that in Korea all large whales whether bycaught, stranded or floating at sea, have been subject to a national reporting scheme since 1996. All such animals have to be reported to the marine police agency located in every port. The marine police assess the cause of death and make a thorough report. The Prosecutor then judges whether the law has been breached based on the report. Domestic disposition of bycatch is only allowed through this system, which now works routinely.

Biological sampling in Korea has proven difficult because it requires appropriate expertise. Kim stated that starting this year a biological sampling programme is being implemented by hiring experts to sample whale carcasses in collaboration with the regional authorities and the marine police. Furthermore, guidelines on bycatch reporting will soon be incorporated into the fisheries law. Sohn asserted that the existing mandatory reporting scheme in Korea made any further attempts to estimate bycatch unnecessary there. He further pointed out that whale bycatch is highly sporadic in a range of coastal fisheries and occurs mainly within three miles of the coast. Fisheries operating in this area are small scale and there are few relevant data that could help in any bycatch estimation methods.

Nagatomo reported that all bycatches of large cetaceans also had to be reported in Japan. It was noted that recent changes in domestic legislation (since 1 July 2001) now make it possible for Japanese fishermen to market bycaught whales, provided each was recorded and a DNA sample taken. More information on this can be found in last year's sub-committee report (IWC, 2002). Prior to 1 July 2001, Mitsutomi reported, it had not been compulsory to report bycaught whales, but Ministry guidance encouraged the reporting of any such events.

The sub-committee noted that the number of minke whales recorded as bycatch in Japan in 2001 (79) was considerably higher than in 2000 (29). In response to a question whether there was any known reason for this increase, and whether there was a breakdown of the number of records by month for 2001, Goto replied that it was known that there had been 54 minke whales reported over the six months since the new legislation was introduced and 25 in the preceding six months. There was some discussion as to why there had been an apparent increase since the introduction of the new legislation, but Nagatomo stated that it was not clear if this was a significant increment, and that several more years of data would be needed to determine this.

Rose noted that bycatch reports in Japan and Korea might be more complete than in other countries because there was no disincentive for reporting. However, in the USA and some other countries there were possible longer-term penalties for reporting bycaught whales which might impede accurate reporting. Mattila confirmed that in the USA records of bycaught whale numbers seemed to be declining in some fisheries, possibly because fishermen were becoming aware of the potential threat to their livelihood posed by the accidental capture of whales.

There was some discussion as to whether incentives for reporting bycatch might actually lead to increases in whale mortalities. The sub-committee recalled that at last year's

meeting it had been stated that the new fisheries Ministerial Ordinance and related guidelines would allow fishermen to kill animals that could not be released from nets in order to market them. Nagatomo stated that even though fishermen are now able to market whale meat from bycatches, they must still make best efforts to release whales from nets when caught, and only if they cannot be released can they be killed. It was not known how many bycaught minke whales had died as a direct result of entanglement and how many had needed to be killed to remove them from the nets.

Some further points were also made about whale entanglement procedures in both Japan and Korea. Mitsutomi reported that Japanese fishermen were able to apply for compensation for nets damaged by bycaught whales. Sohn reported that Korean plans to introduce a scheme to collect DNA samples from all bycaught whales had been delayed due to difficulties in implementing the legislation, but that it was hoped that the scheme could run from next year.

The sub-committee concluded that there was no clear explanation as to why recorded bycatches of minke whales are so much more frequent in some areas than others. It was clear that the total number of animals (as recorded in all National Progress Reports and Table 1) was unlikely to represent an accurate estimate of the total number of such mortalities. To take this matter further the sub-committee **recommended** that member states be encouraged to report more details about the type of fishing gear involved in large whale bycatch in National Progress Reports, and further **recommended** that the Commission should consider the proposal put forward by the sub-committee to ask member states and others to supply some preliminary information on how they classify fisheries nationally (Appendix 3).

5.4 Strandings and questionnaire surveys

The use of strandings data to assess bycatch was discussed last year. The various factors that might determine whether stranded carcasses of incidentally caught whales are recovered and attributed to incidental takes were discussed. It was also suggested that pathology based methods used to identify whether sireniacs had been incidentally caught might also be relevant to cetaceans. It was reiterated that strandings data can indicate where bycatch is occurring but should not be relied upon to estimate the magnitude of the incidental take.

Simmonds noted some stranding events involving large numbers of small cetaceans that occurred in Europe in 2001 had been attributed to incidental takes from pair trawl fisheries. He asked whether these events had involved any large whales. Ridoux commented that 350 animals had stranded on the coast of France over a period of 10 days. The species included common dolphin, striped dolphin, harbour porpoise and pilot whale. Of these, 95% of the individuals were common dolphins and there were no large whales. Simmonds noted that there is some evidence of large whales stranding under similar circumstances in the UK.

5.5 Genetic analyses

5.5.1 Bycatch workshop feasibility Steering Group

Berggren reported on the intersessional activities of this group. The use of market survey data to improve on minimum estimates of bycatch and provide more realistic unbiased estimates of whale bycatch will require information not only on reported bycatch rates but also on market structure and produce pathways, as well as design input for the collection, storage and analysis of genetic

samples in an appropriate manner. To investigate the feasibility of holding a workshop to address these issues, the intersessional group concluded that it would be helpful to: (1) outline the types of information needed in order to design an effective sampling scheme; (2) begin locating potential sources of such information; (3) develop contacts with access to the needed information or who could assist in developing methods to obtain such information; (4) locate experts in the design of market surveys; and (5) locate experts who could actually conduct the surveys. It was recognised that, of necessity, such a process would have to be iterative and that a full list of information needed for design of such a system would require the assistance of experts as noted in points (4) and (5) above. Some members of the Steering Group also met in Vancouver, Canada, in November 2001 during the Biennial Conference on the Biology of Marine Mammals where an initial list of needed information was drawn up which included, for example, that it would be important to find sources of information detailing how the products from bycaught whales are distributed from the bycatch location to the market where the product is eventually sold. It was also then agreed that a paper would be prepared which summarised the information available from earlier DNA identification market surveys on sample and market distribution in Japan (see SC/54/BC3). Further, during the intersessional period an initial search to identify experts on food/market surveillance systems and the statistical design and analysis of markets was also conducted. This resulted in a list of companies with such expertise and who can give advice on best practice (statistical design) to sample the markets in Japan. Further searching for information sources and experts in the pertinent areas resulted in an expanded list plus an initial bibliography (SC/54/BC5).

Given the information obtained intersessionally, the Steering Group concluded that it would be feasible to hold such a workshop. However, more information should be gathered and the experts from the companies with market sampling expertise contacted; with this additional information it would be possible to develop a draft proposal for the workshop at the next meeting of the Scientific Committee.

SC/54/BC5 identified numerous commercial companies capable of undertaking some of the tasks required to design an appropriate market sampling strategy. One or more of such companies could now be contacted for information that could be used to prepare a proposal for the workshop.

Cipriano noted that information relevant to the development of a food surveillance system in Japan was published in the day's 'Japan Times', which mentioned that the Codex Alimentarius Commission had met in Yokohama in March 2002, and that the Japanese Ministry of Agriculture, Forestry and Fisheries had expressed its intent to introduce a traceability system for food products beginning in 2003 (Uranaga, T., *Japan Times*, 2 May 2002).

The sub-committee **agreed** that the working group should continue its work in this area and report back next year. Morishita re-iterated his concern that the workshop would be unlikely to achieve anything useful, and stated that Japan does not endorse the workshop.

5.5.2 Data from market samples

SC/54/BC1 provided an update of previous work and listed the species of cetaceans determined from DNA analysis from market samples in both Japan and Korea. There were

several species found that were considered unlikely to have been derived either from scientific whaling or from bycatch. Baker noted an error in the alignment of Bryde's whale sequences used. After correction of this error the four Bryde's whale samples were found to be consistent with the assumption that these products originated from the North Pacific (see SC/54/SD1).

Dalebout *et al.* (2002) described microsatellite DNA profiling of North Pacific minke whale products from the Japanese and Korean market. The technique was used to determine the minimum number of whales available for sale and to track the movements of products from individual whales through these markets. Dalebout also discussed SC/54/RMP8 (an update of Dalebout *et al.*, 2002), limiting her discussion to results from the Korean market, while SC/54/BC3 focused on results from the Japanese market (see below). The same methods were used in all three papers and are very similar to those used in tagging and recapture studies to investigate populations of living animals. Six microsatellites were used to profile market products identified as derived from North Pacific minke whales through phylogenetic analyses of mitochondrial DNA control region sequences. These loci are a subset of those specified in the Norwegian DNA registry and those used by Japanese researchers. These six microsatellite loci, in combination, gave a reasonably low probability of a match (identity) between products by chance for the Japanese market. The probability of a match by chance was higher for the Korean market due to the lower genetic diversity of the J stock (East Sea/Sea of Japan) North Pacific minke whales.

For Korea (SC/54/RMP8), eight market surveys were conducted between March 1999 and November 2001. Whalemeat products were purchased in southeastern coastal cities (Pusan, Ulsan and Pohang) in short periods of a few days in each survey. Surveys yielded a total of 122 North Pacific minke whale products, which, based on comparisons of microsatellite profiles, represented at least 97 unique individuals. Over 90% of these animals were J-stock based on diagnostic nucleotide substitutions at the mtDNA control region (e.g. Baker *et al.*, 2000). Products from the same individual whales were generally only found within the same survey. In a small number of cases, replicate products were found in consecutive surveys (two to seven months apart), and in very few cases, replicate products from the same individual were found in surveys greater than seven months apart. These results suggest that products from individual whales are not stored long-term in Korea, and in general pass through the market in a period of less than seven months. Given the conservative nature of these censuses, it appears that the total yearly Korean bycatch of minke whales remains high. This conclusion is supported by this year's Korean Progress Report in which 148 North Pacific minke whales were reported as bycatch, 132 of which were taken off the East Sea/Sea of Japan coast.

SC/54/BC3 reported that 167 minke whale samples, purchased in Japanese markets between December 1997 and January 2002, were found to represent 142 individuals. J-stock products, presumed to come from bycatch in the Sea of Japan, contributed 41% of these, while the remainder were O stock animals assumed to have come from scientific whaling in the North Pacific. There was no significant difference in the proportion of products from the two stocks among different prefectures.

Pastene noted that interpretation of market samples is very difficult. Last year he had prepared a document summarising several molecular surveys conducted in the Japanese retail

market (Pastene *et al.*, 2001). He had identified several factors affecting the estimation of the mixing proportion between O and J stocks in the market:

- (1) randomness of the survey;
- (2) geographical variation in the distribution of J/O stock products across Japanese prefectures;
- (3) duplicate sampling;
- (4) period in which products from an individual remain in the market.

Regarding point (4), it was recognised that processed products will stay in the market for a longer period than fresh meat.

In addition, Pastene noted that samples obtained in surveys should be weighted according to the availability of the whale products across the different prefectures.

Baker noted that in SC/54/BC1 and SC/54/BC3 they had conducted analyses to evaluate biases. For example, after eliminating replicate products from the sample of Japanese markets there were no significant differences in the ratio of J:O stock animals by prefecture. He suggested that a larger sample size would still be helpful, but concluded that bycaught whale meat appears to be treated by the market in the same way as JARPN products.

Questioned about the sampling strategy, Funahashi stated that prefectures tended to be visited at least once a year, that it was usually the same retail outlets that were visited (as there are a limited number of these), and that sampling would be expanded to further retail outlets and to other prefectures in future surveys.

The sub-committee **agreed** that sample design was something that required attention, and that the purpose of the proposed workshop would be to develop appropriate sampling strategies for the Japanese whale meat market.

There was general agreement that there were currently too few reference samples to assign sei whale samples uncovered in SC/54/BC1 to individual populations or geographical areas. Baker agreed, but expressed concern as to where any such samples might have come from, with no current legal whaling of sei whales.

Questioned about the individuality of sei and Bryde's whale products uncovered in the sampling, Baker responded that these had mostly been unique individuals. This does not support the suggestion that these samples could have been in the supply chain for a longer period of time than the minke whale products, as might be expected for stockpiles.

Morishita noted that meat from pre-moratorium whaling is still held in cold stores (SC/54/BC5) and therefore is still being marketed, though there are decreasing amounts of it available. It was noted that the data in SC/54/BC5 on whalemeat stockpiles had been updated in 2001.

Baker asked whether there had been any recent attempts to verify the origin of sei and other larger whale products in the stockpile. Morishita responded that verification has been conducted but the report on this was not yet available.

There was some discussion of the apparent increase in bycatch of minke whales including J stock animals. Trends in the population size of J-stock minke whales are unknown but combined Japanese-Korean joint stock surveys (e.g. SC/54/RMP20) had shown very few J-stock animals, although population sizes had not been estimated. Ohsumi pointed out that the survey timing may not have coincided fully with J-stock residence within the survey area, and that a proper J-stock survey was required.

Baker suggested that if samples from reported bycaught minke whales could be compared with samples found in the market, it would be possible to determine what proportion

comes from undocumented sources. The sub-committee **agreed** that this was a promising approach to improve estimation of total bycatch over time.

5.5.3 Analytical tests for assigning stocks

Baker introduced this topic by informing the sub-committee that assignment procedures are becoming more widely used now, so that the geographical provenance of individual samples could be determined. Dizon cautioned that this is only possible where there has been sufficient directed sampling to ensure a baseline of comparative genetic samples. Referring to work ongoing to identify stock origin of white whale samples, Dizon noted that in this specific case there had been a lot of directed sampling, and the stocks of interest showed significant genetic differences, but that these two circumstances were unusual for most cetaceans. The sub-committee **concluded** that there were insufficient reference samples to take this very much further at present.

5.5.4 Other methodological advances

SC/54/SD2 described a web-based programme for phylogenetic species identification. This software arose after a forensic identification workshop (La Jolla, California 1999) at which the need for a database of DNA sequences had been highlighted (Dizon *et al.*, 2000). The web-based software (<http://www.dna-surveillance.auckland.ac.nz>) provides sequence matches, but keeps the reference sequences hidden unless permission is granted by the owner. The sequences are held in a hierarchical structure and the software will provide a closest match. One of the advantages of this approach is that it overcomes the need to export and import samples for comparison, thereby avoiding lengthy permit application procedures (see Item 15 of the Scientific Committee report).

5.6 Other

SC/54/BC6 reported on a bycatch reduction strategy emanating from a workshop held in Annapolis in January 2002. The strategy includes a suggestion that formal national Plans of Assessment to estimate bycatch rates should be developed. Such Plans would include collection and analysis of data to describe fishing fleets, including the size of the fleet (number of vessels), fishing methods, fishing areas and measures of fishing effort. They should also include where appropriate bycatch monitoring schemes based on independent observations when possible. Mattila noted that the workshop had, however, also recognised the utility of rapid appraisals based on other methods to gauge the nature and overall likely extent of bycatch problems. The strategy is currently in draft form for review but was intended to be presented at FAO's next Committee on Fisheries (CoFi) meeting.

Palazzo stressed that international collaboration and exchange of information would be vital to enable developing countries to develop such plans.

Discussion focused to some degree on the entanglement and freeing of large whales from fishing gear, especially in the Northwestern Atlantic. In this context, and with due regard to the sub-committee's terms of reference to examine methods to estimate large whale mortalities due to bycatch, Leaper suggested that for large whales seen entangled in fishing gear at sea, the experience of researchers in the Northwestern Atlantic might be useful in providing a photographic or diagrammatic catalogue of the types of damage likely to prove ultimately fatal, and the types that might be reasonably assumed to be non-fatal. Mattila

responded that there were some types of damage that were clearly potentially fatal, including those where young animals were entangled and could be expected to 'grow into' ropes that could ultimately result in their death.

SC/54/BC2 provided the results of an intersessional group's deliberations on the release of large whales from entanglement. The sub-committee heard that for large whales any type of rope or net in the water column represented a potential danger. On the east coast of the USA the primary dangers are from lobster pot lines and gillnets, and entanglement can involve virtually any part of the gear and several parts of the animal including the head, mouth, pectoral fins, caudal peduncle and flukes. A high proportion of large whales on the east coast have evidence of previous entanglement events through scarring and the sub-committee was reminded of last year's discussion on this topic (Robbins and Mattila, 2001).

Minke whales, as the smallest of the baleen whales are the most likely to die as a result of entanglement in the short term, whereas larger whales may swim away with gear attached and succumb at a later date if feeding is impaired or if the entanglement leads to serious infection.

Berggren asked whether there was any indication of the proportions of animals that become entangled that ultimately are known to have died as a result, and any relationship with fishing effort or gear density. Clapham suggested that colleagues in Newfoundland might have such information given the length of time (more than 30 years) that they have been involved in such research, and it was **suggested** that the sub-committee should contact this group (at Memorial University) to see if a paper could be prepared for next year's SC meeting.

6. ESTIMATION OF MORTALITY FROM SHIP STRIKES

6.1 Mandatory or voluntary reports

Rose presented a summary of ship strikes (including hull strikes and propeller strikes) from National Progress Reports in 2001 (Table 2). There were ten such records, but for many countries there were no records at all.

Parsons reported that the Royal Navy had agreed in principle to collate any records of naval ship strikes annually and report them to the UK's responsible ministry and copy this to the IWC.

Simmonds commented that ship-strikes in Europe were being under-reported. He agreed that asking an agency like the Navy, which might be able to provide effort related data would be a good idea.

Rowles noted that US Navy protocol includes routine recording and reporting of whale collisions.

Mattila noted that since the US had introduced necropsy protocols that included 'flensing to the bone', an increased number of severe traumas and suspected ship strikes had been uncovered among stranded whales. Furthermore as this work progresses it may be possible to ascertain whether the ratio of known ship strike casualties to cryptic ship strike casualties among stranded animals is consistent enough to use this as an estimator of cryptic ship strike mortalities among stranded animals elsewhere.

The sub-committee **agreed** that the existing records of ship strikes, as reported in National Progress Reports, were likely to be a gross under-estimate of the total number of actual ship strike mortalities among large whales globally.

6.2 Observational data

Peddemors presented data on shipping levels in South African waters in relation to ship strikes of right whales. He found no evidence of any centrally-held information on shipping densities around the world. However, the South African Defence Intelligence Agency held information on ships within South African territorial waters and had provided a summary. This showed very high levels of shipping activity in South African waters including those adjacent to KwaZulu Natal and the southern Cape in the austral winter when right whales are most numerous locally, with 1,574 ships recorded passing through territorial waters around the southern Cape during the months of peak right whale abundance July to November.

However, despite high levels of shipping, there were only four known and seven suspected shipstrike mortalities of right whales in 30 years, although full necropsies had not

Table 2

Reports of large whales killed by ship strike (or suspected ship strike) in 2001 (including some reports from 1999 and 2000), as recorded in National Progress Reports submitted to the 2002 meeting.

Country	Species	Number of animals and details
Australia	Southern right	One animal - fatal (female - probable ship strike).
Australia ¹	Blue	One animal - fatal (possible yacht strike).
Australia	Humpback	One animal - non-fatal (boat strike apparently observed - animal probably survived).
Oman	<i>Balaenoptera</i> sp.	One animal - fatal (was found wrapped around the bow of a commercial container ship - could have been a post-mortem strike).
Spain (for 2000)	Sperm	Five animals - fatal (cause of death determined through post-mortem examination).
Spain (for 2000)	Bryde's	One animal - fatal (cause of death determined through post-mortem examination).
Spain (for 2000)	<i>Balaenoptera</i> sp.	One animal - fatal (collision observed).
Spain (for 2001) ²	Sperm	Three animals - fatal (cause of death determined through post-mortem examination).
USA (for 1999)	North Atlantic right	One animal - fatal (female).
USA (for 1999)	Fin	Two animals - fatal (both male).
USA (for 2001)	North Atlantic right	Two animals - fatal.
USA (for 2001)	North Atlantic right	One animal - non-fatal (wound clearly healing at last sighting).

¹ It was noted that a stranding of a blue whale (or pygmy blue whale) in 2000 was also a probable boat strike.

² All of these collisions occurred in the Canary Islands.

been undertaken (Best *et al.*, 2001). Oosthuizen suggested that right whales are mainly confined to coastal waters and that the main shipping lanes are further offshore, thereby reducing the likelihood of ship strikes. The sub-committee agreed that in South African waters the most likely area of ship strikes would be off the eastern Cape and coast of Natal, where migrating humpbacks would cross shipping lanes.

There was some discussion of what factors might lead to ship struck animals being unrecorded:

- (1) Offshore winds and currents would likely limit beaching of many casualties.
- (2) Sharks in some areas could be responsible for preventing ship-struck whale carcasses from reaching shore.
- (3) Large ships would be most unlikely to notice hitting a whale.
- (4) Even if a struck whale was noticed it would be unlikely to be recorded by many mercantile naval officers, unless noticeable damage had been caused, as striking an obstacle is the fault of the officer on watch and he would be held responsible.

Van Waerebeek reported a shipstruck humpback whale in Togo in 2001.

SC/54/BC4 described a simple modelling approach to ship strikes. The model attempts to predict a maximum likely strike rate for a given density of ships and whales, assuming a random orientation of the whales and no behavioural response to an approaching ship. Applying the model to the Canary Islands, where ship strikes, mainly on sperm whales, have been recorded for several years, the model predicted at most seven large whale strikes per year in the Tenerife-Gran Canaria Channel. There have been seven large whales recorded as struck and killed by fast (30nm/h and above) ferries in this location during the last three years of observation, but this may be a minimum estimate as not all would have been noticed or recorded as stranded animals. Tregenza noted that behavioural responses of a whale would greatly influence the predicted strike rate. Ship avoidance would likely be prompted by acoustic cues but sound propagation from an approaching ferry will depend on water depth and stratification. If avoidance responses to such cues are learned over time, then calves and recent immigrants to an area (such as this migration zone) would be most at risk of collision.

The sub-committee recognised the value of this approach for setting an upper bound on likely strike rates, and also noted that the work of N. Aguilar and colleagues in the Canary Islands probably represented the best such dataset in the world, and encouraged them to continue to collect this type of data to improve our understanding of ship strikes, and to provide a basis for quantifying actual collision rates. The sub-committee also encouraged similar work in other parts of the world to be undertaken. The sub-committee briefly considered what other areas and what other data might be most usefully collected. Although it is clear that the Commission's interest in ship strikes is in relation to how the numbers of animals killed might impact on any future implementation of the RMP – most likely in the Northwestern Pacific or the North Atlantic – the sub-committee recognised that by examining other areas of the world and even protected species such as northern right whales, useful insights into the rates at which animals are struck might be gained.

The sub-committee heard that some years ago a fast-ferry line had been introduced between one of the Islands in the Sea of Japan and a western Japanese port. Jet-foil ships had suffered collisions with whales. The ship owners had tried to

avoid collisions by introducing some acoustic warning systems. It was not clear whether this method had worked, but they had also increased the number of people watching out for whales on the trackline and the numbers of collisions had decreased. The report of this work was published in Japanese. The sub-group welcomed this information and asked whether it might be made available next year in a paper to the Environmental Concerns group. It was also suggested that the recorded numbers of animals struck could be usefully included in National Progress Reports.

Weinrich suggested that another useful approach might be to compile a catalogue of fast ferry routes elsewhere, and that fast whalewatching vessels should also be included in future studies as they occurred, by definition, in areas of high whale density.

The sub-committee recommended that data be collected intersessionally on the amount of high-speed ferry and other similar fast-moving vessel traffic. Weinrich agreed to chair a group to collate this information. Emphasis will be placed on two areas, the Northeast Atlantic and western North Pacific. Additional information will be gathered in the western North Atlantic, South America (with a special emphasis on Venezuela where there are reports of collisions with high-speed vessels) and Southeast Asia. It was noted that data relevant to estimating mortality due to ship strikes are so sparse that data from all areas would contribute to understanding the various factors involved. In addition, a list of areas where high-speed vessels are used for whalewatching should be developed, along with a catalogue of known collisions between vessels and whales where data on the type of vessel involved in the collision are available.

6.3 Other

The sub-committee recalled two suggestions from last year's meeting that biopsy samplers might be fitted to vessels in high-risk areas, and secondly that a decelerometer might be developed that could detect whale strikes on large vessels, including fast ferries. Tregenza reported that he had formulated the technical specifications for a decelerometer and that he was in consultation with engineers about its construction. He would report back to the sub-committee next year.

The sub-committee reiterated its request last year that necropsies on stranded animals should examine animals as thoroughly as possible for evidence of ship strikes. Cipriano suggested that some technical innovations, perhaps through the use of ultra-sound might be sought to look for evidence of ship strikes on stranded animals without having to remove all the muscle of a large whale during autopsy.

The sub-committee concluded its deliberations on ship strikes by **recommending** once again that Commissioners should be encouraged to ensure more complete records of ship strikes in the National Progress Reports.

7. METHODS FOR ESTIMATING ADDITIONAL HUMAN-INDUCED MORTALITIES

As last year, the sub-committee briefly discussed other sources of human induced mortality including entanglement in marine debris, mortality resulting from acoustic trauma, mass die-offs due to disease that might be induced through the immuno-suppressive action of pollutants, or kills due to oil spills. The sub-committee recognised that those matters were outside the terms of reference as currently drafted but

agreed that to the extent that these additional human-induced mortalities could reasonably be estimated, they should be flagged for future consideration.

8. OTHER

Last year, the sub-committee recommended that a request be made for further information about a planned cetacean strandings scheme in China. No information was available at this meeting but the Secretary of the Commission will contact Chinese authorities to ask if some written document on the proposed scheme, together with methods of necropsy that would be used, might be submitted to a future meeting of the sub-committee.

Kasuya commented on the surprisingly high proportion of J stock whales in the market samples. Many members of the sub-committee noted that the availability of data on the annual proportion of J stock animals taken in the North Pacific, from incidental catches and JARPN, would allow better estimation of bycatch. Many members of the sub-committee also reiterated that estimation of bycatch would be improved by the ability to compare market samples with a register of all legally caught whales. However, Nagatomo stated that monitoring, control and management of the domestic whalemeat market is the sole responsibility of the government based on its sovereign right, and that matters related to their domestic market are therefore outside the jurisdiction and competence of the IWC. The Government of Japan is consequently in no position to provide its market-related genetic data to the IWC. However, Nagatomo indicated that if data from DNA sequence analyses from parties concerned were forwarded to the Institute of Cetacean Research they would compare the data with their database and provide the results.

Funahashi and Kasuya clarified that the request to the Government of Japan was not for market-related genetic data, but for information on the numbers and locations of J-stock animals from bycatch and JARPN II. This information is required to improve estimates of total takes over time from the J-stock, as required for the RMP. Funahashi also stated that she and colleagues would be glad to discuss cooperative research projects involving an exchange of genetic data. Such an exchange would require third party oversight to resolve possible conflicts in identification as already proposed in 2000 by Baker and Funahashi (2000).

9. WORK PLAN

The sub-committee discussed the priority items for consideration at the next year's meeting and beyond. The following work plan for next year's meeting was agreed:

- (1) Further review of information and methods to estimate bycatch based on fisheries data and observer programmes.
 - (a) Review responses from letters sent out requesting a list of fishery category types.
- (2) Further review of methods to estimate bycatch based on genetic data.
 - (a) Review the proposal developed intersessionally for a workshop on the use of market surveys to improve on minimum estimates of bycatch.
 - (b) Further development of analytical tests for assignment to stocks and/or areas considering both highly differentiated stocks (for example improving assignment of J and O stocks throughout their ranges), and stocks differentiated only by

smaller frequency differences (for example improving assignment between eastern and western North Pacific stocks of gray whales and BCB and Sea of Okhotsk bowhead whales).

- (c) Consider methodological issues in application of capture-recapture models to estimation of bycatch from market data.
- (3) Further review of information and methods to estimate mortality from ship strikes.
 - (a) Review results of data collected on high speed vessels relevant to ship strikes.
- (4) Consider methods for estimating additional human induced mortalities.

10. ADOPTION OF REPORT

The report was adopted on 5 May 2002.

REFERENCES

- Baker, C.S. and Funahashi, N. 2000. Molecular genetic identification of whale products: proposed international validation and investigation of species, stock and individual origins. Paper SC/52/SD8 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- Baker, C.S., Lento, G.M., Cipriano, F. and Palumbi, S.R. 2000. Predicted decline of protected whales based on molecular genetic monitoring of Japanese and Korean markets. *Proc. R. Soc. Lond. Ser. B* 267:1191-9.
- Best, P.B., Peddemors, V.M., Cockcroft, V.G. and Rice, N. 2001. Mortalities of right whales and related anthropogenic factors in South African waters, 1963-1998. *J. Cetacean Res. Manage.* (special issue) 2:171-6.
- Cho, I., Halpin, P.N., Kim, Z.G. and Sohn, H. 2001. Spatial and temporal patterns of minke whale distributions off the east coast of Korea. Papers SC/53/RMP21 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Dalebout, M.L., Lento, G.M., Cipriano, F., Funahashi, N. and Baker, C.S. 2002. How many protected minke whales are sold in Japan and Korea? A census by microsatellite DNA profiling. *Animal Conservation* 5:143-52.
- Dizon, A., Baker, S., Cipriano, F., Lento, G., Palsbøll, P. and Reeves, R. 2000. Molecular Genetic Identification of Whales, Dolphins, and Porpoises: Proceedings of a Workshop on the Forensic Use of Molecular Techniques to Identify Wildlife Products in the Marketplace, La Jolla, CA, USA, 14-16 June 1999. US Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-286. 52pp+xi. [Available from: <http://www.nmfs.gov>].
- International Whaling Commission. 2002. Report of the Scientific Committee. Annex M. Report of the Working Group on Estimation of Bycatch and Other Human-Induced Mortality. *J. Cetacean Res. Manage.* (Suppl.) 4:361-71.
- Kato, H. 2001. Japan. Progress report on cetacean research May 2000 to May 2001. Paper SC/53/ProgRep Japan presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Kim, Z.G. and Sohn, H. 2001. Cruise report of whale sightings survey in the East of Korea, September-October 2000. Paper SC/53/RMP23 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Lien, J. 1994. Entrapments of large cetaceans in passive inshore fishing gear in Newfoundland and Labrador (1979-1990). *Rep. int. Whal. Commn* (special issue) 15:149-57.
- Pastene, L.A., Goto, M. and Kanda, N. 2001. Comments on the estimations of the J and O stocks mixing proportion and level of by-catches of common minke whale using mitochondrial DNA data from the retail market surveys. Paper SC/53/RMP13 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Robbins, J. and Mattila, D.K. 2001. Monitoring entanglements of humpback whales (*Megaptera novaeangliae*) in the Gulf of Maine on the basis of caudal peduncle scarring. Paper SC/53/NAH25 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].

Appendix 1

TERMS OF REFERENCE OF SUB-COMMITTEE ON ESTIMATION OF BYCATCH AND OTHER HUMAN-INDUCED MORTALITY

At its 52nd meeting, under its agenda item 12.1.2, the Commission instructed the Scientific Committee (SC) that catch limits calculated under the Revised Management Procedure (RMP) shall be adjusted downwards to account for human-induced mortalities caused by aboriginal subsistence whaling, scientific whaling, whaling outside IWC, bycatches and ship strikes. The Commission stated that each such adjustment shall be based on an estimate provided by the SC of the size of adjustment required to ensure that total removals over time from each population and area do not exceed the limits set by the RMP. Total removals include commercial catches and the human-induced mortalities listed above to the extent that these are known or can be reasonably estimated (IWC, 2001, p.32).

The Terms of Reference of the sub-committee appointed to this task are:

- (1) Examine methods that have been used to estimate bycatch, and describe acceptable estimators and measures of their precision.

- (2) Consider requirements for sampling to obtain unbiased estimates of specified precision.
- (3) Consider confidence or probability intervals for such estimates that provide reasonable assurance that the Commission's objective regarding total removals over time is met.
- (4) Examine methods for estimating mortalities caused by ship strikes similarly.
- (5) Consider methods for summarising known and estimating unknown mortalities from the types of mortalities listed.
- (6) Consider establishing and maintaining a database containing the requested information.
- (7) Consider how best to communicate this information to the Commission.

REFERENCE

International Whaling Commission. 2001. Chairman's Report of the 52nd Annual Meeting. *Ann. Rep. Int. Whaling Comm.* 2000:11-63.

Appendix 2

AGENDA

1. Conveners opening remarks and terms of reference	5.5.2 Data from market samples
2. Election of Chair and appointment of rapporteurs	5.5.3 Analytical tests for assigning stocks
	5.5.4 Other methodological advances
3. Adoption of agenda	5.6 Other
4. Review of documents	6. Estimation of mortality from ship strikes
	6.1 Mandatory or voluntary reports
	6.2 Observational data
5. Bycatch estimation methods	7. Methods for estimating additional human-induced mortalities
5.1 Report of working group on collation of information from fisheries	8. Other
5.2 Independent observer programmes	9. Work plan
5.3 Mandatory or voluntary reporting schemes	10. Adoption of report
5.4 Strandings and questionnaire surveys	
5.5 Genetic analyses	
5.5.1 Bycatch workshop feasibility Steering Group	

Appendix 3

A RATIONALE FOR SEEKING INFORMATION ON FISHERY CATEGORIES FROM IWC MEMBER STATES

The Scientific Committee (SC) of the IWC has been asked to provide advice on the design of surveys to estimate the entanglement rate of large whales in fishing gear. Such captures are rare events that nevertheless, when summed over a large area or large fishing fleet, may have significant

implications on any future catch limits set by the IWC under its RMP. To this end, information is needed on the types of fishery likely to be involved, and ultimately to find out more about the nature and distribution of such fisheries to advise on sampling methods.

It is well known that fisheries are complex, varying from region to region and with gear type and target species. It is also apparent that some kinds of fisheries are more prone to catch whales than other fisheries. It is not yet known how to characterise such fisheries, which will of course be a first step in addressing how best to sample them.

As an initial step in addressing this issue, a simple list of fishery categories or fisheries as currently recognised by each IWC member state is requested. This should be broken down by gear type, target species and geographical area, to the extent that this is routinely done in each country and should be forwarded to the Secretariat.

Such a list will assist the SC in making comparisons across ocean basins to try to find commonalities among fishery types that might take large whales as bycatch. Furthermore, if and when the SC is able to identify fisheries that may be candidates for the establishment of a monitoring programme to estimate whale bycatch, such a list will assist the SC in focusing on the particular fishery-type(s) on a large scale and seeking additional specific information for that fishery from the relevant countries.

Annex N

Report of the Working Group to Review Sanctuaries and Sanctuary Proposals

Members: Zerbini (Chair), Baba (I), Baldwin, Bannister, Berggren, Best, Bjørge, Brownell, Butterworth, Childerhouse, Clapham, Collins, DeMaster, Diake, Donovan, Fujise, Funahashi, Garrigue, Goodman, Goto, Grønvik, Guiste, Hakamada, Haug, Hatanaka, Hung, Iñiguez, Ishikawa, Kanda, Kawachi, Kawahara, Kell, Kock, Kim, Last, Lawrence, Leaper, Manzanilla, Mattila, Minton, Morishita, Nagahata, Ohsumi, Oosthuizen, Palazzo, Parsons, Pastene, Rambally, Read, Reeves, Rennie, Rose, Rosenbaum, Sakamoto, Santa Maria, Shimada, Simmonds, J., Simmonds, M., Tamura, Thiele, Tomita (I), Tynan, Van Waerebeek, Walløe, Walters, Weinrich, Williams, Yamamura, Yoshida.

1. OPENING REMARKS

The Chair welcomed the participants to the meeting. He noted that at the 53rd Scientific Committee meeting in London, the Chair of the Committee had appointed an intersessional Steering Group to review IWC sanctuaries and sanctuary proposals. The Terms of Reference of this group were to develop:

- (1) a process by which the Committee will complete a review; and
- (2) evaluation criteria for the reviews, taking into account the Commission's previous comments and any further advice that might be offered by the Commission.

The Chair of the Working Group introduced a document developed by the intersessional Steering Group as a proposed framework to evaluate the Indian Ocean Sanctuary (IOS) this year (Appendix 3). This framework included the Instructions for Reviews of Sanctuaries and Sanctuary Proposals developed by the Commission last year. The Working Group should also provide comments and recommendations to improve the process and/or the Instructions during the meeting as the framework was being used on a trial basis by the Committee and the Commission, and if necessary, would be modified and improved in order to review the Southern Ocean Sanctuary (SOS) in 2004.

The Chair of the Working Group noted that the Commission directed the Scientific Committee to restrict their discussion to scientific aspects of the IOS, rather than any economic, social, cultural or political issues. He also noted that, following consultation with the Chair of the Scientific Committee, the Working Group should also concentrate its efforts on reviewing the effectiveness of the IOS in the context of protecting large whale stocks rather than small cetaceans.

There was some discussion of this latter point.

Palazzo noted some objections to the instructions given by the Chair of the Scientific Committee to direct the focus of the review to large whales. He stated that: (1) the exclusion of information related to small cetaceans prevented the discussion of important aspects of the Sanctuary; (2) in 1982, the Scientific Committee itself determined that appropriate research in the IOS should encompass small cetaceans; and (3) the instructions prejudged the position of several Contracting Governments regarding IWC competence. The Working Group noted the objections, which are stated in Appendix 2 under the names of the authors. Some members made reference to the Report of the 1982 Scientific Committee, which clearly referred to both small and large cetaceans (IWC, 1982c, p.132).

Rosenbaum commented that much recent research in the IOS has been conducted on small cetaceans, and has been presented to other sub-committees at this meeting. Sakamoto responded that discussion of small cetaceans was outside the competence of the IWC and stated the position of the Japanese Delegation regarding small cetaceans (see Annex R2).

The Working Group noted that the rationale for concentrating on stocks of large whales reflects the fact that the only management measure IWC sanctuaries [can] impose is the prohibition of whaling on large whales (it is well known that there is no consensus within the IWC on its competence to manage small cetaceans). It was also noted that almost all of the research items proposed by the sub-committee addressing this issue in 1982 (IWC, 1982c, pp.132-5) concerned large whales. Given this, it was noted that for the purposes of this review, references to research on small cetaceans would be restricted to that which was also of relevance to large whales. However, the Working Group recognised that many species and populations of small cetaceans are found within the boundaries of the IOS, that they face a number of actual and potential conservation threats (including *inter alia* incidental capture in fisheries, habitat degradation, pollution, climate change) and that a number of research projects on small cetaceans are underway (e.g. see SC/54/O5). It was noted that a thorough review of all small cetacean populations occurring within the boundaries of the IOS would represent a major task.

2. APPOINTMENT OF RAPPORTEURS

Last and Williams acted as rapporteurs.

3. REVIEW OF AVAILABLE DOCUMENTS

Documents relevant to the Working Group were SC/54/O5, O11, O20, O25 and IWC/54/16.

4. ADOPTION OF AGENDA

The adopted Agenda is given as Appendix 1.

5. REVIEW OF THE INDIAN OCEAN SANCTUARY

5.1 Review of documents

SC/54/O5 summarised the status of populations and present and potential threats to cetaceans and their habitats, including, *inter alia*, directed takes, bycatch, offshore mineral exploitation, shipping, whalewatching, climate change, pollution and other forms of habitat degradation. Highlights of the extensive review document relating to each region were provided.

(1) Southwestern Indian Ocean

In the 1990s, UNEP sponsored two training workshops on marine mammal biology and conservation and small-scale pilot surveys in Africa. In addition, the Western Indian Ocean Marine Science Association (WIOMSA) was established in 1991 to help facilitate marine research. Since 1996, Rosenbaum and colleagues have been conducting research on humpback whales and other marine mammals in Madagascar. In April 2001 a regional planning workshop was held in Cape Town bringing together delegates from eight African countries and Oman. There is limited evidence that the IOS has played a role in stimulating research on cetaceans to date, although this should be seen in the context of the predominantly developing nations involved.

(2) The Maldives

There has been relatively little research on cetaceans in Maldivian waters. However, during the last decade, several papers have reported on strandings and sightings and the Maldives are potentially important for long-term monitoring and conservation of cetaceans, because of their high cetacean abundance and diversity.

(3) Amsterdam and Saint-Paul Islands

A possible connection between the right whales seen in Madagascar with those found in Crozet is suggested, although the Crozet animals could also represent long-range migrants from South Atlantic populations.

(4) Arabian and Red Seas, Gulf of Oman and Persian Gulf

Despite the general lack of research in some parts of the Arabian region, significant data are now available for countries such as Oman, Saudi Arabia and UAE. In all of these countries, and in Kuwait, research is ongoing. The existence of the IOS has been noted as an important element in cetacean research in Oman at least. In spite of serious potential pollution problems, incidental takes may now be the most serious threats for cetaceans of this region.

(5) Northeast IOS

Marine mammals of Southeast Asia were considered in Kyoto in 1993 (IWC, 1994). In 1995, another marine mammal conference was held by the Silliman University, Philippines, in collaboration with UNEP. The Second International Conference on the Marine Mammals of Southeast Asia (which will focus on bycatch), will be held in Dumaguete, Philippines (22-26 July 2002).

(6) Australia

The Australian EEZ is a sanctuary. The federal government has supported long-term humpback, right and blue whale research off Western Australia. One of the main objectives of future cetacean research is to begin the process of utilising appropriate 'platform of opportunity' (POP) vessels to conduct standardised sightings.

(7) Sub-Antarctic waters of the Southern IOS

Most information on cetaceans has been reported from sub-Antarctic islands and from research vessels underway to Antarctica. The authors of SC/54/O5 highlighted the opportunities for further research based on these islands and the need for further observational cetacean research at sea, where research vessels focussed on other investigations may offer suitable POPs.

(8) Central IOS

The cetacean fauna of the central Indian Ocean has not been extensively studied, although a series of surveys have been conducted in recognition of the importance of the IOS. The many merchant vessels that cross the Sanctuary could be investigated as possible POPs for sightings.

Simmonds thanked the many contributors to the review. He noted that the IOS encompasses a large area predominantly surrounded by developing countries and that this can be expected to have a significant effect on research in the region. In the opinion of the authors of the paper, the existence of the IOS has helped to generate research and conservation initiatives, although this is clearly limited by economic considerations in some parts of the Sanctuary. However, the continued existence of the IOS is expected to continue to help in the development of: (1) management strategies and plans for the conservation of cetaceans; (2) further research; and (3) further regional-level initiatives, the need for which is highlighted in the paper.

Butterworth informed the Working Group that some of the concerns raised in SC/54/O5 about perceived threats to whale stocks in the IOS due to fisheries interactions are addressed in the South African region by fisheries management strategies that seek to ensure adequate escapement levels for pelagic populations upon which predators such as inshore Bryde's whales feed. In response to a query regarding the lack of some Australian data in the paper, Simmonds noted that the document was intended to be comprehensive, but it could not practically be exhaustive and he noted new information in other papers presented to the Scientific Committee. Morishita queried whether the authors had considered 'trans-regional collaborative research efforts' within the IOS. He further identified research on the interactions between cetaceans and fisheries in the IOS as an important, but understudied field. He noted that the Indian Ocean Tuna Commission is looking at these interactions, and that their initiatives should be included.

During discussion, Rosenbaum noted that proposals were being developed to act on previous recommendations to build a collaborative research programme on humpback whales throughout the entire Indo-South Atlantic region; SC/54/H4 looks at movements of individually recognisable humpback whales between the Southern Ocean and Oman providing an example of 'trans-regional collaborative research efforts'. He also noted that work on variation in humpback genetics between the IOS and other ocean basins would not be possible without international collaboration. Thiele added that IOS and SOS researchers have formed

collaborations. Proposals to study humpback and sperm whales in the IOS with both IWC member and non-member countries were also reported.

SC/54/O25 described some developments since the Scientific Committee last reviewed the IOS in 1992. At that time the discussion largely focussed on two topics, the value of sanctuaries as a management tool, and the value of sanctuaries for research. On both issues, much of the debate was referred back to previous discussions. Subsequent to these discussions the Commission agreed by consensus to an amendment to the Schedule that extended the IOS indefinitely with a review in 2002. Since then, considerable attention has been given to general issues related to marine reserves in other *fora*, particularly in the context of fisheries management. Some scientific developments since 1992 of relevance to discussions of the scientific aspects of the Sanctuary include: new techniques for studying cetaceans; an increased awareness of climate change and improved understanding of large-scale oceanographic processes; the development of whalewatching in several Indian Ocean coastal states; the revelations of previously unreported pelagic whale catches by the former Soviet Union (e.g. Yablokov, 1994); and initiatives related to cetaceans by other intergovernmental organisations in the region. An important consideration for the Indian Ocean north of the equator is the expectation of a poleward movement of ecosystem components with climate warming. Poleward movement may not be possible for many stocks in the northern Indian Ocean because of the land barrier. Whalewatching within the IOS has grown considerably since 1992, particularly in terms of the geographic spread across a number of countries. Whalewatching has implications due to the possible effects of the operations on whales and also because of the potential opportunities for research. Previously unreported catches were taken from stocks of blue, Bryde's, humpback, right and sperm whales (Yablokov, 1994). Some of these catches were from stocks believed to be confined to the northern Indian Ocean. Other intergovernmental organisations that have recently initiated programmes that relate to cetaceans include CCAMLR and IOTC. The adoption of the SOS by the IWC also provided a sanctuary area contiguous with the southern border of the IOS.

Before presenting SC/54/O20, Morishita recommended that the IOS be reviewed in light of the current conservation situation of the area, rather than when the IOS was established in 1979. The paper provided a response to each item of the Instructions from the Commission concerning review of sanctuaries. It reported that the Sanctuary applies irrespective of the conservation status of different species and stocks even when scientific evidence does not advise protection for them. The paper stated that the Sanctuary is a redundant measure because the commercial whaling moratorium is currently effective and when the moratorium is lifted, the risk-averse Revised Management Procedure (RMP) will provide full protection to whales. The authors believed that the Sanctuary is an inappropriate management strategy because it does not provide additional or necessary protection to whales nor does it improve protection of whale habitat. The paper further reported that: management of large whale stocks is essentially identical inside and outside the IOS boundaries; the IOS fails to address issues of critical versus non-critical habitat, since there are no internal boundaries; and that while research cited to date may have been done *in* the IOS, there is no evidence that it happened *because* of it. SC/54/O20 concluded that the Sanctuary is contrary to Article V of the International Convention for the

Regulation of Whaling, which requires that regulations be based on scientific findings, and should be abolished for these reasons.

Ishikawa expressed support for many of the views expressed in SC/54/O20, commenting that current circumstances render the IOS unnecessary. He also believed that it hindered rather than enhanced research effort directed at assessing the status of large whales and concluded that continuation of the IOS was scientifically unjustifiable.

Several members commented that they did not believe that the current moratorium on whaling and the future implementation of the risk-averse RMP will guarantee stocks adequate protection, and thereby remove the need for sanctuaries. They suggested that establishment of an appropriately designed system of sanctuaries adopts the precautionary approach against the possible failure of the RMP by protecting some stocks in part of their ranges and others in the entirety of their ranges. They noted that considerable uncertainty exists in the RMP inputs and operation and considerable complexity exists in baleen whale population structure and dynamics. They believed that a separate precautionary mechanism, such as a spatially and temporally appropriate sanctuary in addition to the RMP, should be established to protect whale stocks.

Minton presented an update on large whale stocks in the northern Indian Ocean. She highlighted the unique oceanographic features of this area that allow some whale populations to both feed and breed here. Minton cited data from historical observations, Soviet whaling, and recent research that indicate that there are discrete populations of pygmy blue, Bryde's, humpback and sperm whales resident in the northern Indian Ocean. Further research will allow us to better understand their stock structure and relationships to neighbouring populations in the southern Indian Ocean.

Best pointed out that the context and circumstances in which the IOS had been created were very different from those that now prevailed, and that the scientific value of the IOS as a control region had been largely eroded by the adoption of the moratorium and the RMP. He suggested that the boundaries of the Sanctuary should now be re-cast to recognise the unique nature of the whale populations that occur in the northern Indian Ocean, several of which apparently do not make the annual migrations to a high latitude feeding ground typical of most baleen whales. He believed this would create a whale sanctuary that was both biologically relevant and scientifically justifiable.

Tynan summarised significant relationships in climate connectivity between Antarctic sea ice and extratropical climate, such as that in the Indian Ocean. Sea ice edge anomaly in the Antarctic is highly correlated with sea surface temperature in the tropical Indian Ocean. Non-migratory or less-migratory whale populations in the IOS would experience the effects of climate forcing, such as El Niño – Southern Oscillation (ENSO) on the ecosystem, as well as forcing from linked climatological forcing between the Antarctic and tropics. Migratory whales would experience ecological consequences to climate forcing (e.g. ENSO) that transcend both the IOS and SOS. Yuan and Martinson (2000) report that 34% of the variance in sea ice edge anomaly in the Antarctic is linearly related to ENSO. In addition, the Antarctic Semi Annual Oscillation (ASO) has documented climate linkages to the extratropics, especially in the Indian Ocean.

Ishikawa commented that marine sanctuaries can be defined as useful conservation tools to provide protection of critical habitat or refuges for utilised resources as part of a sustainable management regime. They must be defined by

ecologically appropriate boundaries, applied to species subject to management and utilisation, and its duration must reflect conservation needs. He believed that sanctuaries fail to meet this definition if they are totally prohibitive over a large area when the status of stocks allows for sustainable utilisation, or if a management regime in effect is sufficiently precautionary. He noted that the boundaries are not ecologically appropriate since they neither cover the entire range of large whale stocks that migrate through or into the area nor are they limited to critical habitats for these species. He referred to the duration of the IOS as inappropriate, since there have probably been changes to the perceived conditions concerning the status of whale stocks and the need for a prohibition on whaling over a large area since the establishment of the Sanctuary more than 20 years ago. Although such changes have not been assessed, none of the species that occur in the area are in fact present candidates for commercial catch quotas. Nor will they become candidates until they have been assessed, sustainable catch limits established, and quotas set under the RMS. Ishikawa concluded by stating that for these reasons, there is no scientific justification for maintaining the IOS, the SOS, the proposed sanctuaries for the South Pacific and the South Atlantic, or the concept of a global sanctuary.

Many of the points raised in this initially general discussion are revisited in more detail in the following sections.

5.2 Review of the objectives of the Sanctuary

An overview of the history of scientific aspects and objectives of the IOS is given in Appendix 3. The following objectives were developed by Leatherwood and Donovan (1991) based on the original Sanctuary Proposal by the Government of Seychelles (Anon., 1979) and discussion of the Sanctuary during annual meetings of the IWC (e.g. IWC, 1979a; b; 1980a; b; 1981a; b; 1982a; b; 1983a; b; 1984; 1986).

- (1) The Sanctuary should provide an ecologically coherent area where whale populations are protected from whaling for a specified period, avoiding the possibility of stocks being alternately exploited and protected in the short term as a result of small changes in assessments.
- (2) In terms of appropriate research, the IWC Scientific Committee (IWC, 1982c) stated that:
 - (a) it should provide sufficient information to assess stocks of large whales and small cetaceans;
 - (b) it should permit direct comparison of the status of species and/or populations protected by the Sanctuary provision and exploited or unexploited stocks of the same species in other areas;
 - (c) the opportunity should be taken to carry out relevant investigation of certain kinds, which would be impossible or more difficult to undertake in areas where whaling continues.

5.2.1 Objectives of the IOS – Evaluation criteria

The Working Group reviewed the IOS objectives using the following evaluation criteria agreed by the intersessional Steering Group (Appendix 3, item 1):

(1) EVALUATE WHETHER WHALES WERE AND ARE EFFECTIVELY PROTECTED FROM WHALING WITHIN THE SANCTUARY

It was suggested that the Group interpret this question in terms of whether whaling had ever occurred or currently occurs within the IOS. Since whaling occurred in the area

before the establishment of the IOS, it was agreed that since its formation whales have been effectively protected; no evidence exists of research, illegal or commercial whaling within its boundaries (see Item 5.4, Section 4, sub-group C). Sakamoto noted that the IOS does not apply to research whaling. It was noted that the current moratorium prohibits commercial whaling both inside and outside the IOS, however the moratorium does not apply to non-member states.

(2) EVALUATE WHETHER THE BOUNDARIES OF THE SANCTUARY WERE APPROPRIATELY ESTABLISHED

In discussion of this evaluation criterion, the Working Group noted that the Instructions from the Commission gave no definition of the term 'appropriate.' It was noted that it is difficult to define ecologically relevant boundaries for the protection of several species simultaneously. Sakamoto expressed that the boundaries were designed to define a large, rather than biologically relevant area. Sakamoto noted that the boundaries are not scientifically relevant, in that the moratorium prevents commercial whaling inside and outside the Sanctuary. It was noted however that there are climatologically relevant connections between sea ice in the Antarctic and extra-polar climate, such as that in the Indian Ocean (e.g. ENSO) that would be relevant to the consideration of boundary definition. Numerous climate studies on these complex connections have been published and are ongoing. The importance of distinguishing between partial protection on breeding and feeding grounds was noted, and that protection of a stock's entire range might be justification for extending the boundaries.

(3) EVALUATE IF THE IOS HAS PROVIDED 'SUFFICIENT' INFORMATION TO RELIABLY ASSESS STOCKS OF LARGE WHALES

Table 1 provides available information relating to the current abundance, stock boundaries and occurrence of the large whale species in the IOS. In regard to the information available for large whale stocks in the IOS, the Working Group agreed that:

- (a) progress has been made on some stocks of large whales, namely right whales and humpback whales off South Africa and western Australia, but that this is insufficient for a comprehensive assessment of stocks in the entire IOS;
- (b) studies are underway on some of the other stocks;
- (c) some species, especially Bryde's whales, are hardly studied; and
- (d) not all of the research that has occurred in the IOS can be definitively attributed to the formation of the IOS. Some felt that there was a strong link between the formation of the IOS and their own research, while others asserted that their own research would have occurred regardless of the formation of the IOS.

(4) EVALUATE IF THE IOS HAS PERMITTED DIRECT COMPARISON OF SPECIES/STOCKS WITHIN THE SANCTUARY WITH (i) EXPLOITED AND (ii) UNEXPLOITED STOCKS OUTSIDE THE SANCTUARY

Continued series of abundance estimates of West Australian humpback and South African right whale populations may allow for comparative studies with similarly unexploited populations of these species outside the IOS. However, the absence of exploitation outside the Sanctuary following the declaration of the moratorium has precluded comparative studies with exploited stocks.

Table 1
Large whale species and stocks inhabiting the Indian Ocean Sanctuary.

Species	Stocks affected	Stock boundaries	Seasonal occurrence	Trends in abundance (period)	Most current population estimate	Comments and references
Blue whale, <i>B. musculus intermedia</i>	Part of Area III	Area III (0-70°E)	Winter and spring	n.a	n.a	
	Area IV	Area IV (70-130°E)	Winter and spring	n.a	n.a	
Pygmy blue whale <i>B. m. breviceauda</i>	Northern Indian Ocean	Indian Ocean north of Equator	Year round	n.a	n.a	Rice (1998)
	Part of Area III	Area III (0-70°E)	Winter and spring	n.a	478 (CV = 0.48) ¹	Best <i>et al.</i> (2003)
	Area IV	Area IV (70-130°E)	Winter and spring	n.a	n.a	
Fin whale, <i>B. physalus</i>	Part of Area III	Area III (0-70°E)	Winter and spring	n.a	n.a	
	Area IV	Area IV (70-130°E)	Winter and spring	n.a	n.a	
Sei whale, <i>B. borealis</i>	Part of Area III	Area III (0-70°E)	Year round	n.a	n.a	
	Area IV	Area IV (70-130°E)	Year round	n.a	n.a	
Bryde's whale, <i>B. edeni</i>	Northern Indian Ocean	Indian Ocean north of Equator	Year round	n.a	n.a	
	Southern Indian Ocean	20-130°E	Year round	n.a	534±184	Best <i>et al.</i> (1984)
	Part of South African Inshore	South African coast, west of 27°E until to the 200m isobath	Year round	n.a	n.a	
Antarctic minke whale, <i>B. bonaerensis</i>	Part of Area III	Area III (0-70°E)	Winter and spring	Under review	57,000 (CV=0.2) ²	Branch and Butterworth (2001)
	Area IV	Area IV (70-130°E)	Winter and spring	Under review	6,600 (CV=0.34) ²	Burt and Stahl (2001)
Common minke whale, <i>B. acutorostrata</i>	Part of Area III	Area III (0-70°E)	Winter and spring	n.a	n.a	
	Area IV	Area IV (70-130°E)	Winter and spring	n.a	n.a	
Humpback whale, <i>Megaptera novaenaglie</i>	Northern Indian Ocean	Indian Ocean north of Equator	Year round	n.a	n.a	n.a
	Breeding stock C	East coast of Africa	Winter and spring	n.a	Natal/Mozambique: 1,800 (1990)	Findlay and Best (1996)
				n.a	South Madagascar: 2,500 (1994)	Best <i>et al.</i> (1996)
				n.a	North Madagascar 1,746	Rosenbaum <i>et al.</i> (2000)
	Breeding stock D	West coast of Australia	Winter and spring	10.15±4.6% (1982-1991)	8,207-13,640 (1999)	Bannister and Hedley (2001)
Right whale, <i>Eubalaena australis</i>	South African breeding stock	Southern Africa	Winter and spring	+7.2%/yr (1982-1996)	3,104	Best <i>et al.</i> (2001), IWC (2001)
	Australian breeding stock	Southern Australia	Winter and spring	+(7.1-13.5%)/yr (1983/86 – 1997)	1,897	Bannister (2001) and pers. comm.
Sperm whale, <i>Physeter macrocephalus</i>	Northern Indian Ocean		n.a	n.a	n.a	
	Division 3	20-60°E	Females and juveniles year round, males winter and spring	n.a	n.a	
	Division 4	60-90°E		n.a	n.a	
	Division 5	90-130°E		n.a	n.a	

¹This estimate refers to approximately a third of the stock distribution area.

²This estimate was obtained in the Antarctic, outside the IOS. The Area IV estimate quoted must be viewed in the context of discussions recorded in the report of the IA sub-committee.

n.a = not available.

(5) IDENTIFY WHAT KINDS OF INVESTIGATIONS WERE CARRIED OUT IN THE SANCTUARY, WHICH WERE MORE DIFFICULT TO UNDERTAKE IN AREAS WHERE WHALING CONTINUED

Some members believed that this criterion was irrelevant due to the cessation of whaling under the current moratorium. Other members noted that research could be conducted

within the IOS that could be compared with stocks that are subject to non-commercial exploitation. The Working Group was not aware of any such studies that had been conducted, however reference was made to one study that opined that their biopsy research was assisted by working with an undisturbed stock (SC/54/O5).

5.3 Review of large whale research developed in the IOS and its implications for the work of the Scientific Committee and the Comprehensive Assessment of Whale Stocks (CAWS)

A workshop held in Zeist, Netherlands, in 1981 prepared a list of research objectives within the IOS, some of which would satisfy the SC needs in obtaining information for assessment-related matters. These objectives, listed below, were used to develop the evaluation criteria for reviewing research in the IOS:

- (i) to satisfy the needs of the IWC Scientific Committee particularly in obtaining adequate information about the distribution and abundance of whales, their reproductive behaviour and related matters relevant to assessment of stocks;
- (ii) to obtain scientific information pertinent to assessing and realising the economic, cultural and scientific values of living cetaceans;
- (iii) to enhance the understanding of the ecological roles of cetaceans in marine biological systems and to permit assessment of the impact of human activities on recovering and unexploited populations;
- (iv) to focus attention on the development and application of benign research techniques;
- (v) to foster investigations on the frontiers of research on living cetaceans, such as communication, navigation, behaviour and physiology of diving;
- (vi) to ensure the establishment of centres of research on cetaceans in the Indian Ocean and to further communication about research among Indian Ocean coastal states and between them and others involved in such research.

The Zeist Workshop also recognised one research area that required attention: the establishment of a stranding network. The meeting noted the value of such networks in areas where the knowledge of cetaceans is very limited. A sub-group was set up to discuss practical ways of implementing such networks.

5.3.1 Research in the IOS – Evaluation criteria

The Working Group reviewed research in the IOS using the following evaluation criteria agreed by the intersessional Steering Group (Appendix 3, item 2).

- (1) The objectives listed above could be addressed with or without the existence of a sanctuary. The SC should evaluate the extent to which the establishment of the IOS furthered the achievement of these objectives.
- (2) Briefly assess the past and present status and results of the 24 projects identified by the Zeist Workshop and how they contributed to the research needs of the SC.
- (3) List other projects developed within the IOS and how they contributed to meet the research needs of the SC.
- (4) Evaluate the progress in implementing stranding networks in the IOS.

Table 2 summarises the status of the research projects identified at the Zeist Workshop that were expected to contribute to meeting the six objectives from the Zeist Workshop.

During discussion it was noted that, in general, progress has been made towards meeting the above objectives of the IOS (SC/54/O5) but that it is difficult to determine conclusively what the effect was of establishing the Sanctuary on this progress. Much of the research conducted on stocks before the establishment of the IOS was obtained from whaling operations. Three well-known longitudinal

studies that began before the establishment of the IOS were cited: right whales off South Africa (e.g. Best *et al.*, 2001) and western Australia (e.g. Bannister, 2001); and humpbacks off western Australia (e.g. Bannister and Hedley, 2001). At least three studies were initiated in direct response to the IOS (Gordon, 1991; Ballance and Pitman, 1998; Ballance *et al.*, 2001), and numerous studies began after the establishment of the IOS occurred.

5.3.2 The IOS and the Comprehensive Assessment of Whale Stocks – Evaluation criteria

The Working Group reviewed the IOS and its implication for the Comprehensive Assessment of Whale Stocks using the following evaluation criteria agreed by the intersessional Steering Group (Appendix 3, item 3).

(1) EVALUATE PAST AND CURRENT DATA ON ABUNDANCE ESTIMATES AND TRENDS FOR WHALE STOCKS WITHIN THE IOS

Table 1 provides an update of abundance estimates for large whale species and stocks inhabiting the IOS. During discussion, the Working Group acknowledged that considerable information exists for right and humpback whale stocks. Studies on pygmy blue whales in western Australia and Bryde's whales in the northern Indian Ocean are ongoing and information is forthcoming.

(2) EVALUATE PROGRESS IN STOCK IDENTIFICATION SINCE THE IOS WAS CREATED

Progress on stock identity for humpback and right whales using genetic data from the southwest Indian Ocean was noted. Reference was also made to ongoing research that uses new genetic techniques to establish links between feeding and breeding grounds. Links between Indo-Atlantic and South Pacific samples will allow a much better understanding of stock identification. There is some on-going research on stock identification of blue whales from western Australia. No information was presented on progress in stock identification for any of the other large whales. The progress on stock definition in areas outside the IOS was noted.

The Working Group agreed that considerable advances have been made for some stocks (humpbacks and right whales in some portions of the IOS, and some information on pygmy blue whales), but for the others, no information is currently available.

(3) EVALUATE PROGRESS IN ESTIMATION OF DEMOGRAPHIC PARAMETERS AND VITAL RATES SINCE THE IOS WAS CREATED

The Working Group came to a similar conclusion as above. Some information exists on trends for right and humpback whales in portions of the IOS (with additional research ongoing), but no information is currently available for other stocks. The Working Group noted that in terms of assessing whether the existing research allows us to reliably assess stocks of large whales, what has been done so far is limited.

(4) LIST AND EVALUATE THE RESULTS OF PROJECTS FOCUSED ON THE DEVELOPMENT OF CALIBRATION AND ASSESSMENT METHODS

Attention was drawn to SC/54/O25, which provides examples of research techniques that have evolved directly from research initiated in response to the adoption of the Sanctuary.

The Working Group regarded that the information provided under (3) to summarise the status of knowledge on the stocks present in the IOS is also relevant here.

Table 2

Status of the 24 projects identified at the Zeist Workshop as contributions to meet the research objectives of the IOS.

No.	Project	Status in 1987	Status in 2002
1	Review of available data on Indian Ocean cetaceans	Unfunded but initiated	See paper SC/54/O5
2	Study of historical materials relating to 19th Century whaling in the western Indian Ocean	Not funded and not implemented	In prep. (Reeves and Rosenbaum)
3	Analysis of logbook records from the eastern Indian Ocean	Partially implemented	Wray and Martin (1983)
4	To promote and coordinate use of platforms of opportunity	Not funded but partially implemented	Partially implemented Bannister <i>et al.</i> (1981)
5	Conduct a series of field trips to locate possible sites for long-term studies involving close encounters with whales	Not implemented as envisioned but some work was carried out	Partially implemented (e.g. Corbett, 1994; Ballance and Pitman, 1998; De Boer, 2001; Baldwin, pers. comm.; Tynan, 1996, 1997)
6	Investigate the presence of sperm whales in the waters around Mauritius	Not implemented	Various surveys carried out
7	Identify optimal sampling strategies for estimating the mean density of a given whale target in a given region over a given interval	Not implemented	Corbett (1994), continued by a local NGO
8	Sub-surface observation (diving and submersibles), particularly of sperm whales	Partially implemented, most work carried out outside the IOS	Findlay and Best (1996) and planned 2002
9	To determine to what extent the blue whales seen in the Sanctuary are 'normal' blue, pygmy or both	Partially implemented	No information available
10	Conduct a long-term study of Bryde's whales in south-western Indian Ocean	Partially implemented	Best (1998), IDCR surveys, Japanese surveys
11	To detail the existence of killer whale populations within the Sanctuary and the feasibility of conducting assessment studies by applying techniques of photographic and acoustic identification developed elsewhere	Not implemented but a cruise was carried out	To be implemented
12	Investigation of transequatorial links among humpback whales	Not funded but initiated	Not implemented (sightings available in several publications)
13	Photo identification of humpbacks off Western Australia	Not implemented	Being implemented SC/54/H4
14	Estimates of relative abundance of sperm whales off recently closed land stations	Partially implemented	Jenner and Jenner (1994), Burton and Bannister, ongoing
15	Survey of sperm whales and other cetaceans in the Seychelles area	Not implemented	Not implemented
16	Behaviour of sperm whales in the Indian Ocean	One aerial survey carried out	Robineau (1991)
17	Status of cetaceans in the waters of Oman	Funded	About to begin as part of ISAHWN
18	Identification of minke whales	Partially accomplished	Kasuya and Wada (1991), Baldwin (1998)
19	Photogrammetric aerial surveys of inshore delphinids off Natal and Transkei and offshore Delphinus delphis in the same area	Not implemented	Baldwin (1997)
20	Aerial and shore inventory of cetacean species east and west of southern Madagascar	Partially implemented	Ongoing SC/54/SM6, 34
21	Placement of observers on <i>R.V. Marion Dufresne</i> , sailing between France and Terres Australes et Antartiques Françaises	To be initiated	SC/54/H3, H4, O4
22	Obtain biological information and continuing statistics regarding subsistence whaling in Indonesia	Implemented	Not implemented
23	To study cetaceans in the Sanctuary	Implemented	Completed (see Cockcroft <i>et al.</i> 1990, 1991, 1992).
24	Data collection and administration	Not implemented	Implemented and ongoing
		?	SC/54/H18, H20
			See paper SC/54/O5
			Barnes (1991)
			Partially implemented
			?

(5) EVALUATE THE EFFECTIVENESS OF WHALE STOCK MONITORING PROGRAMMES AND HOW THEY CONTRIBUTED TO COMPREHENSIVE ASSESSMENT OF WHALE STOCKS (CAWS)

The surveys cited above on southern right, humpback and pygmy blue whales have contributed data to the Comprehensive Assessment of stocks of the first two species. No additional data are available from other large whale stocks in the IOS, however studies are underway on Bryde's whales in the northern Indian Ocean.

5.4 Review of the IOS based on the Instructions provided by the Commission in 2001

The Chair noted that the lack of consensus in earlier discussions suggested that there may be insufficient time to complete the full Agenda unless an alternative mechanism for arriving at detailed statements incorporating all

viewpoints was established. Given the general tenor of previous discussions he proposed establishing three working groups that broadly encompassed the range of views expressed. Their terms of reference were to:

- (1) evaluate the effectiveness of the IOS according to the Commission's Instructions (IWC, 2002a);
- (2) make recommendations to any aspect of the IOS the sub-group thought might be appropriate to improve it (Appendix 3, item 5); and
- (3) make recommendations for the Commission's Instructions for Reviews of Sanctuaries and Sanctuary Proposals.

The Chair noted his reluctance to establish this procedure but believed it represented the only viable solution.

Each sub-group was assigned a convenor and was named in the order in which the rapporteurs received summaries from the conveners (sub-groups A, B and C).

After producing sub-group evaluations of the effectiveness of the IOS according to the Instructions of the Commission, the Working Group reconvened and attempted to assess whether there was any consensus under each Instruction. The following section contains a compilation of the views expressed by the three sub-groups followed by a Working Group evaluation for each Instruction. Full sub-group reports A-C are given as Appendices 4-6 respectively.

(1) Give attention to assessing how well the scientific aspects of the agreed objectives of the Sanctuary have been met, and how well they might be met if the Sanctuary continues.

SUB-GROUP A

There are no agreed objectives for the IOS so it is difficult to respond directly to the question. However, it can be noted that the IOS serves no scientific or conservation purpose primarily for the following reasons: (1) it has been made redundant by the moratorium; (2) research in the IOS has not provided sufficient information to assess stocks of large whales; (3) even if the moratorium is lifted, the RMP provides more than adequate conservation measures; and (4) its boundaries are ecologically inappropriate. Continuation of the Sanctuary will not resolve these issues. For these reasons the Sanctuary should be abolished.

SUB-GROUP B

The IOS effectively provides direct protection from commercial whaling to the breeding stocks of all large whales in the Indian Ocean although the precise locations of some of these breeding areas are still unknown. Much of the research in the Sanctuary is aimed at the identification and assessment of other threats. A difficulty in evaluating the Sanctuary is determining which of the research and other activities in the Sanctuary have taken place as a direct or indirect consequence of the Sanctuary designation, and which may have occurred anyway. It is also becoming increasingly apparent that the time period required to reach an adequate assessment of something such as the effectiveness of a sanctuary is likely to be much longer than might have been anticipated.

SUB-GROUP C

The objectives have been met in part, but not to any great extent. The major contributions have been continuation of South African right whale and West Australian humpback and right whale surveys, though these would likely have continued with or without the IOS. Some work on humpbacks and blue whales in the western Indian Ocean has taken place. However, there has been an absence of the major pelagic surveys necessary were the IOS to have played its intended role as a control region. In particular, there is no such work on pelagic Bryde's whales, the primary concern of the IOS when motivated. More resources need to be committed if the IOS is to play this intended control role. The IOS may, however, serve to assist to promote some fundraising efforts for research, although this should not be a function of a sanctuary.

WORKING GROUP EVALUATION

There was no consensus among the three sub-groups on how well the scientific aspects of the agreed objectives of the Sanctuary have been met, or on how well they might be met

if the Sanctuary continues. Details regarding areas where opinions differed are presented in the sub-groups' full reports in Appendices 4-6.

(2) Provide advice on the status and trends of whale stocks in the Sanctuary in so far as these are known.

SUB-GROUP A

Meaningful advice cannot be provided on the status and trends of whale stocks in the Sanctuary because neither systematic sighting survey (except for some work on humpback and right whales) nor commercial whaling have been conducted in the Sanctuary since the establishment of the IOS.

SUB-GROUP B

The status of stocks in the Sanctuary is summarised in Table 1. The Sanctuary contains examples of: (1) populations which are depleted but known to be recovering; (2) populations which are depleted where the current trend is unknown; (3) populations such as minke whales, which are probably not depleted, but the current trend is under assessment by the Scientific Committee; and (4) populations which are probably not depleted but whose current trend is unknown.

SUB-GROUP C

See all of Appendix 6.

WORKING GROUP EVALUATION

It was **agreed** that sufficient information exists to review the status and trends of humpback and right whale stocks in western Australia and southern Africa. There is insufficient information available to review the status and trends of other large whale stocks in the Sanctuary.

(3) Assess whether the Sanctuary distinguishes between species and stocks that are depleted and apparently slow to recover, those that are increasing rapidly, and those that are abundant and not threatened.

SUB-GROUP A

The IOS does not distinguish between species and stocks. The prohibition on commercial whaling applies to all species and stocks irrespective of the status of stocks. This is one of the major arguments against the Sanctuary in that it provides protection for stocks even when scientific advice demonstrates that such protection is not required for conservation reasons.

SUB-GROUP B

The Sanctuary gives complete protection from commercial whaling to populations in all of the four categories listed above, but distinction between the categories can still be made for research and conservation purposes.

SUB-GROUP C

The IOS does not distinguish between such species and stocks.

WORKING GROUP EVALUATION

It was **agreed** that the Sanctuary provision does not distinguish between species and stocks that are depleted and apparently slow to recover, those that are increasing rapidly, and those that are abundant and not threatened.

(4) Assess the present and potential threats to whale stocks and their habitats in the area of the Sanctuary and how the Sanctuary addresses these. Such factors may include inter alia: whaling; fishing; oil and gas exploitation including seismic surveys; shipping; whalewatching; climate change; other environmental factors.

SUB-GROUP A

No information is available to assess the threats to whale stocks and their habitats. The IOS addresses only commercial whaling. Commercial whaling is not a potential threat because any resumption of whaling would only occur under the risk-averse RMP. It does not address aboriginal/subsistence whaling, fishing, oil and gas exploration, whalewatching, climate change or other environmental factors.

SUB-GROUP B

Although the Sanctuary currently only provides direct protection to whales from commercial whaling, much of the research in the Sanctuary is aimed at the identification and assessment of other threats. The results of the research have importance for the development of national protective measures, and for the development of future regional and international measures.

SUB-GROUP C

There is at present an aboriginal sperm whale fishery in Indonesia. Potential for unregulated whaling is always present. Known fisheries considerations include: drift and gillnet entanglements off Oman (humpback, Bryde's), Zanzibar, and in shark nets off South Africa (humpback, right whale); pot line entanglements off Australia; and potential ship strikes in all areas. The group was not aware of any areas where diminished prey due to fishing was affecting whale populations. Oil and gas explorations are taking place and may have detrimental effects near South Africa, Mozambique, Oman, the Straits of Hormuz and Arabian Gulf, and Australia. Whalewatching should be covered by domestic regulations as for example in Australia and South Africa. There is, however, no such coverage in some areas, for example Madagascar. Northern Indian Ocean stocks may be vulnerable to climate change as they are without the option to move to polar grounds. Coastal habitat degradation and shipping, for example, may be concerns around Arabia.

WORKING GROUP EVALUATION

It was **agreed** that currently the IOS protects whales only from commercial whaling. It was also **agreed** that additional threats may be occurring, but that these have not been rigorously assessed.

(5) Consider the relationship of the Sanctuary with other existing measures to protect whales from anthropogenic and environmental factors.

SUB-GROUP A

The Sanctuary does not improve protection of whales. It simply duplicates the unnecessary protection afforded by the moratorium on commercial whaling. Neither does it improve the conservation of breeding sites, migratory routes and/or feeding grounds. The Sanctuary does not complement the Commission's current management regime (the moratorium) nor will it complement the proposed regime of the RMP/RMS, because safe quotas will only be adopted for abundant stocks to ensure whaling is sustainable.

SUB-GROUP B

The Commission's Revised Management Scheme is still under development but it is envisaged that the RMS and sanctuaries would represent mutually complementary management measures.

SUB-GROUP C

See Group C's comment on Items 6.1-6.3 below.

WORKING GROUP EVALUATION

There was no consensus on the relationship of the Sanctuary with other existing whale protection measures from anthropogenic and environmental factors.

(6) Assess the anticipated effects of the proposed sanctuary in terms of: (6.1) improving protection of whales, in breeding areas, feeding grounds and/or migratory routes; (6.2) improving the conservation of breeding sites, migratory routes and/or feeding ground; and (6.3) complementing existing or potential protection including the Commission's management regime and regional and international agreements concerning biodiversity and conservation of nature.

SUB-GROUP A

(6.1) The Sanctuary does not improve protection of whales. It simply duplicates the unnecessary protection afforded by the moratorium on commercial whaling.

(6.2) Neither does it improve the conservation of breeding sites, migratory routes and/or feeding grounds.

(6.3) The Sanctuary does not complement the Commission's current management regime (the moratorium) nor will it complement the proposed regime of the RMP/RMS, because safe quotas will only be adopted for abundant stocks to ensure whaling is sustainable.

SUB-GROUP B

(6.1) The Sanctuary provides protection for the breeding stocks of all Indian Ocean baleen whales. The boundary at 55°S confers protection to feeding grounds of Bryde's and sei whales, the main feeding grounds for southern right whales, and part of the feeding grounds of Southern Hemisphere fin whales. Southern Hemisphere blue and humpback whales and Antarctic minke whales migrate outside the IOS. Female and juvenile sperm whales are protected throughout their range.

(6.2) The issues of habitat protection have only recently been considered by the IWC and to date no international measures have been taken. Whale habitat is specifically included in some national marine protected areas in the Indian Ocean.

(6.3) CCAMLR requires that the fisheries management take into account the needs of dependent species. The IOS provides protection to those dependent species during the part of the year for which they are outside the CCAMLR area.

SUB-GROUP C

(6.1) The IOS offers no such further protection given the moratorium. Furthermore, were the moratorium lifted, species migrating beyond its borders would not enjoy full protection.

(6.2) The IOS does not improve the conservation of any of these.

(6.3) The IOS could provide a control area, should the RMP be applied globally. However, it may be more appropriate to consider different areas within the Southern Hemisphere for different species.

WORKING GROUP EVALUATION

There was no consensus on the role of the IOS in terms of: improving protection of whales in breeding areas, feeding grounds and/or migratory routes; improving the conservation of breeding sites, migratory routes and/or feeding ground; or complementing existing or potential protection including the Commission's management regime and regional and international agreements concerning biodiversity and conservation of nature.

(7) Provide advice on whether the boundaries of the Sanctuary are ecologically appropriate.

SUB-GROUP A

Boundaries of the IOS were established simply to cover as wide an area as possible without regard to ecological principles or specific conservation needs for whale stocks. The boundaries of the IOS neither cover the entire range of large whale stocks that migrate through or into the area nor are they limited to critical habitats for the species. For this reason, the IOS boundaries are not ecologically appropriate and are not consistent with the common concept of a sanctuary.

SUB-GROUP B

The current boundaries are simply defined in terms of latitude and longitude and include an ecologically coherent area with land boundaries forming the majority of the eastern, western and northern boundaries. Most previous discussions regarding the boundary largely concentrated on the southern boundary. The original proposal was for the entire Indian Ocean including the Southern Ocean sector, but for operational reasons this was revised to 55°S while recognising that this had only limited ecological significance. The current Sanctuary boundaries provide opportunities for comparison of the potentially unique (in terms of genetics, behaviour and physiology) northern Indian Ocean whale stocks with southern Indian Ocean stocks across the same ocean basin.

SUB-GROUP C

For many species, the boundaries do not encompass their full distributional range, and so are not appropriate. Other options considered to be superior to the IOS include: (1) extending the IOS southward to the ice-edge, together with possible east-west broadening to encompass the assessed range of biological stocks; (2) limiting the IOS to a northern part of the area, given the unique situation there of whales precluded from polar migration; and (3) selecting a longitudinal slice of the Southern Hemisphere to serve as a control region, with the choice based upon simulation studies to assess optimality. This choice may be species-specific.

WORKING GROUP EVALUATION

There was no consensus on whether the boundaries of the Sanctuary are ecologically appropriate.

(8) Provide advice on whether the Sanctuary addresses the issue of critical habitat and non-critical whale habitat.

SUB-GROUP A

The Sanctuary does not address any habitat issues. It is simply a blanket prohibition on commercial whaling in the area. The issue of critical habitat is, however, addressed by the RMP, which does not provide quotas in breeding areas.

SUB-GROUP B

Since the competence of the IWC to include habitat protection measures in its Schedule has not yet been established, the Sanctuary provision *per se* contains no measures for habitat protection. However, the Sanctuary is of sufficient size to encompass the complete habitat for some populations.

SUB-GROUP C

Not in general, but a sanctuary restricted to the northern part of the area could more defensively be argued to do so.

WORKING GROUP EVALUATION

It was **agreed** that the Sanctuary does not currently address the issue of critical and non-critical whale habitat.

(9) Evaluate whether the Sanctuary may contribute to or impede the conduct of scientific research useful for meeting the IWC objectives and facilitate coordinated and integrated research and monitoring programmes.

SUB-GROUP A

While initially the establishment of the Sanctuary is reported to have resulted in an increase in research funding from NGOs and some research on sperm whales reported to be useful for meeting the IWC objectives, it also resulted in a decrease in national research funding in the area, except for Sri Lanka. Although a number of long-term research projects have been suggested, very few such projects have been initiated. The Sanctuary has therefore impeded the conduct of scientific research useful for meeting the IWC objectives. This is confirmed by the absence of any recent reports of such research in the list of bibliographic references prepared for the IWC Sanctuary Review Steering Group.

SUB-GROUP B

An important consideration when considering the level of research in the Sanctuary is that the coastal states are predominantly developing countries. The increase in research effort since 1992 is partly a reflection of the increase in cetacean research worldwide, but some of the projects have been initiated in response to the Sanctuary designation. One of the difficulties in evaluating the Sanctuary is knowing which activities are a direct result of the Sanctuary and which would have happened without it. In the case of research, the sub-group mainly relied on whether the reports of the research indicated that the existence of the Sanctuary had been of benefit. Indirect benefits that were referred to included: a focus on regional initiatives and cooperation; a greater awareness of cetaceans in coastal states; facilitation of the initial phase of integrated research between Indian Ocean and Southern Ocean; additional sources of funding.

SUB-GROUP C

The current combination of the IOS and the SOS impedes research, as the associated inability to compare stocks both under exploitation and unexploited in a control area detracts from capabilities to estimate demographic parameters relevant to the IWC objective of sound management on a scientific basis. Species-specific sanctuaries in parts of the Southern Hemisphere could, however, play some useful role towards that end.

WORKING GROUP EVALUATION

There was no consensus on whether the Sanctuary may contribute to or impede conduct of scientific research useful for meeting IWC objectives or facilitating coordinated and integrated research and monitoring programmes.

(10) *Provide advice on whether the Sanctuary is consistent with the precautionary approach.*

SUB-GROUP A

No widely accepted or pragmatic definition of the precautionary approach provides for the implementation of measures for the total protection of whales irrespective of their conservation status. Further, no such definition recommends unnecessary or duplicative measures such as the IOS. By contrast, although the RMP is unnecessarily precautionary and wasteful of resources, its implementation would be consistent with broadly accepted definitions of the precautionary approach.

SUB-GROUP B

The central tenet of the precautionary approach is that lack of information shall not delay potentially necessary conservation measures. The adoption of the IOS in 1979 at a time when relatively little was known about the whale populations in the region was a precautionary measure adopted by the IWC. While the RMP is designed to be more precautionary than its predecessors, the establishment of an appropriately designed system of sanctuaries can be regarded as a precautionary safeguard to mitigate the effects of possible failure of the RMP to adequately protect whale stocks after the current moratorium ends.

SUB-GROUP C

Superficially, a positive answer would seem obvious. However, the precautionary approach, taken to extremes, implies no utilisation of any natural resources. A pragmatic and balanced interpretation is necessary, taking account of the precautionary nature of the RMP, and the fact that the data contrast provided by limited exploitation is a necessary component of input to the development of a sound scientific basis for management. In this context, the precautionary approach should be seen as consistent with a set of species-specific sanctuaries of limited scope only.

WORKING GROUP EVALUATION

There was no consensus on whether the Sanctuary is consistent with the precautionary approach.

5.5 Recommendations for the IOS

Each sub-group was asked to provide recommendations for the IOS. These are given below.

Sub-group A

The IOS has been made redundant by the moratorium on commercial whaling and unnecessary by the RMP, both of which were adopted after the Sanctuary. The Sanctuary is an inappropriate management strategy that does not provide additional or necessary protection to whales, nor does it improve protection of whale habitat. Further, it does not address other anthropogenic or environmental factors. The Sanctuary impedes the conduct of scientific research and is inconsistent with the precautionary approach. Finally, the Sanctuary does not meet the requirement of the Convention that regulations be based on scientific findings. For these reasons, the IOS should be abolished.

Sub-group B

The sub-group recommended that the IOS continue in its current form, based on the available data. However, should the SOS provisions be changed in the future it may be considered prudent to extend the southern boundary of the IOS to the Antarctic continent. The sub-group considered

that there were insufficient data to define a smaller area (such as the Indian Ocean north of the equator) that would achieve the Sanctuary objectives. In addition, current boundaries provide opportunities for comparison of behaviour, physiology and the effects of climate change on unique northern Indian Ocean stocks with southern Indian Ocean stocks afforded the same protection across an ocean basin. The sub-group recommends that the Commission and the Scientific Committee encourage regional research cooperation and provide advice to coastal states on ways to address threats to large and small cetaceans in their waters.

Sub-group C

The sub-group considered that sanctuaries should be motivated on a species-by-species basis and as an integral part of an overall management plan, such that maximum scientific value can be achieved. In particular, in the IOS context, it sees merit in reformulating this to apply only to the northern part of that area, given the unique situation there of whale populations precluded from polar migration, although other options are also put forward in response to Instruction (7) above.

6. COMMENTS/RECOMMENDATIONS CONCERNING THE INSTRUCTIONS FROM THE COMMISSION FOR THE REVIEWS OF SANCTUARIES AND SANCTUARY PROPOSALS

Each sub-group was asked to make comments and recommendations concerning the Instructions from the Commission. Specific recommendations were incorporated in the evaluation of each Instruction below, while more general recommendations are listed under 'General Comments and Recommendations'.

Sakamoto asked that it be noted that existing sanctuaries have no scientific basis and that sanctuaries are not necessary as a conservation measure even when the moratorium is lifted because of the precautionary nature of the RMP. Sakamoto suggested that the Scientific Committee does not need guidelines for the review of sanctuaries, since there should be no sanctuaries to review. This includes the SOS to be reviewed in 2004. The Chair noted that sanctuaries are currently in place, that additional sanctuary proposals are forthcoming, and that the Commission expects the Scientific Committee to review each of these sanctuaries and sanctuary proposals. Sakamoto noted that his comments mean that he is unable to agree with the Working Group's evaluation of the Instructions.

The following section contains the Working Group's evaluation of each Instruction from the Commission.

(1) Give attention to assessing how well the scientific aspects of the agreed objectives of the Sanctuary have been met and how well they might be met if the Sanctuary continues

It was **agreed** that this aspect of the review would benefit from explicitly stated scientific objectives in sanctuary proposals.

(2) Provide advice on the status and trends of whale stocks in the Sanctuary

It was **agreed** that this item is clear.

(3) Assess whether the Sanctuary distinguishes between species and stocks depleted and apparently slow to recover, those rapidly recovering and those abundant and not threatened

It was **agreed** that this item is not clearly worded, and needs to define how the Sanctuary provision is intended to distinguish among such species and stocks.

(4) Assess present and potential threats to whale stocks and their habitats in the area of the Sanctuary, including: whaling; fishing (including bycatch); oil and gas exploration (including seismic surveys); shipping; whalewatching; climate change; and other environmental factors

It was noted that it is unclear how to interpret the Instruction to assess various non-whaling threats, since the Commission does not currently adopt management measures that directly address these threats. It was **agreed** that this Instruction requires clearer linkage between IWC sanctuaries and assessing non-whaling activities.

(5) Consider relationship of the Sanctuary with other existing whale protecting measures from anthropogenic and environmental factors

It was **agreed** that this instruction was clear.

(6) Assess the anticipated effects of the proposed sanctuary in terms of: (i) Improving protection of whales, in the breeding areas, feeding grounds and/or migratory routes; (ii) Improving the conservation of breeding sites, migratory routes and/or feeding grounds; and (iii) Complementing existing or potential protection including the Commission's current management regime and regional and international agreements concerning biodiversity and conservation of nature

It was **agreed** that clarification is needed to define a link between the act of establishing an IWC sanctuary and additional present and potential threats. In particular, the sense in which responses to (ii) are intended to address this needs to be expanded.

(7) Provide advice on whether the boundaries of the Sanctuary are ecologically appropriate

It was **agreed** that this question can be easily interpreted so long as the scientific objectives of the Sanctuary are well defined.

(8) Provide advice on whether the Sanctuary addresses the issues of critical and non-critical whale habitat

It was **agreed** that definition of 'critical and non-critical whale habitat' is required, and that linkages, as suggested in the response above to (6), would be helpful.

(9) Evaluate whether the Sanctuary may contribute to or impede the conduct of scientific research useful for meeting IWC objectives and facilitate coordinated and integrated research and monitoring programmes

It was noted that this Instruction poses scientific and non-scientific questions simultaneously, and would benefit from clarification. Members disagreed on whether the SC is able to address whether IWC sanctuaries facilitate

coordinated and integrated research and monitoring programmes. It was agreed that this Instruction requires objective criteria for evaluation.

(10) Provide advice on whether the Sanctuary is consistent with the precautionary approach

It was **agreed** that the term 'the Precautionary Approach' must be clearly defined.

General comments and recommendations

Some members provided additional general comments and recommendations concerning reviews of sanctuaries and sanctuary proposals. These are presented below for information only, and were not discussed by the Working Group.

- (1) It is unclear how the Commission's questions as to how a sanctuary addresses various non-whaling threats are intended to be interpreted. The Commission knows that it does not currently adopt management measures that directly tackle these threats, and presumably it is not asking the SC whether it does. These questions were interpreted in terms of how the Sanctuary may encourage cooperation in the region to research and address these threats.
- (2) Guidelines for sanctuary reviews should include an evaluation of the appropriateness of the timing of reviews and this should take into account the long life span of whale species and the time frames over which the necessary scientific work needs to be conducted. The review criteria need to take into account any changes to the objectives of the Sanctuary as these evolve. The SC also needs to be kept up to date with evolving objectives of a sanctuary so that it can prioritise accordingly.
- (3) The SC could contribute more effectively to the realisation of the objectives of a sanctuary if it were given a mandate to develop a framework for the facilitation of collaborative research in the region. An essential component of this is to assist the involvement of scientists from developing countries within or bordering the Sanctuary.
- (4) If one of the objectives of a sanctuary proposal is to promote scientific research, then the Commission should increase budgetary resources towards this end.
- (5) The question about the status and trends of whale stocks within a sanctuary could be more effectively answered if the SC were given a mandate to conduct an assessment of the current state of knowledge of the conservation status of whale populations in the Sanctuary, with respect to the cumulative impact of the threats mentioned in the Commission's guidelines, namely whaling, bycatch, shipping, etc. Such an assessment could be conducted as part of the review of a proposed sanctuary or following its adoption with a view to designing a suitable programme of research for the Sanctuary.

7. SOUTH PACIFIC SANCTUARY PROPOSAL

Paper IWC/54/16 introduced a proposal for a South Pacific whale sanctuary submitted by Australia and New Zealand. It was noted that the content was the same as last year, but that it had been reformatted in accordance with the Instructions from the Commission. A record of the discussion of this document is given in last year's report (IWC, 2002b, p.67) and hence there was no need for further discussion.

8. OTHER SANCTUARIES

SC/54/O11 reported on the declaration of a whale sanctuary by the Government of the Cook Islands. The Cook Islands Whale Sanctuary (CIWS) was declared on 19 September 2001; it covers an area of approximately one million n.miles². Although there was little commercial whaling in the Cook Islands *per se*, local populations of humpback and sperm whales were heavily exploited (including by illegal catches) in other portions of their range; as in other areas of Oceania, recovery of these populations in the Cook Islands appears to have been slow. Cetacean species known to occur in the CIWS include four baleen whales and ten odontocetes; the occurrence in the region of an additional two mysticetes and nine odontocetes is considered likely. Humpback and sperm whales are the two most commonly observed large whales, and the former have been the subject of much research in recent years. Humpback whales (probably from the Area VI stock) are present in the CIWS during the austral winter; they appear to use the region as a calving and mating ground. A long-term study of this species is aimed at estimating abundance, documenting habitat use, assessing the degree of exchange with other areas of the South Pacific, and collecting biopsy samples for analyses of the genetic structure of South Pacific humpbacks. Other research in the CIWS is focused on beaked whales (*Ziphius cavirostris* and *Mesoplodon densirostris*), and on documentation of cetacean diversity in the region through surveys. Research in the CIWS is coordinated with work in other portions of Oceania through the South Pacific Whale Research Consortium (SC/54/O14). Regulations enacted to accompany the CIWS forbid the killing, injuring or harassing of cetaceans within sanctuary waters.

It was noted that a proposal for a South Atlantic Sanctuary would be resubmitted to the Commission this year and that its supporting document remains the same as that presented to the Scientific Committee last year (Government of Brazil, 2001).

The Working Group was informed that in November 2000, the Tristan da Cunha Island Council officially adopted the Tristan da Cunha Whale Sanctuary, which includes the 12 n.mile territorial waters of the Islands of Tristan, Inaccessible, Nightingale and Gough. The Sanctuary is designed to protect all cetacean species inhabiting or using these waters and is in place for an indefinite period of time.

9. FUTURE WORK

The Working Group outlined the following items to be addressed in the future:

- (1) Further develop generic criteria for reviewing sanctuaries (e.g. based on the criteria used in the IOS review), given feedback and clarification from the Commission.
- (2) Initiate the Review of the SOS based on instructions from the Commission, by beginning to collate the information required to follow the Instructions.
- (3) Discuss a mechanism for reviewing IWC Sanctuaries in combination, where biologically relevant.
- (4) Discuss a mechanism for introducing Marine Protected Areas (MPA) scientific concepts, such as critical habitat, into the IWC Sanctuaries and Sanctuary Proposals. In addition, consideration should be given to cooperating with appropriate international organisations to consider ways to evaluate non-whaling threats to cetaceans included within appropriate sanctuary/MPA boundaries.

This might best be achieved by creating linkages to international organisations that have the expertise to address non-whaling threats to cetaceans in the area covered by the Sanctuary.

- (5) Discuss a mechanism, such as a standard form to proposals, through which the Commission could assist Member Countries in developing Sanctuary Proposals, if the Commission would welcome such a mechanism. This mechanism would in particular include identifying the objectives of the sanctuary and establishing a scientific monitoring programme that allows evaluation of these objectives.

It was **agreed** that an intersessional Steering Group be formed to make progress on the above tasks before the meeting in 2003, giving priority to items 1 and 2. It was **agreed** that the Steering Group would comprise Zerbini (Convener), Bjørge, Butterworth, Childerhouse, Donovan, Kell, Koch, Leaper, Manzanilla, Morishita and Thiele.

10. ADOPTION OF THE REPORT

The meeting thanked the Chair, the rapporteurs and the conveners of the sub-groups. The report was adopted at 19:45 on 7 May 2002.

REFERENCES

- Anonymous. 1979. The Seychelles Initiative. Paper IWC/31/6 presented to the International Whaling Commission, July 1979 (unpublished). [Paper available from the Office of this Journal].
- Baldwin, R.M. 1997. *Whales and Dolphins of Oman*. Ministry of Regional Municipalities and Environment, PO Box 323, Muscat 113, Sultanate of Oman. 34pp.
- Baldwin, R. 1998. A note on sightings of sperm whales off the coasts of the Sultanate of Oman and the United Arab Emirates, October 1994-October 1997. Paper SC/50/CAWS22 presented to the IWC Scientific Committee, April 1998 (unpublished). [Paper available from the Office of this Journal].
- Ballance, L.T. and Pitman, R.L. 1998. Cetaceans of the Western Tropical Indian Ocean: distribution, relative abundance, and comparisons with cetacean communities of two other tropical ecosystems. *Mar. Mammal Sci.* 14(3):429-59.
- Ballance, L.T., Anderson, R.C., Pitman, R.L., Stafford, K., Shaan, A., Waheed, Z. and Brownell, R.L. 2001. Cetacean sightings around the Republic of the Maldives, April 2001. *J. Cetacean Res. Manage.* 3(2):213-8.
- Bannister, J. 2001. Status of southern right whales (*Eubalaena australis*) off Australia. *J. Cetacean Res. Manage.* (special issue) 2:103-10.
- Bannister, J.L. and Hedley, S.L. 2001. Southern Hemisphere group IV humpback whales: their status from recent aerial survey. *Mem. Queensl. Mus.* 47(2):587-98.
- Bannister, J.L., Taylor, S. and Sutherland, H. 1981. Logbook records of 19th Century American sperm whaling: a report on the 12 month project, 1978-79. *Rep. int. Whal. Commn* 31:821-35.
- Barnes, R.H. 1991. Indigenous whaling and porpoise hunting in Indonesia. pp. 99-106. In: S. Leatherwood and G.P. Donovan (eds.) *Marine Mammal Technical Report. 3. Cetaceans and Cetacean Research in the Indian Ocean Sanctuary*. United Nations Environment Programme, Nairobi, Kenya. viii+287.
- Best, P. 1998. Blue whales off Namibia — a possible wintering ground for the Antarctic population. Paper SC/50/CAWS14 presented to the IWC Scientific Committee, April 1998 (unpublished). [Paper available from the Office of this Journal].
- Best, P.B., Butterworth, D.S. and Rickett, L.H. 1984. An assessment cruise for the South African inshore stock of Bryde's whales (*Balaenoptera edeni*). *Rep. int. Whal. Commn* 34:403-23.
- Best, P.B., Sekiguchi, K., Rakotonirina, B. and Rossouw, A. 1996. The distribution and abundance of humpback whales off southern Madagascar, August-September 1994. *Rep. int. Whal. Commn* 46:323-31.

- Best, P.B., Brandão, A. and Butterworth, D.S. 2001. Demographic parameters of southern right whales off South Africa. *J. Cetacean Res. Manage.* (special issue) 2:161-9.
- Best, P.B., Rademeyer, R.A., Burton, C., Ljungblad, D., Sekiguchi, K., Shimada, H., Thiele, D., Reeb, D. and Butterworth, D.S. 2003. The abundance of blue whales on the Madagascar Plateau, December 1996. *J. Cetacean Res. Manage.* [Accepted].
- Branch, T.A. and Butterworth, D.S. 2001. Southern Hemisphere minke whales: standardised abundance estimates from the 1978/79 to 1997/98 IDCR-SOWER surveys. *J. Cetacean Res. Manage.* 3(2):143-74.
- Burt, M.L. and Stahl, D. 2001. Minke whale abundance estimation from the 1998/99 IWC-SOWER Antarctic Cruise in Area IV. Paper SC/53/IA3 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal]. [Plus 10pp. Errata].
- Cockcroft, V.G., Ross, G.J.B. and Peddemors, V.M. 1990. Bottlenose dolphin *Tursiops truncatus* distribution in Natal's coastal waters. *S. Afr. J. mar. Sci.* 9:1-10.
- Cockcroft, V.G., Ross, G.J.B. and Peddemors, V.M. 1991. Distribution and status of bottlenose dolphin *Tursiops truncatus* on the south coast of Natal, South Africa. *S. Afr. J. mar. Sci.* 11:203-9.
- Cockcroft, V.G., Ross, G.J.B., Peddemors, V.M. and Borchers, D. 1992. Estimates of density and undercounting of bottlenose dolphins off northern Natal, South Africa. *S. Afr. J. Wildl. Res.* 22:102-9.
- Corbett, H.D. 1994. The occurrence of cetaceans off Mauritius and in adjacent waters. *Rep. int. Whal. Commn* 44:393-8.
- De Boer, M.N., Eyre, L., Jenner, M.-N.M., Keith, S.G., McCabe, K.A., Parsons, E.C.M., Rosenbaum, H.C., Rudolph, P. and Simmonds, M. 2001. Cetaceans in the Indian Ocean: a preliminary review. Paper SC/53/O6 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- Findlay, K.P. and Best, P.B. 1996. Estimates of the numbers of humpback whales observed migrating past Cape Vidal, South Africa, 1988-1991. *Mar. Mammal Sci.* 12(3):354-70.
- Gordon, J.C.D. 1991. The World Wildlife Fund's Indian Ocean sperm whale project: an example of cetacean research within the Indian Ocean Sanctuary. *UNEP Mar. Mamm. Tech. Rep.* 3:219-39.
- Government of Brazil. 2001. A South Atlantic whale sanctuary. Paper IWC/53/7 presented to the IWC 53rd Annual Meeting, July 2001, London (unpublished). [Paper available from the Office of this Journal].
- International Whaling Commission. 1979a. Chairman's Report of the Thirtieth Annual Meeting. *Rep. int. Whal. Commn* 29:21-37.
- International Whaling Commission. 1979b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 29:38-105.
- International Whaling Commission. 1980a. Chairman's Report of the Thirty-First Annual Meeting. *Rep. int. Whal. Commn* 30:25-41.
- International Whaling Commission. 1980b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 30:42-137.
- International Whaling Commission. 1981a. Chairman's Report of the Thirty-Second Annual Meeting. *Rep. int. Whal. Commn* 31:17-40.
- International Whaling Commission. 1981b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 31:51-165.
- International Whaling Commission. 1982a. Chairman's Report of the Thirty-Third Annual Meeting. *Rep. int. Whal. Commn* 32:17-42.
- International Whaling Commission. 1982b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 32:43-149.
- International Whaling Commission. 1982c. Report of the Scientific Committee. Annex L. Report of the sub-committee on research on cetaceans in the Indian Ocean sanctuary. *Rep. int. Whal. Commn* 32:132-5.
- International Whaling Commission. 1983a. Chairman's Report of the Thirty-Fourth Annual Meeting. *Rep. int. Whal. Commn* 33:20-42.
- International Whaling Commission. 1983b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 33:43-190.
- International Whaling Commission. 1984. Report of the Scientific Committee. *Rep. int. Whal. Commn* 34:35-181.
- International Whaling Commission. 1986. Report of the Scientific Committee. *Rep. int. Whal. Commn* 36:30-140.
- International Whaling Commission. 1994. Report of the Scientific Committee, Annex F. Report of the sub-committee on small cetaceans. *Rep. int. Whal. Commn* 44:108-19.
- International Whaling Commission. 2001. Report of the Workshop on the Comprehensive Assessment of Right Whales: A worldwide comparison. *J. Cetacean Res. Manage.* (special issue) 2:1-60.
- International Whaling Commission. 2002a. Chair's Report of the 53rd Annual Meeting. Annex E. Instructions from the Commission to Scientific Committee for Reviews of Sanctuaries. *Ann. Rep. Int. Whaling Comm.* 2001:65.
- International Whaling Commission. 2002b. Report of the Scientific Committee. *J. Cetacean Res. Manage. (Suppl.)* 4:1-78.
- Jenner, K.C.S. and Jenner, M.-N. 1994. A preliminary population estimate of the group IV breeding stock of humpback whales off western Australia. *Rep. int. Whal. Commn* 44:303-8.
- Kasuya, T. and Wada, S. 1991. Distribution of large cetaceans in the Indian Ocean: data from Japanese sightings records, November-March. *UNEP Mar. Mamm. Tech. Rep.* 3:139-70.
- Leatherwood, S. and Donovan, G.P. (eds.). 1991. *Marine Mammal Technical Report. No. 3. Cetaceans and Cetacean Research in the Indian Ocean Sanctuary.* 1st Edn. UN Environment Programme, Nairobi. vii+287pp.
- Rice, D.W. 1998. *Marine Mammals of the World. Systematics and Distribution.* Special Publication No. 4. The Society for Marine Mammology, Lawrence, Kansas. 231pp.
- Robineau, D. 1991. Balaenopterid sightings in the western tropical Indian Ocean (Seychelles area), 1982-1986. pp. 171-8. In: S. Leatherwood and G.P. Donovan (eds.) *Marine Mammal Technical Report 3. Cetaceans and Cetacean Research in the Indian Ocean Sanctuary.* United Nations Environment Programme, Nairobi, Kenya. viii+287pp.
- Rosenbaum, H.C., Razafindrakoto, Y., Ersts, P. and Ventresca, G. 2000. A preliminary population estimate for humpback whales from the Antongil Bay, Madagascar wintering ground in the southwestern Indian Ocean. Paper SC/52/IA10 presented to the IWC Scientific Committee, June 2000, Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].
- Tynan, C. 1996. Characterization of oceanographic habitat of cetaceans in the southern Indian Ocean between 82°-115°E: cruise report from World Ocean Circulation Experiment (WOCE) 18S and 19S. NOAA Technical Memorandum NMFS-AFSC-64. US Department of Commerce, Seattle, WA. 53pp.
- Tynan, C. 1997. Cetacean distributions and oceanographic features near the Kerguelan Plateau. *Geophys. Res. Lett.* 24(22):2793-6.
- Wray, P. and Martin, K.R. 1983. Historical whaling records from the western Indian Ocean. *Rep. int. Whal. Commn* (special issue) 5:213-41.
- Yablokov, A.V. 1994. Validity of whaling data. *Nature, Lond.* 367(6459):108.
- Yuan, X. and Martinson, D.G. 2000. Antarctic sea ice extent variability and its global connectivity. *Journal of Climate* 13:1697-717.

Appendix 1

AGENDA

1. Opening remarks
2. Appointment of the rapporteurs
3. Review of available documents
4. Adoption of the agenda
5. Review of the IOS
 - 5.1 Review of documents
 - 5.2 Review of the objectives of the Sanctuary

5.2.1 Objectives of the IOS – Evaluation criteria 5.3 Review of large whale research developed in the IOS and its implications for the work of the Scientific Committee and the Comprehensive Assessment of Whale Stocks (CAWS) 5.3.1 Research in the IOS – Evaluation criteria 5.3.2 The IOS and the Comprehensive Assessment of Whale Stocks – Evaluation criteria 5.4 Review of the IOS based on the Instructions provided by the Commission in 2001	5.5 Recommendations for the IOS 6. Comments/recommendations concerning the Instructions from the Commission for Reviews of Sanctuaries and Sanctuary Proposals 7. South Pacific Sanctuary Proposal 8. Other sanctuaries 9. Future work 10. Adoption of the report

Appendix 2

A NOTE ON THE DECISION NOT TO CONSIDER SMALL CETACEAN DATA RELATED TO THE INDIAN OCEAN SANCTUARY REVIEW

R. Brownell, S. Childerhouse, P. Deimer, M. Iniguez, H. Oosthuizen, J. Palazzo, V. Peddemors,
M. Simmonds and K. Van Waerebeek

The IOS Working Group was advised by its Chair that, according to instructions given by the Chair of the Scientific Committee, focus should be directed to ‘large whales’, while reviewing the IOS.

We respectfully disagree and regard this decision as unfortunate. There are many issues related to ‘small cetaceans’ and their environment that apply equally to the species arbitrarily defined as ‘large whales’; the exclusion of such information from a scientific review prevents the discussion of important aspects of the Sanctuary and its proper assessment.

Moreover, the Scientific Committee itself, in addressing the issue of appropriate research related to the IOS, stated *inter alia* that ‘it should provide sufficient information to assess stocks of large whales and small cetaceans’ (IWC, 1982, p.132).

We are also concerned that the instructions regarding this matter prejudice the position of several Contracting Governments regarding the taxonomic coverage of the IWC regulatory mandate, and this unnecessarily imports a political debate into the Committee. The Committee has in the past agreed that ‘small cetaceans’ can be discussed and reviewed in a science-only basis and we would welcome the continuation of this interpretation in the future.

REFERENCE

International Whaling Commission. 1982. Report of the Scientific Committee. Annex L. Report of the sub-committee on research on cetaceans in the Indian Ocean sanctuary. *Rep. int. Whal. Commn* 32:132-5.

Appendix 3

PROPOSED PROCEDURES TO REVIEW THE INDIAN OCEAN SANCTUARY

Members: Zerbini (Chair), Bjørge, Butterworth, Childerhouse, Donovan, Kell, Kock, Morishita and Thiele

INTRODUCTION

This paper is presented in order to provide the IWC SC with proposed criteria to evaluate the scientific objectives of the Indian Ocean Sanctuary (IOS) both in their content and whether they have been addressed and/or achieved. The review should focus primarily on the large whales stocks¹ inhabiting the Indian Ocean.

History

The IOS (Fig. 1) was proposed by the Government of

Seychelles (Anon., 1979) and adopted by the IWC in 1979 (IWC, 1980a, p.27)

in accordance with Article V(1) (c) of the Convention, commercial whaling, whether by pelagic operations or from land stations, is prohibited in a region designated as the Indian Ocean Sanctuary. This comprises the waters of the Northern Hemisphere from the coast of Africa to 100° East, including the Red and Arabian Seas and the Gulf of Oman and the waters of the Southern Hemisphere in the sector from 20° East to 130° East, with the Southern boundary set at 55° South. This prohibition applies irrespective of the classifications of baleen or toothed whale stocks in the sanctuary, as may from time to time be determined by the Commission. This prohibition will apply for ten years, with the provision for a general review after five years, unless the Commission decides otherwise.

From 1981 to 1985, three meetings were held to consider research relevant to the IOS. A workshop was convened in Zeist, Netherlands, in September/October 1981 to plan a Programme of Scientific Research on Cetaceans in the IOS. The workshop agreed on a series of objectives for a research programme in the Sanctuary (see below). The workshop also identified 24 projects that would contribute to meet these objectives (Leatherwood and Donovan, 1991, pp.22-24). At that time, some were already implemented or partially

¹ In this document, the term ‘stock’ refers to the management areas and divisions as classified in the Schedule of the International Convention for the Regulation of Whaling.

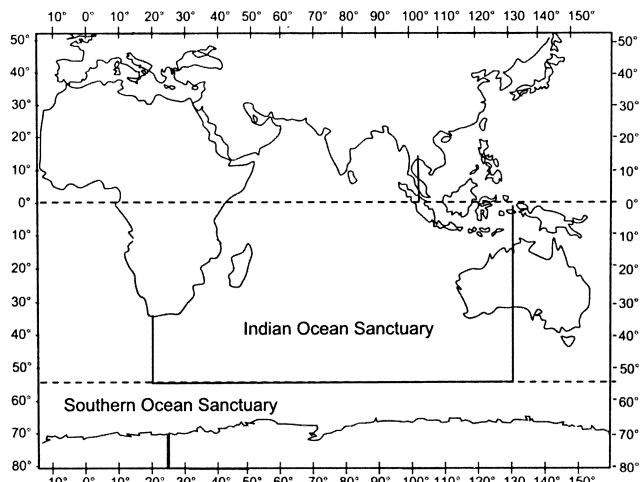


Fig. 1. Boundaries of the Indian Ocean Sanctuary.

implemented and others were waiting for funding to become available.

An International Conference on Conservation and Management of Marine Mammals was held in Colombo, Sri Lanka, in February 1983. Many recommendations were related to some of the proposals of the Zeist Workshop and were thought to be feasible for many Indian Ocean coastal states. Another meeting, a Symposium on Endangered Marine Animals and Marine Parks was held in Cochin, India, from 12-16 January 1985. No recommendations were made, although papers relevant to scientific work in the IOS were presented (Leatherwood and Donovan, 1991).

From 24-28 February 1987, a meeting was held in Anse aux Pins, Seychelles to review the IOS, in particular the scientific component of the review process. The report of this meeting was published by the United Nations Environment Programme (UNEP) as a Technical Report (Leatherwood and Donovan, 1991). Relevant aspects of this meeting were:

- (1) a review of past research and its main results;
- (2) an evaluation of the impact of the existence of the Sanctuary on research;
- (3) a discussion of the scientific aspects of the effectiveness of the Sanctuary in meeting the objectives of the Commission;
- (4) a discussion of the scientific contribution of the sanctuary to the comprehensive assessment of whale stocks and the cetacean component of the (UNEP) global action plan for marine mammals;
- (5) an evaluation of the present boundaries of the IOS and suggestions for change;
- (6) the identification of possible sub-areas within the IOS for special purposes;
- (7) future research and management actions in the IOS.

In 1989 the IOS was extended for three years (IWC, 1990, pp.21-22), and for a further ten years in 1992, when the IWC agreed that it should be reviewed by the Commission at its Annual Meeting in 2002 (IWC, 1993, p.27).

The current Schedule text states,

In accordance with Article V(1)(c) of the Convention, commercial whaling, whether by pelagic operations or from land stations, is prohibited in a region designated as the Indian Ocean Sanctuary. This comprises the waters of the Northern Hemisphere from the coast of Africa to 100°E, including the Red and Arabian Seas and the Gulf of Oman; and the waters of the Southern Hemisphere in the sector from 20°E to 130°E, with the Southern boundary set at 55°S. The

prohibition applies irrespective of such catch limits for baleen or toothed whales as may from time to time be determined by the Commission. This prohibition shall be reviewed by the Commission at its Annual Meeting in 2002.

Species and stocks affected by the IOS

Large whales from a total of 25 stocks inhabit the IOS. Stocks of migratory species (blue, fin, sei, Antarctic minke, common minke, humpback and right whales) are present in the IOS during their breeding season. The Southern Ocean Sanctuary (SOS) provides additional protection of some stocks in the feeding grounds. A substantial component of the sei and right whale stocks are believed also to feed within the IOS boundaries, although some animals may be found further south. The geographic boundaries of the Indian Ocean stock of Bryde's whales overlaps with the IOS limits, while just part of the South African coastal stock range is found within the IOS. Finally, three sperm whale stocks (divisions) are found in the Sanctuary. Juveniles and females occur in tropical and sub-tropical waters while mature males migrate in and out the IOS, towards higher latitudes.

Annex N, table 1 summarises stocks totally or partially encompassed by the IOS and provides information on the seasonal occurrence of each stock, population size estimates and trends in abundance, if available. Figs 2-5 illustrate the geographic distribution of each stock in the Indian Ocean.

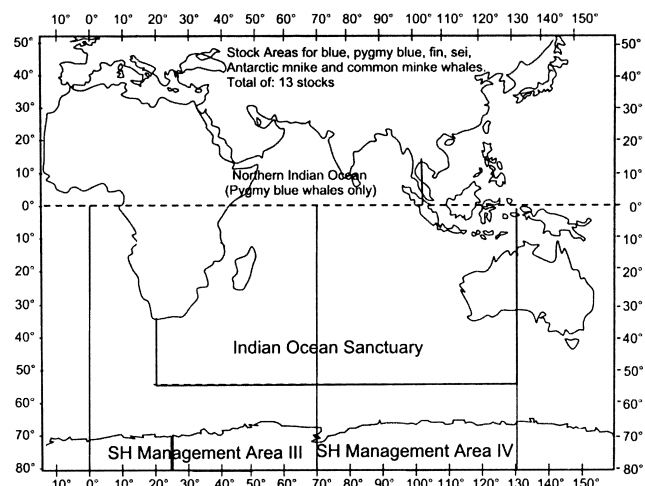


Fig. 2. IWC Management Areas for migratory *Balaenoptera* whales in the Indian Ocean.

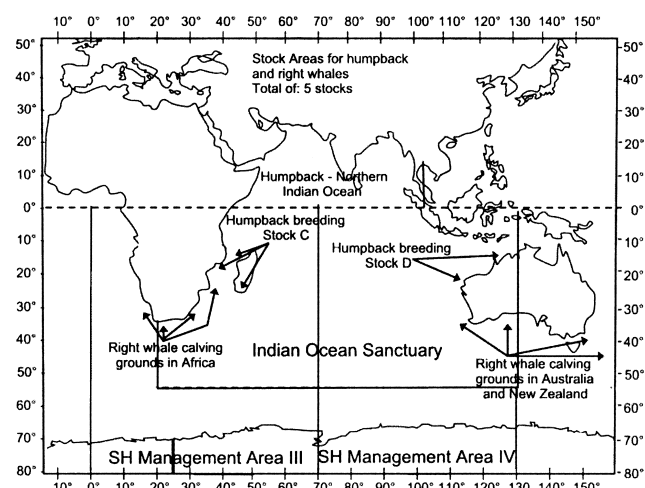


Fig. 3. IWC Management Areas and breeding stocks of humpback and right whales in the Indian Ocean.

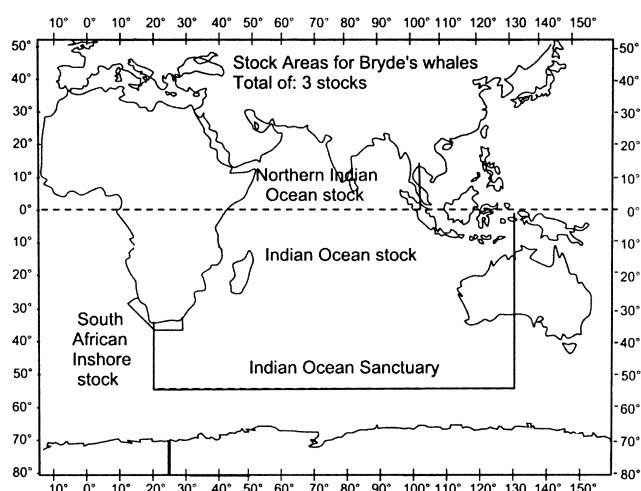


Fig. 4. IWC Management Areas for Bryde's whales in the Indian Ocean.

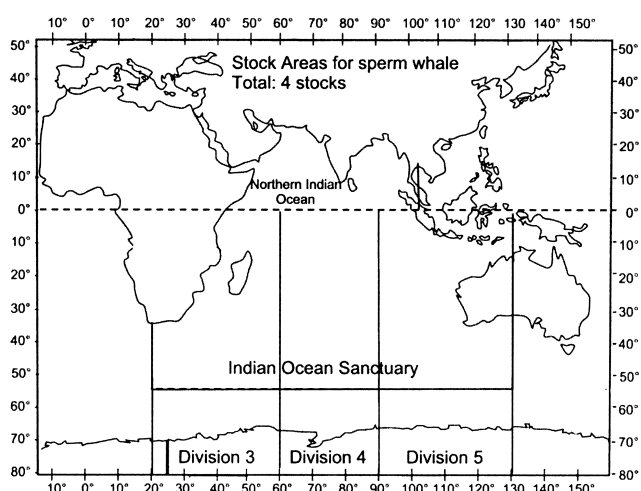


Fig. 5. IWC Management Divisions for sperm whales in the Indian Ocean.

EVALUATION CRITERIA AND REVIEW PROCESS

In order to evaluate whether the scientific objectives of the IOS were achieved, this document proposes that the following aspects be considered.

(1) Objectives of the IOS

While the IOS was established in 1979, the IWC did not agree on a list of objectives for the Sanctuary. In 1987, a workshop was held in Anse aux Pins, Seychelles, with the purpose of reviewing the IOS, in particular the scientific components of the review process (Leatherwood and Donovan, 1991). Several 'objectives' were listed based on the document provided by the Government of Seychelles (Anon., 1979) and discussion of the Sanctuary as reflected in the Chairman's and in the IWC Scientific Committee reports (IWC, 1979a; b; 1980a; b; 1981a; b; 1982a; b; 1983a; b; 1984; 1986). These were (Leatherwood and Donovan, 1991)²:

- (1) The Sanctuary should provide an ecologically coherent area where whale populations are protected from whaling for a specified period, avoiding the possibility

² The IWC did not comment on the scientific objectives derived at the Seychelles meeting.

of stocks being alternately exploited and protected in the short term as a result of small changes in assessments.

- (2) In terms of appropriate research, the IWC Scientific Committee (IWC, 1982c) stated that:
 - (a) it should provide sufficient information to assess stocks of large whales and small cetaceans;
 - (b) it should permit direct comparison of the status of species and/or populations protected by the Sanctuary provision and exploited or unexploited stocks of the same species in other areas;
 - (c) the opportunity should be taken to carry out relevant investigation of certain kinds, which would be impossible or more difficult to undertake in areas where whaling continues.

Evaluation criteria

- (1) Evaluate whether whales were and are effectively protected from whaling within the Sanctuary.
- (2) Evaluate whether the boundaries of the Sanctuary were appropriately established.
- (3) Evaluate if the IOS has provided 'sufficient' information to reliably assess³ stocks of large whales.
- (4) Evaluate if the IOS has permitted direct comparison of species/stocks within the Sanctuary with (i) exploited and (ii) unexploited stocks outside the Sanctuary.
- (5) Identify what kind of investigations were carried out in the Sanctuary, which were more difficult to undertake in areas where whaling continued.

(2) Research in the IOS

Research in the IOS was reviewed by the SC, which considered three main headings in which research could be implemented in the Sanctuary: open ocean research on large whales; research on large whales by coastal states; and examination of other sources of information. Although the SC was not able to formulate specific proposals within those headings, it identified sources of relevant information: incidental takes, strandings, systematic sightings, historical records, observations of whales from platforms of opportunity, research catches and captive animals.

During the workshop convened in Zeist in September/October 1981⁴, the SC proposals were reviewed and three main conclusions were reached (Leatherwood and Donovan, 1991): a proposed five-year time constraint for estimating population sizes was unrealistic; research within the IOS should be coordinated with research in adjacent areas; the IWC's ability to identify and assess whale populations' status, ecological roles and vulnerability to human activities would be enhanced by information obtained from research carried out in the area (undisturbed by whaling for a substantial period of time). The Zeist workshop prepared its own list of research objectives within the IOS, some of which would satisfy the SC needs in obtaining information for assessment-related matters.

The Zeist workshop objectives were:

- (1) to satisfy the needs of the IWC Scientific Committee particularly in obtaining adequate information about the distribution and abundance of whales, their reproductive behaviour and related matters relevant to assessment of stocks;
- (2) to obtain scientific information pertinent to assessing and realising the economic, cultural and scientific values of living cetaceans;

³ The term 'assess' refers to such matters as stock identity, abundance (and trends in abundance), status and production.

⁴ The Zeist workshop was sponsored by the Governments of Seychelles and the Netherlands with support from the IWC, IUCN and WWF.

- (3) to enhance the understanding of the ecological roles of cetaceans in marine biological systems and to permit assessment of the impact of human activities on recovering and unexploited populations;
- (4) to focus attention on the development and application of benign research techniques;
- (5) to foster investigations on the frontiers of research on living cetaceans, such as communication, navigation, behaviour and physiology of diving;
- (6) to ensure the establishment of centres of research on cetaceans in the Indian Ocean and to further communication about cetacean research among Indian Ocean coastal states and between them and others involved in such research.

In addition, the workshop identified 24 projects that were expected to contribute to meet these objectives (Leatherwood and Donovan, 1991, pp.22-24). Some were already implemented or partially implemented and others were waiting for funding to become available. The Seychelles meeting agreed that this list of projects constituted a research framework within which many of the SC (and the Commission) research needs could have been met.

Evaluation criteria

- (1) The objectives listed above could be addressed with or without the existence of a sanctuary. The SC should evaluate the extent to which the establishment of the IOS furthered the achievement of these objectives.
- (2) Briefly assess the past and present status and results of the 24 projects identified by the Zeist workshop and how they contributed to the research needs of the SC.
- (3) List other projects developed within the IOS and how they contributed to meet the research needs of the SC.

The Zeist workshop also recognised that one research area that required attention had not been implemented: the establishment of a stranding network. The meeting noted the value of such networks and the usefulness in stimulating public and scientific interest in areas where the knowledge of cetaceans is very limited. A sub-group was set up to discuss practical ways of implementing such networks.

- (4) Evaluate the progress in implementing the stranding network in the IOS.

(3) The IOS and the Comprehensive Assessment of Whale Stocks

The Seychelles meeting noted that many of the projects focusing on large whales listed in by the Zeist workshop would be of direct relevance for the Comprehensive Assessment of Whale Stocks (CAWS). The meeting also recognised that a long-term sanctuary has a unique and essential scientific role in managing whale stocks for sustainable exploitation, under the assumption that whaling will resume sometime in the future outside the sanctuary.

Evaluation criteria

- (1) Evaluate past and current data on abundance estimates and trends for whale stocks within the IOS.
- (2) Evaluate progress in stock identification since the IOS was created.
- (3) Evaluate progress in the estimation of demographic parameters and vital rates since the IOS was created.
- (4) List and evaluate the results of projects focused on the development of calibration and assessment methods.
- (5) Evaluate the effectiveness of whale stock monitoring programmes and how they contributed to the CAWS.

(4) Instructions from the Commission for Reviewing Sanctuaries and Sanctuary Proposals

During the 53rd Meeting of the IWC, the Commission prepared instructions for reviewing sanctuaries and sanctuary proposals. Both general and specific instructions were provided and the current review of the IOS should take these into account (IWC, 2002).

As a general recommendation to review existing Sanctuaries the Commission proposed:

- (1) Give attention to assessing how well the scientific aspects of the agreed objectives of the Sanctuary have been met and how well they might be met if the Sanctuary continues.

As specific instructions the Commission listed:

- (2) Provide advice on the status and trends of whale stocks in the Sanctuary.
- (3) Assess whether the Sanctuary distinguishes between species and stocks depleted and apparently slow to recover, those rapidly recovering and those abundant and not threatened.
- (4) Assess present and potential threats to whale stocks and their habitats in the area of the Sanctuary, including: whaling; fishing (including bycatch); oil and gas exploration (including seismic surveys); shipping; whalewatching; climate change; other environmental factors.
- (5) Consider the relationship of the Sanctuary with other existing measures to protect whales from anthropogenic and environmental factors.
- (6) Assess the anticipated effects of the proposed sanctuary in terms of:
 - (a) improving protection of whales, in the breeding areas, feeding grounds and/or migratory routes;
 - (b) improving the conservation of breeding sites, migratory routes and/or feeding grounds; and
 - (c) complementing existing or potential protection including the Commission's current management regime and regional and international agreements concerning biodiversity and conservation of nature.
- (7) Provide advice on whether the boundaries of the sanctuary are ecologically appropriate.
- (8) Provide advice on whether the sanctuary addresses the issues of critical and non-critical whale habitat.
- (9) Evaluate whether a sanctuary may contribute to or impede the conduct of scientific research useful for meeting IWC objectives and facilitate coordinated and integrated research and monitoring programmes.
- (10) Provide advice on whether a sanctuary is consistent with the precautionary approach.

(5) Conclusions and Recommendations

The implications of the IOS to the conservation and sustainable use of whales depends on the management regime adopted by the Commission in the years to come. Future decisions on the RMP/moratorium may require a re-evaluation of the role of the sanctuaries in the Commission's management strategy. In addition to its review of the IOS at this meeting the Working Group may also wish to prepare a list of recommendations to the Commission. This might include consideration of: (1) an

adaptive management experiment; and (2) an agreed research plan on stock identity, abundance, trends in abundance for the large whales stocks.

REFERENCES

- Anonymous. 1979. The Seychelles Initiative. Paper IWC/31/6 presented to the International Whaling Commission, July 1979 (unpublished). [Paper available from the Office of this Journal.]
- International Whaling Commission. 1979a. Chairman's Report of the Thirtieth Annual Meeting. *Rep. int. Whal. Commn* 29:21-37.
- International Whaling Commission. 1979b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 29:38-105.
- International Whaling Commission. 1980a. Chairman's Report of the Thirty-First Annual Meeting. *Rep. int. Whal. Commn* 30:25-41.
- International Whaling Commission. 1980b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 30:42-137.
- International Whaling Commission. 1981a. Chairman's Report of the Thirty-Second Annual Meeting. *Rep. int. Whal. Commn* 31:17-40.
- International Whaling Commission. 1981b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 31:51-165.
- International Whaling Commission. 1982a. Chairman's Report of the Thirty-Third Annual Meeting. *Rep. int. Whal. Commn* 32:17-42.
- International Whaling Commission. 1982b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 32:43-149.
- International Whaling Commission. 1982c. Report of the Scientific Committee. Annex L. Report of the sub-committee on research on cetaceans in the Indian Ocean sanctuary. *Rep. int. Whal. Commn* 32:132-5.
- International Whaling Commission. 1983a. Chairman's Report of the Thirty-Fourth Annual Meeting. *Rep. int. Whal. Commn* 33:20-42.
- International Whaling Commission. 1983b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 33:43-190.
- International Whaling Commission. 1984. Report of the Scientific Committee. *Rep. int. Whal. Commn* 34:35-181.
- International Whaling Commission. 1986. Report of the Scientific Committee. *Rep. int. Whal. Commn* 36:30-140.
- International Whaling Commission. 1990. Chairman's Report of the Forty-First Annual Meeting. *Rep. int. Whal. Commn* 40:11-37.
- International Whaling Commission. 1993. Chairman's Report of the Forty-Fourth Annual Meeting. *Rep. int. Whal. Commn* 43:11-53.
- International Whaling Commission. 2002. Chair's Report of the 53rd Annual Meeting. Annex E. Instructions from the Commission to Scientific Committee for Reviews of Sanctuaries. *Ann. Rep. Int. Whaling Comm.* 2001:65.
- Leatherwood, S. and Donovan, G.P. (eds.). 1991. *Marine Mammal Technical Report*. No. 3. *Cetaceans and Cetacean Research in the Indian Ocean Sanctuary*. 1st Edn. UN Environment Programme, Nairobi. vii+287pp.

Appendix 4

REPORT OF SUB-GROUP A

INTRODUCTION

It is generally acknowledged that sanctuaries or marine protected areas can serve a useful conservation purpose by providing protection of critical habitat or a refuge for utilised resources as part of a sustainable management regime. For this purpose however it is important that a sanctuary be defined by ecologically appropriate boundaries, that it apply to species subject to management and utilisation and that its duration reflects conservation needs.

In the context of the conservation and management of living resources, a sanctuary means a limited land or sea area where harvesting activities of the resource is prohibited in order to achieve sustainable utilisation of the resource outside the area. This area is expected to provide a 'refuge' for a certain part of the migration, distribution, and/or life stage of the resource so that the resource is not over-harvested. In the context of utilised resources, conservation measures that are totally prohibitive over a large area when the status of stocks allows for sustainable utilisation or when a management regime in effect is sufficiently precautionary can not be scientifically justified and negate the principle of sustainable utilisation. This is in fact the situation with the IOS.

APPROPRIATENESS OF IOS BOUNDARIES

Boundaries of the IOS were established simply to cover as wide an area as possible without regard to ecological principles or specific conservation needs for whale stocks. The boundaries of the IOS neither cover the entire range of large whale stocks that migrate through or into the area nor are they limited to critical habitats for these species. For this reason, the IOS boundaries are not ecologically appropriate and are not consistent with the common concept of a sanctuary.

DURATION OF THE IOS

It has now been more than 20 years since the establishment of the IOS and the prohibition of commercial whaling within its boundaries. Since that time, the perceived conditions concerning status of whale stocks and the need for a prohibition on whaling over a large area that were used to justify its establishment are likely to have changed significantly. Although such changes have not been assessed, none of the species that occur in the area are in fact present candidates for commercial catch quotas. Nor will they become candidates until they have been assessed, sustainable catch limits established, and quotas set under the RMS. Under these conditions, scientific justification does not exist for maintaining the IOS.

DOES THE IOS MEET THE STATED OBJECTIVES AND IS IT A USEFUL CONSERVATION MEASURE?

In the Instructions from the Commission to the Scientific Committee for Reviews of Sanctuaries and Sanctuary Proposals (IWC, 2002), the SC was requested to 'give primary attention to assessing how well the scientific aspects of the agreed objectives of the sanctuary have been met'.

Because the original IOS proposal did not specify its objectives and the Commission itself has not formally agreed on objectives for the IOS, the following scientific objectives have been gleaned by some from IWC documents. Our evaluation of how the IOS meets or does not meet these objectives also follows.

- (1) The Sanctuary should provide an ecologically coherent area where whale populations are protected from whaling for a specified period, avoiding the possibility of stocks being alternately exploited and protected in the short term as a result of small changes in assessments.

This 'objective' can be interpreted in many different ways. However, under any interpretation, the current IOS is irrelevant as a conservation measure because the moratorium for commercial whaling has been in place worldwide since 1986. Since the moratorium applies to all waters where whaling is conducted, an 'ecologically coherent area' has no meaning. Similarly, a 'specified period' is losing its meaning in the context of the moratorium. Consequently, the IOS is playing no conservation role and is not required to 'avoid the possibility of stocks being alternately exploited and protected ...'.

(2) In terms of appropriate research, the Scientific Committee (IWC, 1982) stated that:

- (a) It should provide sufficient information to assess stocks of large whales and small cetaceans. Research in the IOS has not provided sufficient information to assess stocks of large whales. No extensive sighting survey, for example, has been conducted in the area since the establishment of the IOS. In fact, the establishment of the IOS has removed any incentive for such research.
- (b) It should permit direct comparison of the status of species and/or populations protected by the Sanctuary provision and exploited or unexploited stocks of the same species in other areas. It is impossible to conduct a comparison of stock status between inside and outside of the IOS because of the presence of the moratorium. Protection status of a whale species does not change across the boundary of the IOS.

- (c) The opportunity should be taken to carry out relevant investigation of certain kinds which would be impossible or more difficult to undertake in areas where whaling continues.

Again, under the moratorium on commercial whaling, 'investigation of certain kinds which would be impossible or more difficult to undertake in areas where whaling continues', is meaningless.

Evaluation of the IOS also requires consideration of whether or not it serves as a useful conservation measure irrespective of its objectives. In this regard and as noted above, the IOS was adopted before the moratorium on commercial whaling which has made the IOS redundant. In addition, the IOS was adopted prior to the development of the risk averse RMP so that even when the moratorium is no longer in place, there will be no threat to whale stocks from commercial whaling. This fact makes the IOS twice redundant meaning that it clearly does not serve a useful or necessary conservation measure.

In conclusion, from a scientific point of view, continuation of the IOS cannot be justified.

REFERENCES

- International Whaling Commission. 1982. Report of the Scientific Committee. Annex L. Report of the sub-committee on research on cetaceans in the Indian Ocean sanctuary. *Rep. int. Whal. Commn* 32:132-5.
- International Whaling Commission. 2002. Chair's Report of the 53rd Annual Meeting. Annex E. Instructions from the Commission to Scientific Committee for Reviews of Sanctuaries. *Rep. int. Whal. Commn* 2001:65.

Appendix 5

REPORT OF SUB-GROUP B

The sub-group considered its term of reference to be to evaluate the existing Indian Ocean Sanctuary under the guidelines provided by the Commission (IWC, 2002), focussing in each case on the scientific dimension of the questions posed by the Commission in its guidelines. These include consideration of the appropriate boundaries as well as other issues.

GENERAL

Although the Sanctuary currently only provides direct protection to whales from commercial whaling, much of the research in the Sanctuary is aimed at the identification and assessment of other threats. The results of the research have importance for the development of national protective measures, and for the development of future regional and international measures (see section 4).

In evaluating the effect of the Sanctuary, a recurring difficulty is determining which of the research and other activities in the Sanctuary have taken place as a direct or indirect consequence of the Sanctuary designation, and which may have occurred regardless. However, many of the research activities in the region have been specifically conceived, funded or conducted in response to the Sanctuary

designation or regional initiatives arising therefrom (SC/54/O5 and see section 5).

The IOS coastal states are predominantly developing countries. Many of these countries face pressing problems resulting in cetacean research being given low priority. However, some countries are now coming into a position where there is potential for developing research projects.

One aspect that is worth noting is the increased attention being given to more general issues surrounding Marine Protected Areas. Not only are these becoming increasingly recognised as a valuable management tool in other fora, including fisheries management, but attention is also being given to quantitative assessment of their effectiveness. However, in relation to the life-history time-scale of the species it is designed to protect, the IOS is relatively young compared to many Marine Protected Areas, despite having been in place for over twenty years. In the context of marine protected areas there is considerable support for measures on the spatial scale of an ocean basin (e.g. Allison *et al.*, 1998).

It is also becoming increasingly apparent in all the endeavours of the SC that the time period required to reach an adequate assessment of something such as the effectiveness of a sanctuary is likely to be much longer than might have been anticipated a decade ago. As well as

reviewing how the scientific aspects of the objectives of the Sanctuary have been met, the SC is also tasked with reviewing how well these might be met if the Sanctuary continues. An alternative approach may be consideration of what opportunities might be lost from a scientific point of view if the Sanctuary was not continued. This needs to be done across a realistic time frame in relation to the longevity of the species protected, and the practicalities of marine research. This is difficult to predict but it is worth noting that the zero catch limit for whales in the Indian Ocean provides the longest time period (with no commercial whaling for seven years prior to the moratorium) to evaluate the effect of no commercial catches across an ocean basin.

It has been suggested (SC/54/O20) that the adoption of the moratorium has made the Sanctuary redundant, but the appropriate duration of a sanctuary of this kind depends on factors other than those determining the short-term management policy of the Commission. The moratorium is a temporary measure pending the adoption of a more satisfactory management procedure, whereas a sanctuary is a measure that applies independently of management in other areas. Temporary overlap in management measures does not invalidate the long-term scientific and conservation value of the Sanctuary.

SPECIFIC

(1) Provide advice on the status and trends of whale stocks in the (proposed) sanctuary in so far as these are known. Assess whether the sanctuary distinguishes between species and stocks that are depleted and apparently slow to recover, those that are increasing rapidly, and those that are abundant and not threatened

The status of stocks in the Sanctuary is summarised in table 1 of Annex N. The Sanctuary contains examples of:

- (a) populations which are depleted but known to be recovering;
- (b) populations which are depleted where the current trend is unknown;
- (c) populations such as minke whales, which are probably not depleted, but the current trend is under assessment by the Scientific Committee; and
- (d) populations which are probably not depleted but whose current trend is unknown.

The Sanctuary gives complete protection from commercial whaling to populations in all of the four categories listed above, but distinction between the categories can still be made for research and conservation purposes.

Assess the present and potential threats to whale stocks and their habitats in the area of the (proposed) sanctuary and how the (proposed) sanctuary addresses these. Such factors may include, inter alia:

(a) Whaling

Important considerations with regards to whaling are the revelations of the unreported Soviet catches in the Indian Ocean which occurred prior to the adoption of the Sanctuary but have been revealed since the Sanctuary was last reviewed in 1992. These catches are of particular concern because of the likelihood that some of these were taken from small isolated stocks and may have depleted these stocks substantially. In addition to catches within the Sanctuary area, unreported catches have also been revealed in the Southern Ocean from populations that are believed to

migrate into the Sanctuary. The SC has received new information on unreported catches each year but these still require further investigation and consideration of the implications.

Directed takes of large whales for subsistence purposes still occur from two communities, Lamalera and Lamakera, on the Indonesian islands of Lembata and Solor respectively.

(b) Fishing, including bycatch

Cetacean bycatch is known to occur in many fisheries in the Indian Ocean and is established as a significant concern for some stocks. Incidental takes are known to occur in coastal and high-seas fisheries and also expanding aquaculture facilities (e.g. interactions between humpback and right whales with pearl/oyster farms on the west coast of Australia). Although limited schemes to monitor bycatch exist in some countries, there are no estimates of bycatch for most Indian Ocean fisheries. However, for the southern areas of the Sanctuary that lie within the CCAMLR boundary a bycatch reporting scheme has been in place since 1984 and data on other operational interactions between cetaceans and fishing gear are collected. These include operational interactions between sperm whales and killer whales with long-line fisheries in the southern Indian Ocean (CCAMLR areas 58.6, 58.7, 58.5, 58.4.4). The Indian Ocean Tuna Commission has also initiated a research programme to study interactions between cetaceans and long-line fisheries.

(c) Oil and gas exploitation, including seismic surveys

Hydrocarbon exploration and production are known to have impacts on whales. These activities occur in many areas of the Indian Ocean with concentrated activity in areas such as NW Shelf of Australia, South Africa, Indonesia and Oman. A specific concern for stocks with a limited geographic range is the possibility of displacement for long periods of time during important feeding periods, as has been reported for some species. Since 1997, the Government of Oman has required that all seismic survey vessels off Oman have dedicated cetacean observers on board. A transregional feasibility study is currently underway to evaluate potential health effects due to exposure to hydrocarbon development using exposed and non-exposed populations of humpback whales in the Indian Ocean.

(d) Shipping

Collisions with vessels are an unmeasured cause of mortality but in areas of high shipping activity where areas of whale concentration and migration routes overlap (such as East Coast of US, Europe and Mediterranean) strandings records suggest that collisions form a substantial proportion of mortality in populations of several whale species. There are heavy shipping traffic lanes in many parts of the Indian Ocean (e.g. east coast South Africa, Indonesia, Oman), but levels of shipping vary considerably in the Indian Ocean. The average speed of large commercial vessels has increased in recent years and there is evidence that faster vessels may pose a higher risk. Increased military activity in the northern Indian Ocean may pose additional threats from shipping.

(e) Whalewatching

Responsible whalewatching can bring tremendous benefits to coastal communities and should not, if carefully designed, necessarily be considered a threat. The scientific issues related to whalewatching in the sanctuary include potential impacts on whales and the potential for research from

whalewatching platforms. Whalewatching is an important activity in several coastal states around the Indian Ocean. There is also potential for development in other areas that has not yet been realised.

(f) Climatic change

There are significant relationships in global climatological effects. For example, changes in sea ice in the Antarctic are highly correlated with sea surface temperatures in the tropical Indian Ocean. Populations of whales in the Indian Ocean will thus experience ecological consequences of climate forcing (e.g. ENSO) that transcend the Sanctuary boundaries. Whales north of the equator in the Indian Ocean may be more vulnerable to climate change than those in other regions because they have a limited distributional range and have no possibilities to shift to higher latitudes, e.g. Arabian Sea stocks of humpback and sperm whales.

(2) Assess the anticipated effects of the proposed sanctuary in terms of:

- (a) improving protection of whales, in breeding areas, feeding grounds and/or migratory routes;**
- (b) improving the conservation of breeding sites, migratory routes and/or feeding grounds; and**
- (c) complementing existing or potential protection including the Commission's current management regime and regional and international agreements concerning biodiversity and conservation of nature**

The Sanctuary provides protection for the breeding stocks of all Indian Ocean baleen whales although the precise locations of some of these breeding areas are still unknown. Available data suggest that some stocks of humpback whales and possibly blue, Bryde's and sperm whales are both feeding and breeding in the northern Indian Ocean. Because of the boundary at 55°S, feeding grounds of Bryde's and sei and part of the feeding grounds of Southern Hemisphere fin whales are protected. The main feeding grounds of southern right whales are believed to be within the Sanctuary. Southern Hemisphere blue whales, Antarctic minke whales and Southern Hemisphere humpback whales migrate outside the IOS area. Female and juvenile sperm whales are protected throughout their range. Some whales breeding outside the Sanctuary may move into the Sanctuary to feed, such as right whales off the west coast of South Africa. The issues of habitat protection have only recently been considered by the IWC and to date no international measures have been taken although whale habitat is specifically included in some national marine protected areas in the Indian Ocean.

Other international agreements that affect the conservation of whales include CCAMLR which requires that the management of fishing takes into account the needs of dependent species. The IOS provides protection to those dependent species during the part of the year for which they are outside the CCAMLR area. The Commission's Revised Management Scheme is still under development but it is envisaged that the RMS and sanctuaries would represent mutually complementary management measures.

(3) Provide advice on whether the proposed boundaries of the Sanctuary are ecologically appropriate

The current boundaries are simply defined in terms of latitude and longitude and include an ecologically coherent area with a land boundary, or island chain forming the majority of the eastern, western and northern boundaries. The majority of previous discussions regarding the boundary largely concentrated on the southern boundary. The original

proposal was for the entire Indian Ocean including the Southern Ocean sector, but for operational reasons this was revised to 55°S while recognising that this had only limited ecological significance. However, this is now contiguous with the northern boundary of the Southern Ocean Sanctuary (SOS) hence the southern boundary question is not critical at this time. However, it was agreed at the 1987 meeting in the Seychelles that extending the sanctuary to the Antarctic would enhance its ecological coherence and should the SOS provisions be changed in the future, it may be considered prudent to extend the southern boundary of the IOS to the Antarctic continent.

The current sanctuary boundaries provide opportunities for comparison of the potentially unique (in terms of genetics, behaviour and physiology) northern Indian Ocean whale stocks with southern Indian Ocean stocks across the same ocean basin.

Genetic, acoustic and satellite tagging studies are in progress to explore movements and stock structure for several species within the Indian Ocean (e.g. studies of humpback whales in SC/54/H4; SC/54/H20; Rosenbaum *et al.*, 2000).

(4) Provide advice on whether the sanctuary addresses the issue of critical habitat and non-critical whale habitat

Since the competence of the IWC to include habitat protection measures in its Schedule has not yet been established, the sanctuary provision *per se* contains no measures for habitat protection. Current understanding of critical habitat for whales is not sufficient to be confident that a substantially smaller area would include the critical habitat for all populations. In particular, many species are known to undertake long migrations. However, the Sanctuary is of sufficient size to encompass the complete habitat for some populations. Many research projects within the Sanctuary identify important areas of whale habitat, e.g. breeding and feeding grounds. Some areas have been identified which provide what is probably critical habitat for some stocks, e.g. the area of upwelling in the Arabian Sea, and the Antongil Bay, Madagascar breeding and calving ground (Rosenbaum *et al.*, 1997) which are probably critical habitat for humpback whales.

The Sanctuary is complemented by national measures protecting cetaceans, for example marine reserves in Australia, Indonesia, Oman and South Africa.

(5) Evaluate whether the Sanctuary may contribute to or impede the conduct of scientific research useful for meeting IWC objectives and facilitate coordinated and integrated research and monitoring programmes

SC/54/O5 summarised some of what is currently known about cetaceans in the IOS. Most of this information has come from data collected since the Sanctuary was adopted, especially since the 1992 review. An important consideration when considering the level of research in the Sanctuary is that the coastal states are predominantly developing countries. The increase in research effort since 1992 is partly a reflection of the increase in cetacean research world-wide but some of projects have been initiated in response to the Sanctuary designation. SC/54/O25 also describes research techniques that have evolved directly from projects initiated as a result of the Sanctuary.

One of the difficulties in evaluating the Sanctuary is knowing which activities are a direct result of the Sanctuary and which would have happened without it. In the case of research, the sub-group mainly relied on whether the reports

of the research indicated that the existence of the Sanctuary had been of benefit. Indirect benefits included: a focus on regional initiatives and cooperation (including international workshops such as those held in Colombo, Sri Lanka in 1983 and Cochin, India, 1985); facilitation of the initial phase of integrated research between Indian Ocean and Southern Ocean; a greater awareness of cetaceans in coastal states; and additional sources of funding.

In assessing population structure, whaling on Indian Ocean stocks will affect the interpretation of genetic data. Potentially selective removal of individuals without *a priori* knowledge of their genetic 'type' with respect to overall stock structure may confound ability to discriminate stocks.

(6) Provide advice on whether the Sanctuary is consistent with the precautionary approach

The central tenet of the precautionary approach is that lack of information shall not be a reason to delay potentially necessary conservation oriented management action. The adoption of the IOS in 1979 at a time when relatively little was known about the whale populations in the region was one of the first precautionary measures adopted by the IWC. (In fact there was one provision in the then current New Management Procedure that was precautionary, namely the requirement that an abundance estimate be available before exploitation commences on initial management stocks. Bryde's whales in the Indian Ocean were protected by this provision for several years.)

While the RMP is designed to be more precautionary than its predecessors, the establishment of an appropriately designed system of sanctuaries can be regarded as a precautionary safeguard to mitigate the effects of possible failure of the RMP to adequately protect whale stocks after the current moratorium ends.

The complex nature of baleen whale population structure, and its interaction with potential harvesting regimes, continue to impede progress on implementation of the RMP, which was originally designed to manage the exploitation of baleen whales on high-latitude feeding grounds (IWC, 1999, p.254). In the North Pacific, there is continuing difficulty with the management of breeding stocks which are being harvested on both migration routes and feeding grounds where mixing in space and time may occur in varying proportion with other stocks. The extended debate regarding these and other factors within the Committee highlights the considerable uncertainty associated with RMP inputs and operation. Whilst the Committee continues to work towards resolving these issues, any management system that must accommodate such complexity inevitably risks some chance of performance failure. A precautionary response to these problems would be to protect, where possible, baleen whales outside of high latitude feeding grounds, through the designation of appropriate sanctuary areas, such as the IOS. Retention of the IOS would seem especially prudent while the difficulties of RMP implementation in the North Pacific are still being resolved.

CONCLUSIONS AND SUGGESTIONS

According to instructions from the Chair, the sub-group did not include any information on small cetaceans in this review. However, the group noted that the omission of

information on small cetaceans resulted in a wide body of research being omitted that could have made a substantial contribution to the Sanctuary review.

The sub-group noted that many of the considerations related to the research efforts in the Sanctuary were unique to the Indian Ocean, where the coastal states are predominantly developing countries. The sub-group noted the increased attention now given by the IWC to building cetacean research capacity in these countries. In addition, there are increasing opportunities for affordable cetacean research from platforms of opportunity in the Indian Ocean, including multi-disciplinary research cruises and whalewatching. Unlike the Southern Ocean, it is only recently that the significance of the Indian Ocean to physical oceanographic and climatological processes has been realised. This has resulted in new ocean-basin scale marine research projects providing potential for the type of multi-disciplinary research already underway in the Southern Ocean. The IOS provides a focus for encouraging regional research cooperation and the sub-group recommended that these opportunities be encouraged. The sub-group also recommended that because the Indian Ocean has been recognised as a special area, the Commission and the SC provide advice to the coastal states on ways to address threats to cetaceans in their waters.

The sub-group found that based on available data there was no basis for changing the current Sanctuary provisions. In particular, the sub-group considered that there were insufficient data to define a smaller area (such as the Indian Ocean north of the equator) that would achieve the sanctuary objectives. In addition, current boundaries provide opportunities for comparison of behaviour, physiology and the effects of climate change on unique northern Indian Ocean stocks with southern Indian Ocean stocks afforded the same protection across an ocean basin. However, should the SOS provisions be changed in the future, it may be considered prudent to extend the southern boundary of the IOS to the Antarctic continent. In the meantime, the sub-group recommended that the IOS should continue in its current form.

REFERENCES

- Allison, G.W., Lubchenco, J. and Carr, M.H. 1998. Marine reserves are necessary but not sufficient for marine conservation. *Ecol. Appl.* 8(1):79-92.
- International Whaling Commission. 1999. Report of the Scientific Committee. Annex N. The Revised Management Procedure (RMP) for Baleen Whales. *J. Cetacean Res. Manage. (Suppl.)* 1:251-8.
- International Whaling Commission. 2002. Chair's Report of the 53rd Annual Meeting. Annex E. Instructions from the Commission to Scientific Committee for Reviews of Sanctuaries. *Rep. int. Whal. Commn* 2001:65.
- Rosenbaum, H.C., Walsh, P.D., Razafindrakoto, Y., Vely, M. and DeSalle, R. 1997. First description of a humpback whale breeding ground in Baie d'Antongil, Madagascar. *Conserv. Biol.* 11(2):312-4.
- Rosenbaum, H.C., Best, P.B., Findlay, K.P., Engel, M.H., Pomilla, C., Razafindrakoto, Y., Morete, M.E., Vely, M., Freitas, A.C., Baker, C.S., Jenner, C., Jenner, M.-N. and Bannister, J. 2000. Mitochondrial DNA variation among humpback whales from the wintering grounds in the South Atlantic and southwestern Indian Oceans. Paper SC/52/IA11 presented to the IWC Scientific Committee, June 2000, in Adelaide, Australia (unpublished). [Paper available from the Office of this Journal].

Appendix 6

REPORT OF SUB-GROUP C

The view of this sub-group is that the IOS has some value but that some modifications are needed.

- (1) The IOS was conceived in a very different era, before the introduction of the moratorium or the development of the RMP, and against a background of special scientific catches of Bryde's whales in the Indian Ocean (despite a long-standing ban on the use of factory ships north of 40°S for taking baleen whales other than minke). To the extent that no further exploitation of Bryde's whales occurred in the region, the Sanctuary can be said to have been successful. However the intention that the Sanctuary would also serve as a control area, in which the behaviour of populations undisturbed by whaling could be studied, was largely overtaken by events.
 - (2) In 1983 the worldwide moratorium on commercial whaling was adopted, so that in effect all the world's oceans became 'sanctuaries'. Furthermore, in 1993 the Commission accepted in principle the Revised Management Procedure, so that if commercial whaling was to be allowed to resume, it would be on such a conservative basis that a sanctuary would seem redundant. Nevertheless, there is no reason why the Commission should not also decide to establish a suitable sanctuary as a 'belt-and-braces' approach to the RMP, but presumably the location of such a protected area would be best decided on a species by species basis, and not necessarily always in the same ocean basin.
 - (3) The opinion of this sub-group is that it is impossible to judge objectively whether the creation of the IOS was responsible for an upsurge in scientific research in the region or not, as this would require an assumption about the level of research that would have occurred in the absence of a sanctuary (which would be pure speculation). Certainly the Sanctuary Journal (in which the results of such research were to be published) never appeared, and systematic surveys of whale populations in the region have generally been too widely separated in time and space to monitor the effects of the Sanctuary. This is not surprising, as at the time of the original sanctuary debate, it was pointed out that the region was surrounded largely by developing nations who would be unlikely to be able to provide sufficient financial support for such programmes. In any case, this group believes that the promotion of whale research should be at most a secondary rather than the primary objective of a sanctuary.
 - (4) With the loss of its unique status as a large ocean area where whaling is prohibited, it is entirely appropriate at the time of this review to question whether the IOS as such still has a role in whale conservation, or whether it should be re-formulated. The contention of this group is that the current Sanctuary is too large and non-specific, with boundaries that are not biologically meaningful for all species, for it to be an effective management tool under current circumstances. The validity of the Sanctuary would be greatly improved if it could be made more focussed and biologically appropriate.
 - (5) Over the last few years, evidence has been gathering that the northern Indian Ocean may contain populations of humpback, blue, Bryde's and maybe other species of large whale that are on Northern Hemisphere reproductive schedules, and which may therefore never make the extensive latitudinal migrations typical of large baleen whales in general. To this extent, the northern Indian Ocean is unique, as no such situation exists in the Atlantic or Pacific Oceans. Such isolated populations that have no access to polar feeding grounds also provide opportunities for the study of possible climate change effects. Redrawing the Sanctuary's boundaries such that they form a more compact, self-contained region in the northern Indian Ocean would create a whale sanctuary that is both biologically relevant and scientifically justified.
 - (6) Other possible re-formulations include ensuring boundaries compatible with the migratory ranges of stocks, and optimal choice of area in the Southern Hemisphere (conceivably outside the Indian Ocean) to serve as a control area.
 - (7) In conclusion, the group is not opposed in principle to proposals for whale sanctuaries, but feels strongly that these should be motivated on a species-by-species basis and as an integral part of an overall management plan, such that their maximum scientific value can be achieved.
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Annex O

Summary of Information from Progress Reports

This Annex summarises information presented in National Progress Reports. For further information (including the address of contact persons/institutes), consult the authors of

the Progress Reports whose names and addresses are given in Appendix 1.

NATURAL MARKING DATA

Species	Feature	Area/stock	Calendar year/season/ no. photographed	Catalogued (Y/N)	Catalogue total	Contact person/institute
Australia						
Blue whale	Flank	WA	2001	Y	16	P. Gill/Australocetus
Blue whale	Lateral body	Off Rottnest I, WA	Fieldwork under way	N	-	J. Bannister/WA Museum, C. Jenner/Centre for Whale Research, WA
Humpback whale	Fluke	QLD	2001		1	P. Hale/University of Queensland, D. Paton/Southern Cross University
Humpback whale	Fluke	Hervey Bay Group V	2001/Aug-Oct/ 947	In progress	4,572 (1992-2001)	W&P Franklin/the Oceania Project
Humpback whale	Left & right dorsal	Hervey Bay Group V	2001/Aug-Oct/ 947	In progress	4,572 (1992-2001)	W&P Franklin/the Oceania Project
Humpback whale	Left & right lateral body markings	Hervey Bay Group V	2001/Aug-Oct/ 947	In progress	4,572 (1992-2001)	W&P Franklin/the Oceania Project
Humpback whale	Laterals Fluke ¹	Area IV Group V	2001/00-01 season/12 2001	Y Y	?	IWC, D Thiele/SOCEP
Humpback whale	Fluke	WA	1990/2001	Y to 1998	1,283	D. Paton/Southern Cross University, C. Jenner/Centre for Whale Research
Humpback whale	Left Lateral Body	WA	1990/2001	Y to 1998	1,661	C&M Jenner/Centre for Whale Research
Humpback whale	Right Lateral Body	WA	1990/2001	Y to 1998	1,682	C&M Jenner/Centre for Whale Research
Humpback whale	Sex ID	WA	1990/2001	Y to 1998	23	C&M Jenner/Centre for Whale Research
Southern right whale	Callosities	Head of Bight, SA	2001/ Approx. 80	Ongoing	>400	S. Burnell/Eubalaena Pty Ltd ²
Southern right whale	Head	Area IV	2001/00-01 season/1	Y	?	S Burnell, D Thiele ²
Southern right whale	Head	Area IV	2001/00-01 season	Y	?	WA Museum
Dwarf minke whale		N Great Barrier Reef, QLD	2001 / June-July / 50	In progress	50	A. Birtles/Dept of Tourism, James Cook University
Sperm whale	Dorsal area, Fluke	Off WA	2001 /?	In progress	?	Ocean Alliance/H. Whitehead, Dalhousie University
Bottlenose dolphin	Dorsal fin ³	Port Stephens, NSW	2001			L. Moller, S. Allen/GSE, Macquarie University
Bottlenose dolphin	Dorsal Fin ³	Jervis Bay, NSW	2001			M. Lemon, GSE/Macquarie University
Indo-Pacific humpback dolphin	Left & right lateral body markings	Moreton Bay & Great Sandy Strait, QLD	To date /? /150	Y	150	P. Hale/Ecology Centre, University of Queensland
Indo-Pacific humpback dolphin	Dorsal surface	Cleveland Bay, QLD	1999/summer/winter	Y	37	G. Parra/TESG, James Cook University
			2000/summer/winter	Y	48	
			2001/summer/winter	Y	50	
Irrawaddy dolphin	Dorsal surface	Cleveland Bay, QLD	1999/summer/winter	Y	38	G. Parra/TESG, James Cook University
			2000/summer/winter	Y	58	
			2001/summer/winter	Y	64	
Brazil						
Humpback whale	Fluke	W. S. Atlantic	218 (2000 season)	Y	982 (until 2000) ¹	Instituto Baleia Jubarte
Bottlenose dolphin	Dorsal fin	ASPSP	2	Y	8	G. Caon & P.H. Ott/GEMARS
Southern right whale	Callosities	Southern Brazil	~30	Y	70 ²	P.A. Flores/International Wildlife Coalition/Brazil
Marine tucuxi	Dorsal fins and body marks	Central SC	On-going analysis	Y	~ 130	Paulo A.C. Flores
Bottlenose dolphin	Dorsal fin	Central SC	10	Y	35	Paulo A.C. Flores
Southern right whale	Head callosities	SC	50	On-going analysis	~ 180 79	Karina R. Groch

Cont.

Natural marking data continued.

Species	Feature	Area/stock	Calendar year/season/ no. photographed	Catalogued (Y/N)	Catalogue total	Contact person/institute
France						
Humpback whale	Fluke	NW Atlantic	2001/not available	Y	Few	CCS
Humpback whale	Fluke	N. Caledonia	2000/57 (27 new id.)	Y	250	OCNC
Fin whale	Dorsal Fin	NW Med	2001/15	Y	15	CEBC
Fin whale	Dorsal Fin	NW Med	2001/summer/180	Y	70	EPHE
Fin whale	Dorsal Fin	NW Med	2001/summer/140	Y		GREC
Sperm whales	Fluke	NW Med	2001/summer/few	Y	Few	EPHE
Sperm whale	Fluke	NW Med	2001/25	Y		GREC & NAMSWC
Sperm whale	Fluke	Caribbean	2001/100	Y	100	Etr
Bottlenose dolphin	Dorsal Fin	Eng. Channel	2001/summer/50	Y	80+	GECC
Bottlenose dolphin	Dorsal fin	Brittany	2001/summer/NA	Y	42	Océanopolis
Bottlenose dolphin	Dorsal fin	Bay of Biscay	2001/summer/6	Y	6	CRM
Bottlenose dolphin	Dorsal Fin	Bay of Biscay	2001/summer/15	Y	15	GEFMA
Bottlenose dolphin	Dorsal fin	NW Med	2001/summer/150	Y	80	EPHE
Common dolphin	Dorsal Fin	Bay of Biscay	2001/summer/30	Y	30	GEFMA
Risso's dolphin	Dorsal Fin	NW Med	2001/summer/160	Y		GREC
Risso's dolphin	Dorsal fin	NW Med	2001/summer/500	Y	200	EPHE
Long fin pilot whale	Dorsal fin	NW Med	2001/summer/few	Y	Few	EPHE
Long fin pilot whale	Dorsal Fin	Bay of Biscay	2001/summer/30	Y	30	GEFMA
Long-fin. pilot whale	Dorsal Fin	NE Atlantic	2001/summer/26	Y	47	CRM
Killer whale	Dorsal Fin	Southern Ocean	2001	Y	63	CEBC
Ireland						
Bottlenose dolphin	Dorsal fin	NE Atlantic	>120	Y	>200	UCC
Italy						
Bottlenose dolphin	Dorsal fin	Lampedusa Island – Archipelago	2001/7-10	Y	125	CTS
Bottlenose dolphin	Dorsal fin	Maddalena archipelago National Park,	2001/8	Y	16	CTS
Bottlenose dolphin	Fluke	Mediterranean	2	Y	NA	AQ
Bottlenose dolphin	Dorsal fin	Sardinian Channel (MPA Capo Carbonara)	12	Y	15	ICRAM
Bottlenose dolphin	Dorsal fin	Corsican sea (Asinara National Park)	9	Y	39	ICRAM
Japan						
Bryde's whale	Dorsal fin	Kochi		Y	43	NRIFS
Bryde's whale	Dorsal fin	Kasasa		Y	36	NRIFS
Blue whale	Dorsal pigmentation	North Pacific	1			
Mexico						
Blue whale	Right + left side flukes	N. Pacific Baja California	100	No	(300+)	D. Gendron CICIMAR-IPN
Fin whale	Right + left side	Gulf of California	45	Yes	(350+)	J. Urbán UABCS
Gray whale	Right side	Laguna Ojo de Liebre	450	No	1,600+	J. Urbán UABCS
Sperm whale	Flukes	N. Pacific Gulf of California	20	No		
Bottlenose dolphin	Dorsal fin	Gulf of California and Pacific Coast of Baja California	150	N	?	Pérez-Cortés, INE
New Zealand						
Bottlenose dolphin	Fin/body	Doubtful Sound	1990-2002	Yes	83	D. Lusseau/ Otago Univ.
Bottlenose dolphin	Fin/body	Milford Sound	2000-2002	Yes	50	D. Lusseau/ Otago Univ.
Bottlenose dolphin	Fin/body	Bay of Islands	1993-2002	Yes	392	R. Constantine/ Auckland Univ.
Brydes whale	Fin/body	Hauraki Gulf	2001-02	Yes	>20	K. Thompson/ Auckland Univ.
Common dolphin	Fin/body	Whitianga/ Whakatane	1998-2001	Yes	408	D. Neumann/ Massey Univ.
Hector's dolphin	Fin/body	North I.	1998-2002	Yes	34	K. Russell/ Auckland Univ.
Hector's dolphin	Fin/body	East South I.	1984-2002	Yes	500	E. Slooten/ Otago Univ.
		West South I.	1994-1997, 2001- 2002			
Humpback whale	Fluke	Area V	1991-2002	Yes	440	R. Constantine, C. S. Baker/ Auckland Univ.
Humpback whale	Fluke	New Zealand	1995-2002	Yes	6	R. Constantine/ Auckland Univ.
Killer whale	Fins/saddles/ eye patches	NZ	1993-2000	Yes	117	I. Visser/ The Orca Project
Killer whale	Fins/saddles/ eye patches	Area V	2001	Yes	11	C. Olavarria/ Auckland Univ.
Southern right whale	Callosities/ lip lines	Area V	2001	Yes	2	C. Olavarria/ Auckland Univ.
Southern right whale	Callosities/ lip lines	NZ sub-Antarctic	1995-1999	Yes	402	N. Patenaude/ Auckland Univ.; B. Todd/ Project Tohoro
Sperm whale	Fluke	Kaikoura	1990-2002	Yes	190	E. Slooten/ Otago Univ.

Cont.

Natural marking data continued.

Species	Feature	Area/stock	Calendar year/season/ no. photographed	Catalogued (Y/N)	Catalogue total	Contact person/institute
Norway						
Humpback whale	Fluke	Barents Sea/Norwegian Sea	2001			IMR
Oman						
Humpback whale	Fluke	Arabian Sea/Gulf of Oman	2000-2002	Y	21	Oman Whale and Dolphin Research Group
Humpback whale	Right dorsal fin	Arabian Sea/Gulf of Oman	2000	Y	26	OWDRG
Humpback whale	Left dorsal fin	Arabian Sea/Gulf of Oman	2000	Y	18	OWDRG
South Africa						
Southern right whale	Callosity pattern	South Africa	186 cow-calf pairs	N	640 cows	MRI Whale Unit
Southern right whale	Callosity pattern	Southeast coast	100	Y	>150	CDS
Southern right whale	Callosity pattern	South coast	9	N	9	DEAT
Humpback whale	Dorsal fin, flukes	West coast	100	N	?	MRI Whale Unit
Humpback whale	Dorsal fin, flukes	Southeast coast	? (120)	Y	?	CDS
Humpback whale	Dorsal fin, flukes	East coast	198	N	198	DEAT
Bryde's whale	Dorsal fin	Southeast coast	? (27)	N	>150	CDS
Killer whale	Dorsal fin, body scarring	Marion Island	26	Y	26	University of Pretoria
Heaviside's dolphin	Dorsal fin	South Africa	7	N	?	MRI Whale Unit
Indian Ocean bottlenose dolphin	Dorsal fin	Southeast coast	547	Y	>3500	CDS
Indian Ocean bottlenose dolphin	Dorsal fin	Durban	>700	N	>250	NSB
Indo-Pacific humpback dolphin	Dorsal fin	Southeast coast	156	Y	>443	CDS
Indo-Pacific humpback dolphin	Dorsal fin and hump	Richards Bay	?	Y	91	EWT
Common dolphin	Dorsal fin	Southeast coast	? (700)	N	?	CDS
Spain						
Short finned pilot whale	Fin	Canary Is.		N		ULL
Bottlenose dolphin	Fin	Canary Is.		Y	145	T C
UK						
Minke whale	Scars/fin shape/colouration	Scotland		Yes	70+	HWDT
Bottlenose dolphin	Dorsal fin	W. Scotland		Yes	10+	HWDT
Bottlenose dolphin	Dorsal fin	Saudi Arabia		Yes		UMBSM
Killer whale	Dorsal fin	Scotland		Yes	12+	HWDT
Indo-Pacific hump-backed dolphins	Dorsal fin	Saudi Arabia		Yes		UMBSM
USA						
North Atlantic right whale		Bay of Fundy, Roseway and Grand Manan Basins	N/A		30	T. Cole, D.Potter, W. Perryman
North Atlantic right whale		Bay of Fundy, Roseway and Grand Manan Basins	N/A		87	T. Cole, D.Potter, W. Perryman
Bottlenose dolphin		Mississippi Sound	15		809	K. Mullin SEFSC
Killer whale		Gulf of Mexico	1		47	K. Mullin SEFSC
Sperm whale		Gulf of Mexico	55		94	K. Mullin SEFSC
Killer whale		SE Alaska	N/A		13 groups	M. Dahlheim, AFSC
Killer whale		Central AK & Aleutians	N/A		18 groups	M. Dahlheim, AFSC
Humpback whale		Central AK & Aleutians	N/A		8 groups	M. Dahlheim, AFSC
Humpback whale		Kodiak, AK	N/A		6 individuals	S. Mizroch, AFSC
Fin whale		Kodiak, AK	N/A		34 individuals	S. Mizroch, AFSC
Gray whale		NW Washington, Vancouver Is.	N/A		114 individuals	M. Goshko, AFSC
Right whale		SE Bering Sea	N/A		5 individuals	R. LeDuc, SWFSC

Australia: ¹Data currently being analysed. ²Natural markings for humpbacks are in the form of photographs and digital video records, and include right and left lateral/dorsal views. Only one photograph of callosities on one southern right whale was collected. ³Opportunistic photo-identification.

Brazil: ¹Data from the 2001 whale season is currently being analysed. ²These include only biopsied right whales photo-identified during the genetic study carried out in southern Brazil since 1998.

ARTIFICIAL MARKING DATA

Species	Tag type	No. branded	Location	Brand no.	Contact
Australia					
Bottlenose dolphin	Brand	1	Gold Coast, QLD	-	C. Limpus, QPWS
Denmark					
Harbour porpoise	Freeze brand	4	Skagen to Gedser	1-4	DMU, DFU, FBC
UK					
Boto	Freeze brand/plastic tag	30	Brazilian Amazon		SMRU/INPA
Tucuxi	Freeze brand/plastic tags	3	Brazilian Amazon		SMRU/INPA

TELEMETRY DATA

Species	Tag type	No. successfully deployed	Maximum time transmitting	Contact person/institute
Australia				
Humpback whale	Satellite	2	16 hours	C Jenner/Centre for Whale Reseach, N.Gales/ Australian Antarctic Division
Pygmy blue whale	Satellite	1	7 days	C Jenner/CWR, N.Gales/AAD
Brazil				
Humpback whale	Satellite	1		Biodinamical/Universidade Federal de Santa Catarina - Lamac
Canada				
Bowhead (HB-FB)	Satellite	4	4 days from one whale	Larry Dueck
White whale (CS)	Satellite	7	On-going	Pierre Richard
Narwhal	Satellite	12	On-going	Pierre Richard
Denmark				
Harbour porpoise	Satellite	17	Between 21 and 306 days	DMU, DFU, FBC
Bowhead whale	Satellite	5	-	-
Fin whale	Satellite	1	23 days	-
France				
Fin whale	Satellite	4	<1 month	CEBC
Iceland				
Fin whale	Satellite	3	1 day	MRI
Minke whale	Satellite	2	60 days	MRI
Mexico				
Fin whale	Satellite	11	158 days	Bruce Mate OSU/ J. Urbán UABCS
Blue whale	Satellite	4		Bruce Mate OSU/ J. Urbán UABCS
Blue whale	Crittercam	2	12	John Calambokidis Cascadian Research Collective
Norway				
Minke whale	VHF	4	-	IMR
Harbour porpoise	Satellite	3	-	IMR
Killer whale	Satellite	5	-	IMR
White whale	Satellite	3	-	C. Lydersen, NP
South Africa				
Southern right whale	Satellite	21	4-5 months	Oregon State University/MRI Whale Unit
UK				
White whale	CTD tag	3		SMRU/NPI
USA				
North Atlantic right whale	TDR	23		T. Cole, NEFSC
North Atlantic right whale	TDR	2		T. Cole, NEFSC
Sperm whale	Digital Acoustic Tag (DTAG)	13		K. Mullin, SEFSC
Sperm whale	Satellite	4		K. Mullin, SEFSC
White whale	Long term location tag	7		R. Hobbs, AFSC
White whale	Short term location tag	5		R. Hobbs, AFSC
Pantropical spotted dolphin	Radio with TDR	3		S. Chivers, SWFSC
Pantropical spotted dolphin	Radio with TDVR	4		S. Chivers, SWFSC
Pantropical spotted dolphin	Radio TDVR/heat flux	2		S. Chivers, SWFSC
Pantropical spotted dolphin	Satellite	6		S. Chivers, SWFSC
Pantropical spotted dolphin	Short range bullet radio tag	7		S. Chivers, SWFSC
Pantropical spotted dolphin	Visual roto tag	213		S. Chivers, SWFSC

Cont.

Telemetry data continued.

Species	Tag type	No. successfully deployed	Maximum time transmitting	Contact person/institute
USA continued				
Spinner dolphin	Short range bullet radio tag	1		S. Chivers, SWFSC
Harbour porpoise	PPT/VHF	4		B. Hanson, AFSC
Harbour porpoise	TDR/VHF	2	32 hours	B. Hanson, AFSC

BIOPSY SAMPLES

Species	Area/stock	Calendar year/ season/ no. collected	Archived (Y/N)	No. analysed	Total holdings	Contact person/institute
Australia						
Humpback whale	Group D/E	2001/cy00-01/3	Y		3	C.S. Baker, D. Thiele
Humpback whale	Area V	145	Y	145	To be confirmed	D. Paton/Southern Cross University ¹
Humpback whale	Group V / Hervey Bay	2000/140 2001/287	Y	0	427	W&P Franklin/the Oceania Project
Blue whale	Off WA	Field work under way	N	-	34 skin samples and sloughed skin	J. Bannister/WA Museum, C. Jenner/ Centre for Whale Research, WA
Dwarf minke whale	N Great Barrier Reef	To date	Y	0	16	A. Birtles/Dept of Tourism, James Cook University
Sperm whale	Off WA	2001/9	Y	?	Skin and blubber	R. Clark, Ocean Alliance
Bottlenose dolphin	Port Stephens, NSW	2001/?	?	?	Biopsy samples	NSW NPWS
Short-beaked common dolphin	SA coastline	2001/1	Y	1	Genetic tissue, reproductives, toxins	C. Kemper/SA Museum
Bottlenose dolphin	SA coastline	2001/2	Y	2	Genetic tissue, reproductives, toxins	C. Kemper/SA Museum
Southern Right whale	SA coastline	2001/2	Y	2	Genetic tissue, reproductives, toxins	C. Kemper/SA Museum
Short-beaked common dolphin	SA coastline	2001/1	Y	1	Genetic tissue, reproductives, toxins	C. Kemper/SA Museum
Indo-Pacific humpback dolphin	Australia	To date	Y	?	40	P. Hale/University of Queensland
Brazil						
Humpback whale	W. S. Atlantic	43	Y	43	197	Instituto Baleia Jubarte
Southern right whale	Southern Brazil	9 skin samples + 9 blubber	Y	On-going study	84 skin + 44 blubber	P. H. Ott/GEMARS
Pantropical spotted dolphin	Northeastern coast	1	Y	No	1 blubber sample	D. Danilewicz (GEMARS)
Canada						
Bowhead	BB-DS	2	Y	2	3	Lianne Maiers
Bowhead	HB-FB	46	Y	46	84	Lianne Maiers
France						
Fin whale	Mediterranean	2001/summer	N	0	17	CEBC
Humpback whale	N. Caledonia	2001	Y		217	OCNC & S. Baker, Univ. Auckland
Iceland						
Killer whale	Vestmannaeyjar, S. Iceland	2001/17	-	-	-	OF
Japan						
Blue whale	Antarctic	15	Y	0	15	NRIFS
Humpback whale	Antarctic	1	Y	0	1	NRIFS
Bryde's whale	North Pacific	1	Y	0	1	NRIFS
Humpback whale	Antarctic	31				ICR
Blue	Antarctic	1				ICR
Fin whale	Antarctic	4				ICR
Right whale	Antarctic	16				ICR
Bryde's whale	North Pacific	5		5		ICR

Cont.

Biopsy samples continued

Species	Area/stock	Calendar year/ season/ no. collected	Archived (Y/N)	No. analysed	Total holdings	Contact person/institute
Sperm	N. Pacific	16		11		ICR
Minke whale	N. Pacific	2		2		ICR
Blue whale	N. Pacific	2		1		ICR
Mexico						
Fin whale	Gulf of California	30	Y	No	200+	J. Urbán
Blue whale	N. Pacific Baja California	6	Y	No	6	D.Gendron, CICIMAR-IPN
New Zealand						
Bottlenose dolphin	NZ	9	No	0	9	D. Neumann/ Massey Univ.; K. Russell/ Auckland Univ.
Hector's dolphin	NZ	24	Yes	23	116	K. Russell, F. Pichler/ Auckland Univ.
Hector's dolphin	Porpoise Bay	21	Yes	0	?	E. Slooten, S. Dawson/Otago Univ., K. Russell, F. Pichler/ Auckland Univ.
Killer whale	Area V	1	Yes	0	1	C. Olavarria/ Auckland Univ.
Southern right whale	Area V	1	Yes	0	1	C. Olavarria/ Auckland Univ.
Norway						
White whale	Svalbard	2001/8	Y			C. Lydersen, NP Tromso
White-beaked dolphin	Barents	2001				IMR
Humpback	Sea/Norwegian Sea	2001				IMR
Minke whale	Barents	2001				IMR
Fin whale	Sea/Norwegian Sea	2001				IMR
Minke whale	Barents	2001				IMR
	Sea/Norwegian Sea	2001				IMR
	Vestfjord	2001				IMR
Oman						
Humpback whale	Arabian Sea/Gulf of Oman	2000-2002		18	18	OWDRG
Humpback whale	Arabian Sea/Gulf of Oman	2000-2002		9	9	OWDRG
Bryde's whale	Arabian Sea/Gulf of Oman	2000-2002		0	2	OWDRG
South Africa						
Humpback whale	West coast	43	Y	?	67	MRI Whale Unit/AMNH
Southern right whale	South Africa	4	Y	?	631	MRI Whale Unit/AMNH
Heaviside's dolphin	West coast	42	N	?	110	DEAT
Dusky dolphin	West coast	15	N	?	89	DEAT
USA						
North Atlantic right whale	Roseway Basin	2				T. Cole, NEFSC
Pilot whale	Roseway Basin	1				T. Cole
Fin whale	Maine/Bay of Fundy	1				D. Palka
Bottlenose dolphin	Gulf of Mexico (Outer Continental Shelf)	22				K. Mullin, SEFSC
Bottlenose dolphin	Atlantic (offshore and inshore)	186				
Minke whale	Atlantic	1				
Fin whale	Atlantic	1				
Sperm whale	Gulf of Mexico	65				
Sperm whale	Atlantic	1				
Melon-headed whale	Gulf of Mexico	6				
Pilot whale	Gulf of Mexico	3				
False killer whale	Gulf of Mexico	1				
Killer whale	Gulf of Mexico	2				
Atlantic spotted dolphin	Gulf of Mexico	33				
Atlantic spotted dolphin	Atlantic	60				
Pantropical spotted dolphin	Gulf of Mexico	4				
Spinner dolphin	Gulf of Mexico	2				
Spinner dolphin	Atlantic	1				
Striped dolphin	Gulf of Mexico	3				
Clymene dolphin	Gulf of Mexico	2				
North Atlantic right whale	Atlantic	1				
Rough-toothed dolphin	Gulf of Mexico	3				
White whale	Cook Inlet	16				R. Hobbs, AFSC
Fin whale	Bering Sea	3				M. Dahlheim, AFSC
Fin whale	Kodiak, AK	14				S. Mizroch, AFSC

Cont.

Biopsy samples continued

Species	Area/stock	Calendar year/ season/ no. collected	Archived (Y/N)	No. analysed	Total holdings	Contact person/institute
Gray whale	Strait of Juan de Fuca	5				M. Gosho, AFSC
Gray whale	Bering Sea, Alaska	3				M. Dahlheim, AFSC
Humpback whale	Bering Sea, Alaska	12				M. Dahlheim, AFSC
Humpback whale	Kodiak, Alaska	5				S. Mizroch, AFSC
Killer whale	SE Alaska, California, Bering Sea	17				M. Dahlheim, AFSC
Killer whale	Prince William Sound, Bering Sea	10				C. Matkin
Long-beaked common dolphin	California/Oregon/Washington	5				S. Chivers, SWFSC
Short-beaked common dolphin	California/Oregon/Washington	104				
Bottlenose dolphin	California/Oregon/Washington	10				
Risso's dolphin	California/Oregon/Washington	5				
Pacific white-sided dolphin	California/Oregon/Washington	11				
Northern right whale dolphin,	California/Oregon/Washington	32				
Killer whale	California/Oregon/Washington	4				
Dall's porpoise	California/Oregon/Washington	9				
Sperm whale	California/Oregon/Washington	10				
Cuvier's beaked whale	California/Oregon/Washington	1				
Gray whale	California/Oregon/Washington	3				
Unidentified Rorqual	California/Oregon/Washington	1				
Fin whale	California/Oregon/Washington	13				
Blue whale	California/Oregon/Washington	12				
Humpback whale	California/Oregon/Washington	16				
Pantropical spotted dolphin	eastern tropical Pacific	208				
Eastern spinner dolphin	eastern tropical Pacific	3				

Australia: ¹21 of the 145 samples could not be identified using microsatellite genotyping.

SAMPLES FROM DIRECTED CATCHES OR BYCATCHES

Species	Area/stock	Calendar year/ Season total	Archived (Y/N)	Tissue type (s)	Contact person/institute
Brazil					
Franciscana	Northern Rio de Janeiro	4	Y	Skin, blubber, liver, kidney	Ana Paula M. Di Benedetto and Renata M. Ramos - UENF
Tucuxi (marine)	Northern Rio de Janeiro	4	Y	Skin, blubber, liver, kidney	Ana Paula M. Di Benedetto and Renata M. Ramos - UENF
Canada					
White whale	Hudson Bay	120	Y		Brigitte de March
Narwhal	Hudson Bay	25	Y		Brigitte de March
White whale	SE Baffin	25	Y		Gary Stern
White whale	High Arctic	30	Y		Gary Stern
White whale	Hudson Bay	15	Y		Gary Stern
Narwhal	High Arctic	20	Y		Gary Stern
Narwhal	Hudson Bay	15	Y		Gary Stern
Denmark					
Fin Whale	Greenland	3	Y	Skin biopsy	GN
Minke Whale	Greenland	39	Y	Skin biopsy	GN
Harbour Porpoise	Danish waters	11	Y	8 full autopsies and sampling for tissue bank	DFU

Cont.

Samples from directed catches of bycatches continued.

Species	Area/stock	Calendar year/ Season total	Archived (Y/N)	Tissue type (s)	Contact person/institute
Germany					
Harbour porpoise	Baltic Sea	5	5	All organs, central nervous system, skeletal system	U. Siebert
Harbour porpoise	Schleswig-Holstein Baltic Sea Meckl.-Prepom.	3	3	All organs, central nervous system, skeletal system?	H. Benke
Ireland					
Harbour porpoise	NE Atlantic	3	Y	Skin, blubber etc	UCC
Japan					
Minke whale	North Pacific	1	Y	Skin and muscle	NRIFS
Korea					
Minke whale	East Sea	14	Y	Skin, blubber, muscle	Z. G. KIM/NFRDI
Minke whale	South Sea	6	Y	Skin, blubber, muscle	Z. G. KIM/NFRDI
Mexico					
Vaquita	Upper Gulf of California	2	N	No	L. Rojas-Bracho
New Zealand					
Common dolphin	NZ	10	Y	Skin, blubber, fixed tissues, skeletons	P. Duignan/ Massey Univ.
Dusky dolphin	NZ	3	Y	Skin, blubber, fixed tissues, skull	P. Duignan/ Massey Univ.
Hector's dolphin	NZ	23	Y	Skin, blubber, fixed tissues, skeletons	P. Duignan/ Massey Univ.; A. van Helden/ Museum of NZ
Norway					
Minke whale				Stomach samples, body condition data, biological material	NIFA
Minke whale	Spitsbergen/Jan Mayen			Biological material	IMR
South Africa					
Indian Ocean bottlenose dolphin	KwaZulu-Natal	22	Y	Skin, gonads, teeth, stomach	NSB
Indo-pacific humpback dolphin	KwaZulu-Natal	2	Y	Skin, gonads, teeth, stomach	NSB
Long-beaked common dolphin	KwaZulu-Natal	13	Y	Skin, gonads, teeth, stomach	NSB
Sweden					
Harbour porpoise	Swedish Skagerrak Sea	2	Y	Skin, blubber, muscle, liver, stomach, reproductive organ, brain, skeleton	P. Rudd
Harbour porpoise	Baltic Sea	1	Y	Skin, blubber, muscle, liver, stomach, reproductive organ, brain, skeleton	P. Berggren
Bottlenose dolphin	Zanzibar, Tanzania	11	Y	Skin, blubber, muscle, liver, stomach, reproductive organ, brain, skeleton	P. Berggren
Humpback whale	Zanzibar, Tanzania	5	Y	Skin, blubber, muscle, liver, stomach, reproductive organ, brain, skeleton	P. Berggren
Spinner dolphin	Zanzibar, Tanzania	19	Y	Skin, blubber, muscle, liver, stomach, reproductive organ, brain, skeleton	P. Berggren
Risso's dolphin	Zanzibar, Tanzania	11	Y	Skin, blubber, muscle, liver, stomach, reproductive organ, brain, skeleton	P. Berggren
Spotted dolphin	Zanzibar, Tanzania	4	Y	Skin, blubber, muscle, liver, stomach, reproductive organ, brain, skeleton	P. Berggren
St Vincent and the Grenadines					
Humpback whale	South of Mustique	2002/2	Y	Tissue samples for DNA	Fisheries Division
UK					
Harbour porpoise	North Sea	6	Y	Various	Paul Jepson (IoZ)
Common dolphin	Ireland	1	Y	Skull	Jerry Herman (NMS)
USA					
White whale	Cook Inlet, Alaska	6			B. Mahoney, AFSC
Bowhead whale	Alaska	105			T. O'Hara, N. Slope Borough

SAMPLES FROM STRANDED ANIMALS

Species	Area/Stock	Calendar year/ season total	Archived (Y/N)	Tissue type (s)	Contact person/institute
Australia					
Pygmy Sperm whale	NSW	2	Y	liver, heart, kidney, muscle	S. Ingleby/AM
Striped dolphin	NSW	1	Y	liver, heart, kidney, muscle	S. Ingleby/AM
Minke whale	NSW	1	Y	Skin	Denis O'Meally / AM
Bryde's whale	NSW	1	Y	Skin	Denis O'Meally / AM
Bottlenose dolphin	Ballina, NSW	1	Y	Skin, blubber, liver, kidney, muscle	Wendy Blanshard, Sea World
Sperm whale	NT	1		Rib bone	Museum and Art Galleries of the NT, Darwin
Short-beaked common dolphin	SA coastline	2001/17	Y	Genetic tissues, reproductives, stomach and intestines, toxic contaminants, skeletal material	C. Kemper/SA Museum
Bottlenose dolphin	SA coastline	2001/21	Y	Genetic tissues, reproductives, stomach and intestines, toxic contaminants, skeletal material	C. Kemper/SA Museum
Dolphin	SA coastline	2001/1	Y	Skeletal material	C. Kemper/SA Museum
<i>Mesoplodon</i> sp.	SA coastline	2001/1	Y	Genetic tissues, toxic contaminants, reproductives, stomach & intestines, skeletal material	C. Kemper/SA Museum
<i>Globicephala</i> sp.	SA coastline	2001/1	Y	Genetic tissues, reproductives, stomach and intestines, toxic contaminants, skeletal material	C. Kemper/SA Museum
Pygmy sperm whale	SA coastline	2001/2	Y	Genetic tissues, reproductives, stomach and intestines, toxic contaminants, skeletal material	C. Kemper/SA Museum
<i>Kogia</i> sp.	SA coastline	2001/1	Y	Genetic tissue, toxic contaminants, skeletal material	C. Kemper/SA Museum
Pygmy right whale	SA coastline	2001/1	Y	Genetic tissue, toxic contaminants, skeletal material	C. Kemper/SA Museum
Humpback whale	QLD	1	Y	Muscle, blood	P. Hale/UQLD, D. Paton Southern Cross Uni; Blood used for path then disposed of.
Humpback whale	QLD	1	Y	Muscle, blood	P. Hale/UQLD, D. Paton/Southern Cross Uni. Blood used for path then disposed of.
Sperm whale	Hunter Is, TAS	1	Y	Muscle block, teeth	R. Gales/Nature Conservation Branch, DPIWE
Sperm whale	Sellars Spit vs Babal Island Spit, TAS	1	Y	Muscle block, bottom jaw	R. Gales/Nature Conservation Branch, DPIWE
S Pygmy Right	Sandford, TAS	1	Y	Muscle blocks, reproductive organs, stomach content and skeleton	R. Gales/Nature Conservation Branch, DPIWE
Hector's beaked whale	Four Mile Creek, TAS	2	Y	Skin, blubber, liver, skeleton, reproductive organs, stomach	R. Gales/Nature Conservation Branch, DPIWE
Unidentified baleen whale	Sloping Main Beach, TAS	1	Y		R. Gales/Nature Conservation Branch, DPIWE
Sperm whale	Port Fairy, VIC	2001	Y	Skin, blubber & muscle, skeletal material	L. Frigo/Museum Victoria
Killer whale	Johanna, VIC	2001	Y	Skin, blubber & stomach contents, skeletal material	L. Frigo/Museum Victoria
Long-finned pilot whale	Sandy Point, VIC	2001	Y	Kidneys & heart, skeletal material	L. Frigo/Museum Victoria
Unidentified dolphin	Apollo Bay, VIC	2001	Y	Skin & blubber, skeletal material	L. Frigo/Museum Victoria
Blue whale	Bass Strait, VIC	1	Y	Tissue	P. Gill/Australocetus, C. Austin, Deakin University

Cont.

Samples from stranded animals continued.					
Species	Area/stock	Calendar year/ Season total	Archived (Y/N)	Tissue type (s)	Contact person/institute
Bottlenose dolphin	Australian, WA	1 (June 2001)		Blubber	WA Department of Conservation and Land Management
Bottlenose dolphin	Australian, WA	1 (September 2001)		Various	WA Department of Conservation and Land Management
Blue whale	Southern Hemisphere, WA	1 (December 2001)		Various	WA Museum
Brazil					
Humpback Whale Franciscana	W. S. Atlantic LNRS	1	Y	Gonads, liver, kidney, blubber, muscle, stomach, teeth and skull.	Instituto Baleia Jubarte Ignacio Moreno GEMARS
Clymene dolphin	LNRS	1	Y	Complete skeleton, gonads, liver, kidney, blubber, muscle, and stomach.	Ignacio Moreno GEMARS
Bottlenose dolphin	LNRS	1	Y	Skull, teeth, muscle, stomachs.	Ignacio Moreno GEMARS
Minke whale	LNRS	2	Y	Skull, muscle, gonads, blubber and baleen	Ignacio Moreno GEMARS
Right whale	LNRS	1	Y	Muscle, blubber, skin, baleen and callosities with (<i>Cyamus</i> spp)	Ignacio Moreno GEMARS
Sperm whale Franciscana	LNRS	1	Y	Skull and muscle	Ignacio Moreno GEMARS
	Northern Rio de Janeiro	1	Y	Skin, blubber, liver, kidney, muscle, blood, stomach contents and gonads	Ana Paula M. Di Benedetto and Renata M. Ramos - UENF
Humpback Whale	W. S. Atlantic	4	Y	Skin and blubber	Instituto Baleia Jubarte
Humpback Whale	W. S. Atlantic	1	Y	skin	CMA/Instituto Baleia Jubarte
	W. S. Atlantic	3	Y	Bones	CMA
Tucuxi	W. S. Atlantic	1	Y,N,N,N	Bones, lung, heart, liver	CMA
Tucuxi	W. S. Atlantic	1	Y,N,N,N,N	Bones, liver, lung, kidney, heart	CMA
Tucuxi	W. S. Atlantic	1	Y	Parasites, small intestine, lung, kidney, bladder, stomach, skin	CMA
Short-finned pilot whale	W. S. Atlantic	1	Y	Skin, tooth	CMA
Sperm whale	W. S. Atlantic	1	Y		
Canada					
Bowhead	HB-FB	3	Y		L. Maiers/O. Neilsen
Sperm whale	Clyde River	1	Y		L. Maiers/O. Neilsen
White whale	James Bay	2	Y	Old skull material	L. Maiers
Denmark					
Harbour Porpoise	Danish waters	17	Y	15 full autopsies	DFU
White-beaked Dolphin	Danish waters	19	Y	Full autopsies and sampling for tissue bank	ZM/FSM
France					
Cetaceans	Mediterranean	2001/NA	Y	Miscellaneous	EPHE
Sperm whale	New Caledonia	2001/1	Y	Skin, liver	OCNC
Germany					
Harbour porpoise	North Sea Schleswig-Holstein	2001/102	22	Different tissues for histopathology, toxicology, genetics	U. Siebert
Harbour porpoise	Lower Saxony	2001/ 9	9	Lung, liver, different tissues	M. Stede
Harbour porpoise	Baltic Sea. Schleswig-Holstein	2001/14	7	Different tissues for histopathology, toxicology, genetics	U. Siebert
Harbour porpoise	Baltic Sea. Meckl.-Prepom.	2001/8	8	Skeleton, various tissues	H. Benke
Iceland					
White-beaked dolphin	W. Iceland	2001/March/ 2002/January 2 animals	Y	Teeth, gonads, stomach, muscle, blubber, skin, blood, heart, liver, kidney	MRI
Minke whale	SW Iceland	2001/Sept./1 animal	Y	Ear plug, stomach, muscle, blubber, skin, blood, kidney	MRI
Northern bottlenose whale	W Iceland	2001/Sept./1 animal	Y	Gonads, stomach, muscle, blubber, skin, blood	MRI
Ireland					
Harbour porpoise	NE Atlantic	12	Y	Skin, blubber etc	UCC
Common dolphin	NE Atlantic	5	Y	Skin, blubber etc	UCC
Striped dolphin	NE Atlantic	2	Y	Skin, blubber etc	UCC
Bottlenose dolphin	NE Atlantic	4	Y	Skin, blubber etc	UCC

Cont.

Samples from stranded animals continued.

Species	Area/stock	Calendar year/ Season total	Archived (Y/N)	Tissue type (s)	Contact person/institute
Atlantic white-sided dolphin	NE Atlantic	3	Y	Skin, blubber etc	UCC
Pilot whale	NE Atlantic	7	Y	Skin	UCC
Killer whale	NE Atlantic	1	Y	Skin, blubber etc	UCC
Minke whale	NE Atlantic	3	Y	Skin, blubber etc	UCC
Cuvier's whale	NE Atlantic	1	Y	Skin	UCC
Italy					
Cuvier's beaked whale	Tyrrhenian Sea	1 male	Y	Kidney, thyroid, liver, spleen, heart, lung, stomach	BIT
Risso's dolphin	Adriatic Sea	1 male	Y	Heart, stomach, intestine, kidney, spleen, trachea, liver, testicle, muscle, lung, kidney, brain, umbilical chord	BIT
Striped dolphin	Adriatic Sea (2); Ligurian Sea (1)	3 males	Y	Tongue, oesophagus, stomach, intestine, diaphragm, heart, pericardium, lung, larynx, liver, spleen, lymph nodes, kidney, urethra, adrenal, bladder, testicle, brain, dorsal fin, aorta, eye, teeth, melon, pancreas, blubber	BIT
Japan					
Sperm whale	Ohura, Kagoshima	12		Teeth, biological samples	ICR
Sperm whale	Ohura, Kagoshima	1		Biological samples	National Science Museum
Korea					
Finless porpoise	East Sea	2	Y	Skin, muscle	Z.G. Kim/NFRDI
Mexico					
Pygmy beaked whale	Pacific	1	N	Muscle	H. Pérez-Cortés
New Zealand					
Andrews' beaked whale	NZ	1	Y	Skin, blubber	M. Dalebout/ Auckland Univ.
Bottlenose dolphin	NZ	1	Y	Skin, blubber	D. Steel & M. Dalebout/ Auckland Univ.
Bottlenose dolphin	NZ	1	Y	Skin, blubber, fixed tissues	P. Duignan/ Massey Univ.
Bryde's whale	NZ	1	Y	Skin, blubber	D. Steel & M. Dalebout/ Auckland Univ.
Common dolphin	NZ	5	Y	Skin, blubber	D. Steel & M. Dalebout/ Auckland Univ.
Common dolphin	NZ	3	Y	Skin, blubber, fixed tissues	P. Duignan/Massey Univ.
Dusky dolphin	NZ	4	Y	Skin, blubber	D. Steel & M. Dalebout/Auckland
Dusky dolphin	NZ	1	Y	Skin, blubber, fixed tissues	M. Dalebout/ Auckland Univ.
Gray's beaked whale	NZ	6	Y	Skin, blubber	M. Dalebout/ Auckland Univ.
Gray's beaked whale	NZ	1	Y	Skin, blubber	M. Dalebout/ Auckland Univ.; P. Duignan/ Massey Univ.
Pygmy right whale	NZ	2	Y	Skin, blubber, fixed tissues	P. Duignan/ Massey Univ.
Pygmy sperm whale	NZ	1	Y	Skin, blubber	D. Steel & M. Dalebout/ Auckland Univ.
Pygmy sperm whale	NZ	8	Y	Skin, blubber, fixed tissues	P. Duignan/ Massey Univ.
Sperm whale	NZ	1	Y	Skin, blubber	D. Steel & M. Dalebout/ Auckland Univ.
Straptoothed whale	NZ	3	Y	Skin, blubber	M. Dalebout/ Auckland Univ.
Straptoothed whale	NZ	1	Y	Skin, blubber, fixed tissues	P. Duignan/ Massey Univ.
Striped dolphin	NZ	2	Y	Skin, blubber	D. Steel & M. Dalebout/ Auckland Univ.
Striped dolphin	NZ	3	Y	Skin, blubber, fixed tissues	P. Duignan/ Massey Univ.
Norway					
Sperm whale	Sola, SW Norway	1		Blubber, eye, teeth	IMR
Oman					
Balaenoptera sp.	Arabian Sea/Gulf of Oman	2001-2002		Skin, muscle, stomach contents	OWDRG/ONHM
Humpback whale	Arabian Sea/Gulf of Oman	2001		Skin, blubber	WCS/OWDRG/ONHM
Sperm whale	Arabian Sea/Gulf of Oman	2001		Skin, muscle, stomach contents	OWDRG/ONHM
Dwarf sperm whale	Arabian Sea/Gulf of Oman	2001		Connective tissue	OWDRG/ONHM
False killer whale	Arabian Sea/Gulf of Oman	2001		Skin, muscle, stomach contents	OWDRG/ONHM
<i>Sousa plumbea</i>	Arabian Sea/Gulf of Oman	2001		Skin, muscle, stomach contents	WCS/OWDRG/ONHM
Rough-toothed dolphin	Arabian Sea/Gulf of Oman	2001		Skin, muscle, liver, kidney, blood, stomach contents	OWDRG/ONHM

Cont.

Samples from stranded animals continued.

Species	Area/stock	Calendar year/ Season total	Archived (Y/N)	Tissue type (s)	Contact person/institute
Risso's dolphin	Arabian Sea/Gulf of Oman	2001		Skin, muscle	OWDRG/ONHM
Tursiops sp.	Arabian Sea/Gulf of Oman	2001		Skin, muscle, liver, kidney, blood, stomach contents	OWDRG/ONHM
Spinner dolphin	Arabian Sea/Gulf of Oman	2001		Skin, muscle, stomach contents	
Long-beaked common dolphin	Arabian Sea/Gulf of Oman	2001		Skin, muscle, stomach contents	OWDRG/ONHM
South Africa¹					
Humpback whale	West coast	1	Y	S,B,L,C	MRI Whale Unit
Southern right whale	South Africa	1	Y	B,C,L	MRI Whale Unit
Southern right whale	South Africa	1	Y	B,C,G,A	MRI Whale Unit
Southern right whale	South Africa	1	Y	S,B,C,A	MRI Whale Unit
Southern right whale	South Africa	1	Y	S	MRI Whale Unit
Southern right whale	South Africa	1	Y	C,A	MRI Whale Unit
Sperm whale	South Africa	1	Y	B,G,T	MRI Whale Unit
Pygmy sperm whale	South Africa	2	Y	G,K,P	MRI Whale Unit
Shortfin pilot whale	East Coast	1	Y	K,T,G	PEM
Pygmy killer whale	East Coast	1	Y	K,T,G	PEM
Mesoplodon spp	East Coast	5	Y	K,T,G	PEM
Layard's beaked whale	South Africa	1	Y	S,B,C,G,K	MRI Whale Unit
Risso's dolphin	South Africa	1	Y	B,G,K	MRI Whale Unit
Common dolphin	South Africa	1	N		MRI Whale Unit
Common dolphin	South Africa	1	N		MRI Whale Unit
Common dolphin	South Africa	1	?	K,S	CDS
Common dolphin	South Africa	1	N	CV	DEAT
Common dolphin	South Africa	1	N	S,T,K,CV	DEAT
Common dolphin	South Africa	1	N	S,B,T,G,K,	DEAT
Long-beaked common dolphin	KwaZulu-Natal	1	Y	S,G,T,ST	NSB
Heaviside's dolphin	South Africa	1	N		MRI Whale Unit
Dusky dolphin	South Africa	1	N		MRI Whale Unit
Dusky dolphin	South Africa	1	Y	T	MRI Whale Unit
Striped dolphin	South Africa	1	Y	K	MRI Whale Unit
Striped dolphin	KwaZulu-Natal	1	Y	S,K,G,T,ST	NSB
Indian Ocean bottlenose dolphin	KwaZulu-Natal	1	Y	S,G,T,ST	NSB
Pan-tropical spotted dolphin	KwaZulu-Natal	2	Y	S,K,G,T,ST	NSB
Spain					
Common dolphin	NE Atlantic/Mediterranean	1/?	Y	All tissues	GRAMPUS/Raga (UV)
Striped dolphin	NE Atlantic/Mediterranean	5/?	Y	All tissues	CRAM/Raga (UV)
Bottlenose dolphin	NE Atlantic/Mediterranean	1/1+?	Y	All tissues	GRAMPUS/CRAM/ Raga (UV)
Risso's dolphin	Mediterranean	1/?	Y	All tissues	CRAM/Raga (UV)
Harbour porpoise	NE Atlantic	2	Y	All tissues	GRAMPUS
Long-finned pilot whale	NE Atlantic/Mediterranean	1/?	Y	All tissues	GRAMPUS/Raga (UV)
Pygmy sperm whale	NE Atlantic	1	Y	All tissues	Lens (IEO)
Minke whale	NE Atlantic	1	Y	Skin, blubber, muscle	GRAMPUS
Sweden					
Harbour porpoise	Swedish Skagerrak and Kattegat Seas, and Oresund	6	Y	Dorsal fin and teeth	P. Rudd
Minke whale	Swedish Skagerrak Sea	2	N	Dorsal fin and teeth	P. Rudd
UK					
Harbour porpoise	UK	112	Y	Various	P. Jepson (IoZ) /R. Sabin (NHM)
	UK	71	Y	Skulls	NMS
	Ireland	11	Y	Skulls	NMS
Common dolphin	UK	33	Y	Various	P.Jepson (IoZ) /R. Sabin (NHM)
	Scotland	2	Y	Skeleton	NMS
	Eng & Wales	8	Y	Skulls	NMS
	Ireland	13	Y	Skulls	NMS
Striped dolphin	UK	10	Y	Various	Paul Jepson (IoZ)
	UK	8	Y	Skulls	NMS
	Ireland	4	Y	Skulls	NMS
Atlantic white-sided dolphin	UK	4	Y	Various	Paul Jepson (IOZ)
	Scotland	4	Y	Skulls	NMS
	Ireland	2	Y	Skulls	NMS

Cont.

Samples from stranded animals continued.

Species	Area/stock	Calendar year/ Season total	Archived (Y/N)	Tissue type (s)	Contact person/institute
White-beaked dolphin	UK	4	Y	Various	Paul Jepson (IOZ)
	UK	2	Y	Skulls	NMS
Pilot whale	UK	3	Y	Various	Paul Jepson (IoZ)
	Scotland	1	Y	Skull	NMS
Sowerby's beaked whale	UK	2	Y	Various	Paul Jepson (IOZ)
	Scotland	2	Y	Skeletons	NMS
Bottlenose dolphin	UK	3	Y	Various	P.Jepson (IoZ) /R. Sabin (NHM)
	Scotland	2	Y	Skeleton	NMS
Risso's dolphin	UK	2	Y	Various	Paul Jepson (IoZ)
	Scotland	2	Y	Skeletons	NMS
Minke whale	UK	2	Y	Various	Paul Jepson (IoZ)
	Scotland	3	Y	Baleen	NMS
Sei whale	UK	1	Y	Various	P. Jepson (IoZ)/R. Sabin (NHM)
Killer whale	UK	1	Y	Various	Paul Jepson (IoZ)
					Richard Sabin (NHM)
Humpback whale	UK	1	Y	Various	Paul Jepson (IoZ)
Northern bottlenose whale	UK	1	Y	Various	Paul Jepson (IOZ)
	Scotland	2	Y	Skeletons	NMS
Pygmy sperm whale	UK	1	Y	Skull	NMS
USA					
White whale	Alaska	6			B. Mahoney, AFSC
Gray whale	Eastern No. Pacific	14			J. Calambokidis, Cascadia Research
Gray whale	Eastern No. Pacific	6			B. Norberg, NWFSC
Harbor porpoise	Central California	2			F. Gulland
	Coast				
Humpback whale	Alaska	1			C. Gabriele, Glacier Bay National Park and Preserve
Stejneger's beaked whale	Washington coast	1			B. Norberg, NWFSC
Pacific white-sided dolphin	Central California	6			F. Gulland, The Marine Mammal Center
	Coast				

South Africa¹ Key: S=skin, B=blubber, T=teeth, W=baleen, G=gonads, C=ext parasites, P=internal parasites, K=skeletal remains, A=pathology samples, CV=cardiovascular systems, ST=stomach.

PREVIOUS YEARS SAMPLES FROM STRANDED ANIMALS

Species	Area/Stock	Calendar year/ season total	Archived (Y/N)	Tissue type (s)	Contact person/institute
Australia					
Blainville's beaked whale	Southern Hemisphere, WA	2000/1		Tissue for DNA, head	WA Museum
Blue whale (pygmy?)	Southern Hemisphere, WA	2000/1		Plug for DNA, baleen sample	WA Museum
Gray's beaked whale	Southern Hemisphere, WA	2000/2		Skin sample	N. Gales, Australian Antarctic Division
Humpback whale	Groups B and C, WA	2000/1		Skin and blubber	M. Jenner, Western Australia Humpback Whale Project
France					
Fin whale	Atlantic and Med	2000/3	Y	Various tissues	CRMM
Delphinids spp	Atlantic	2000/2	Y	Various tissues	CRMM
Common dolphin	Atlantic	2000/126	Y	Various tissues	CRMM
Striped dolphin	Atlantic	2000/12	Y	Various tissues	CRMM
White-beaked dolphin	Atlantic	2000/1	Y	Various tissues	CRMM
Bottlenose dolphin	Atlantic	2000/7	Y	Various tissues	CRMM
Long finned pilot whale	Atlantic	2000/2	Y	Various tissues	CRMM
Harbour porpoise	Atlantic	2000/11	Y	Various tissues	CRMM
Mexico					
Blue whale	El Sauzal port, Ensenada	2000/1		Skin	ICMME

STATISTICS FOR LARGE CETACEANS: DIRECT CATCHES (COMMERCIAL, ABORIGINAL AND SCIENTIFIC PERMITS) FOR THE CALENDAR YEAR 2001 OR SEASON 2001/02

Species	Type of catch	Area/stock	Males	Females	Total landed	Struck and lost
Denmark						
Fin whale	Aboriginal	West Greenland	3	4	7	1
Minke whale	Aboriginal	West Greenland	32	91	136	1
Minke whale	Aboriginal	East Greenland	0	14	14	3
Japan						
Minke whale	Special permit	N. Pacific	93	7	100	
Minke whale	Special permit	Antarctic	201	239	440	
Sei whale	Infraction	N. Pacific	1	0	1	
Bryde's whale	Special Permit	N. Pacific	17	33	50	
Sperm whale	Special permit	N. Pacific	2	6	8	
Norway						
Minke whale	Small-type whaling	EB, EN, ES, EC, CM			552	
St Vincent and the Grenadines						
Humpback whale	Aboriginal	N. Atlantic	1	1	2	
USA						
Bowhead whale	Aboriginal	N. Slope Borough			49	26

OTHER NON-NATURAL MORTALITY FOR THE CALENDAR YEAR 2001 OR THE SEASON 2001/02 (LARGE CETACEANS)

Species	Area/stock	Males	Females	Total	Cause	Methodology
Australia						
Humpback whale	NSW		1	1	Entanglement (float line next to beach shark protection net) – see below	Post mortem
Humpback whale	Gold Coast		Calf?	1	Entanglement (shark protection net)	Found dead
Humpback whale	Area V (NSW)			1	Boat strike – probably survived	
Humpback whale	Area V (NSW)			1	Entanglement	
Humpback whale	Area V (NSW)			1	Unknown	
Southern right whale	Head of the Bight, SA		1	1	Entanglement (tuna long line and buoys) and shark attack	Observation
Southern right whale	Head of the Bight, SA			1	Sub-adult (cause unknown)	Carcass inaccessible
Southern right whale	Victor Harbour, SA		1	1	Probable boat strike	Found dead
Blue whale	WA			1	Possible yacht strike	
Blue whale	VIC			1	?	
False killer whale	NSW	1			Net entanglement	
Denmark						
Humpback whale	West Greenland			2	Bycatch	
Japan						
Minke whale	Hokkaido			9	Trap net	
	Aomori			2	Trap net	
	Iwate			4	Trap net	
	Miyagi			4	Trap net	
	Niigata			5	Trap net	
	Toyama			7	Trap net	
	Ishikawa			25	Trap net	
	Fukui			3	Trap net	
	Kyoto			2	Trap net	
	Chiba			2	Trap net	
	Kanagawa			1	Trap net	
	Shizuoka			1	Trap net	
	Mie			1	Trap net	
	Wakayama			5	Trap net	
	Yamaguchi			1	Trap net	
	Kochi			2	Trap net	
	Nagasaki			4	Trap net	
	Miyazaki			1	Trap net	

Cont.

Other non-natural mortality continued.

Species	Area/stock	Males	Females	Total	Cause	Methodology
Japan continued						
Fin whale	Hyogo			1	Other coastal fishery	
Unidentified balaenopterid	Mie			1	Trap net	
Minke whale	Hokkaido			5	Stranding	
	Aomori			1	Stranding	
	Iwate			2	Stranding	
	Yamagata			1	Stranding	
	Kochi			1	Stranding	
Bryde's whale	Hyogo			1	Stranding	
Humpback whale	Okinawa			1	Stranding	
Sperm whale	Hokkaido			1	Stranding	
	Chiba			1	Stranding	
	Miyazaki			1	Stranding	
Unidentified balaenopterid	Niigata			2	Stranding	
	Yamaguchi			1	Stranding	
Korea						
Minke whale	East Sea	7	25	132	Entangled	Post mortem
Minke whale	East Sea		1	4	Drifted	Post mortem
Minke whale	East Sea			1	Stranded	Post mortem
Minke whale	South Sea	3	6	11	Entangled	Post mortem
Minke whale	South Sea	1	1	2	Drifted	Post mortem
Minke whale	Yellow Sea		1	5	Entangled	Post mortem
Minke whale	Yellow Sea		4	5	Stranded	Post mortem
Oman						
Balaenoptera sp.	Arabian Sea			1	Gillnet entanglement	Photograph
Balaenoptera sp.	Arabian Sea			1	Unknown	Photograph
Sperm whale	Gulf of Oman			1	Unknown	Observation
Spain						
Sperm whale	Canary Is.	1	1	3	Ship strike	Post mortem
UK						
Minke whale	England	1	0	1	Entanglement/by-catch	Post mortem
USA						
Humpback whale	N. Pacific			1	Alaska groundfish fisheries	
Fin whale	Alaska			1	Alaska groundfish fisheries	
Sperm whale	Alaska			1	Alaska groundfish fisheries	

LARGE CETACEANS: EARLIER YEARS' STATISTICS

Incidental mortality					
Year	Species	Area/stock	Reported	Est. total	Source
Australia					
2000	Blue/pygmy blue whale	Troughton Island, WA	1		Ship strike most likely
Spain					
2000	Sperm whale	Canary Is.	5		Ship strike
	Bryde's whale	Canary Is.	1		Ship strike
	Unidentified rorqual	Canary Is.	1		Ship strike
	Minke whale	NE Atlantic	1		Incidental catch
USA					
1999	North Atlantic right whale	Cape Cod, MA	1 female		Ship strike
	North Atlantic right whale	Cape Cod, MA	1 female		Fishery interaction/entanglement
	Humpback whale	Gulf of Maine	1 male		Fishery interaction/entanglement
	Minke whale	Cape Lookout, NC	1 female		Fishery interaction/entanglement
	Minke whale	Orleans, MA	1 female		Fishery interaction/entanglement
	Minke whale	Sakonnet River, RI	1		Fishery interaction/entanglement
	Minke whale	Pt Judith Light, RI	1		Fishery interaction/entanglement
	Minke whale	Provincetown, MA	1 female		Fishery interaction/entanglement
	Fin whale	Virginia Beach, VA	1 male		Ship strike
	Fin whale	Elizabeth, NJ	1 male		Ship strike

STATISTICS FOR SMALL CETACEANS: FOR THE CALENDAR YEAR 2001

		Directed Catch		Incidental Mortality		Live-capture	
Species	Area/stock	Reported	Est. Total	Reported	Est. Total	Source	Reported
Australia¹							
Common dolphin	Sunshine Coast, QLD	-	-	1		QDPI-SCP ²	-
Common dolphin	Sunshine Coast, QLD	-	-	1		QDPI-SCP	-
Common dolphin	Gold Coast, QLD	-	-	1		QDPI-SCP	-
Common dolphin	Gold Coast, QLD	-	-	1		QDPI-SCP	-
Common dolphin	Sunshine Coast, QLD	-	-	1		QDPI-SCP	-
Indo-Pacific humpback dolphin	Sunshine Coast, QLD	-	-	1		QDPI-SCP	-
Indo-Pacific humpback dolphin	Cairns, QLD	-	-	1		QDPI-SCP	-
Tursiops sp.	Gulf of Carpentaria, QLD	-	-	3		N9 gill net fishery	-
Bottlenose dolphin	Sunshine Coast, QLD	-	-	1		QDPI-SCP	-
Bottlenose dolphin	Gold Coast, QLD	-	-	1		QDPI-SCP	-
Bottlenose dolphin	Gold Coast, QLD	-	-	1		QDPI-SCP	-
Bottlenose dolphin	Gulf of Carpentaria, QLD	-	-	1		N9 gill net fishery	-
Bottlenose dolphin	Mackay, QLD	-	-	1		QDPI-SCP	-
Common dolphin	SE Aust, QLD	-	-	2		Gillnet	-
Short-beaked common dolphin	SA coastline	-	-	1	Unknown	Intentional Killing	-
Bottlenose dolphin	SA coastline	-	-	2	Unknown	Probable entanglement	-
Bottlenose dolphin	SA coastline	-	-	1	Unknown	Euthanased	-
Bottlenose dolphin	TAS	-	-	1		Salmon farm net	-
Brazil							
Franciscana	LNRS	0	0	1	-	Gillnet	0
Franciscana	Northern Rio de Janeiro	0	0	18	-	Gillnet	0
Tucuxi	Northern Rio de Janeiro	0	0	4	-	Gillnet	0
Canada							
White whale	Nunavut	375		0			0
White whale	North West Territories-Beaufort Sea	Not available		0			0
Narwhal	High Arctic	451		0			0
Narwhal	Hudson Bay	108		0			0
France							
Spotted dolphin	Caribbean	0	0	1	No data	Etr	
Common dolphin	English Channel	0	0	1	No data	CRMM	
Common dolphin	Atlantic	0	0	117	No data	CRMM	
Striped dolphin	Atlantic	0	0	7	No data	CRMM	
Striped dolphin	Mediterranean	0	0	4	326+/- 146	CRMM	
Bottlenose dolphin	English Channel	0	0	2	No data	CRMM	
Bottlenose dolphin	Atlantic	0	0	7	No data	CRMM	
Bottlenose dolphin	Mediterranean	0	0	1	No data	CRMM	
Long finned pilot	Atlantic	0	0	1	No data	CRMM	
Long finned pilot	Mediterranean	0	0	1	No data	CRMM	
Harbour porpoise	English Channel	0	0	3	No data	CRMM	
Harbour porpoise	Atlantic	0	0	9	No data	CRMM	
Germany							
Harbour porpoise	North Sea	0	0	0	Unknown		0
Harbour porpoise	Baltic Sea	0	0	5	5	Gillnet	0
	Schleswig-Holstein						
Harbour porpoise	Baltic Sea	0	0	3	3	Gillnet	1 doubtful
	Mecklenburg-Prepommerania						
Ireland							
Common dolphin	-	-	-	1	-	Bycatch	-
Harbour porpoise	-	-	-	1	-	Bycatch	-

Cont.

Statistics for small cetaceans continued.

Statistics for small cetaceans continued.							
		Directed Catch		Incidental Mortality			Live-capture
Species	Area/stock	Reported	Est. Total	Reported	Est. Total	Source	Reported
Korea							
Baird's beaked whale	East Sea			1		Gillnet	
	East Sea			2		Stranded	
Stejneger's beaked whale	East Sea			1		Stranded	
	East Sea			3		Drifting	
Risso's dolphin	East Sea			4		Purse-seine	
				5		Gillnet	
				4		Set net	
				1		Long line	
				2		Trap net	
				9		Unidentified	
Common dolphin	East Sea			18		Purse-seine	
				1		Long line	
				8		Gillnet	
				32		Set net	
				3		Trap net	
				2		Stranded	
	South Sea			1		Drifted	
Pacific white-sided dolphin	East Sea			21		Gillnet	
				14		Set net	
				3		Trap net	
				2		Stranded	
				3		Unidentified	
Bottlenose dolphin	East Sea			1		Gillnet	
				1		Set net	
				1		Trawl	
Rough-toothed dolphin	South Sea			1		Stranded	
Dall's porpoise	East Sea			1		Gillnet	
				1		Set net	
Harbour porpoise	East Sea			1		Long line	
				57		Gillnet	
				29		Set net	
				1		Stranded	
				1		Drifted	
Finless porpoise	East Sea			5		Gillnet	
				2		Set net	
				2		Stranded	
				2		Drifted	
	South Sea			4		Stranded	
				2		Drifted	
Mexico							
Bottlenose dolphin	Gulf of California	0	0	1	-		15
Vaquita	Gulf of California	0	0	2	-	Gillnet	0
New Zealand							
Common dolphin	NZ	0	0	3	?	Gillnet/ Trawl	0
Dusky dolphin	NZ	0	0	3	?	Trawl	0
Hectors dolphin	North Island, West Coast	0	0	3	?	Gillnet	0
Hectors dolphin	South Island, West Coast	0	0	6	?	Gillnet	0
Hectors dolphin	South Island, East Coast	0	0	4	?	Gillnet	0
South Africa							
Indian Ocean bottlenose dolphin	KwaZulu-Natal	0		22	22	Shark nets	
Indian humpback dolphin	KwaZulu-Natal	0		2	2	Shark nets	
Longbeaked common dolphin	KwaZulu-Natal	0		13	13	Shark nets	
Spain							
Common dolphin	Canary Is.			3		Fishing interaction	
Common dolphin	NE Atlantic			1			
Striped dolphin	Mediterranean			1		Trammel net	
Atlantic spotted dolphin	Canary Is.			1		Fishing interaction	

Cont.

Statistics for small cetaceans continued.

Statistics for Small Cetaceans continued.							
		Directed Catch		Incidental Mortality			Live-capture
Species	Area/stock	Reported	Est. Total	Reported	Est. Total	Source	Reported
Spain continued							
Bottlenose dolphin	NE Atlantic			2			
Harbour porpoise	NE Atlantic			1			
Pygmy sperm whale	Canary Is.			1		Ship strike	
White sided dolphin	NW Atlantic			1		Bottom trawl	
Unidentified dolphin	NW Atlantic			1		Bottom trawl	
Sweden							
Harbour porpoise	Baltic Sea			1		Gillnet	
Harbour porpoise	Swedish Skagerrak Sea			2		1 gillnet and 1 trawl	
UK							
Harbour porpoise	UK			11		Stranded/necropsy	
Common dolphin	UK			20		Stranded/necropsy	
				52		Pelagic trawling	
Striped dolphin	UK			3		Stranded/necropsy	
USA							
White whale ¹	Beaufort Sea	25 (18)					
	Chukchi Sea	84 (5)					
	Eastern Bering Sea	281 (28)					
	Bristol Bay	22 (ND)					

Australia: ¹Further information from the Queensland Marine Wildlife Stranding and Mortality Database is available from C. Limpus, QPWS. ²QDPI SCP = Queensland Department of Primary Industries Shark Control Program. Further information is available from B. Lane.

USA: ¹Numbers in parentheses provide struck and lost totals. ND=No data.

SMALL CETACEANS: EARLIER YEARS' STATISTICS

			Directed Catch		Incidental Mortality			Live-capture
Species	Year	Area/stock	Reported	Est. Total	Reported	Est. Total	Source	Reported
Australia								
Indo-Pacific humpbacked dolphin	2000	Lee Point Beach, NT			1		Entanglement	
Spain								
Cuvier's beaked whale	2000	Canary Is			1		Ship strike	
Probable pilot whale	2000	Canary Is			2		Ship strike	
Common dolphin	2000	NE Atlantic			3		Trawl/Gillnet/ Net	
Peale's dolphin	2000	SW Atlantic			1		Trawl	
Atlantic spotted dolphin	2000	Central N Atlantic			1		Longline	
Harbour porpoise	2000	NE Atlantic			2		Net	
Unidentified dolphin	2000	NE Atlantic			12		Pair trawl	
USA								
Bottlenose dolphin	1999	Mid-Atlantic			3	63	Coastal sink gillnet	
Bottlenose dolphin	1999	Central Florida			4	52	Florida shark gillnet	
Common dolphin	1999	NW Atlantic			2	146	Sink gillnet	
Common dolphin	1999	NW and Mid-Atlantic			1	49	Squid, mack, butt. trawl	
Harbour porpoise	1999	NW Atlantic			14	270	Sink gillnet	
Harbour porpoise	1999	Mid-Atlantic			3	53	Coastal sink gillnet	
Harbour porpoise	1999	NW and Mid-Atlantic			19	19	Gillnet	
Pilot whale	1999	NW Atlantic			1	228	Bottom trawl	
Pilot whale	1999	NW and Mid-Atlantic			1	49	Squid, mack, butt. trawl	
Pilot whale	1999	Mid-Atlantic			1	94	Pelagic longline	
Risso's dolphin		NW and Mid-Atlantic			1	22	Pelagic longline	
White-sided dolphin	1999	NW Atlantic			4	69	Sink gillnet	

Cont.

Small cetaceans: Earlier years' statistics continued.

			Directed Catch		Incidental Mortality			Live-capture
Species	Year	Area/stock	Reported	Est. Total	Reported	Est. Total	Source	Reported
USA continued								
White whale	2000	Beaufort Sea	16 (ND)					
	2000	Chukchi Sea	2 (3)					
	2000	Eastern Bering Sea	188 (24)					
	2000	Kuskokwim	0 (ND)					
	2000	Bristol Bay	6 (1)					
	1999	Beaufort Sea	33 (ND)					
	1999	Chukchi Sea	52 (0)					
	1999	Eastern Bering Sea	134 (25)					
	1999	Kuskokwim	0 (0)					
	1999	Bristol Bay	11 (0)					
	1998	Beaufort Sea	52 (5)					
	1998	Chukchi Sea	91 (5)					
	1998	Eastern Bering Sea	143 (27)					
	1998	Kuskokwim	2 (ND)					
	1998	Bristol Bay	18 (1)					
	1997	Beaufort Sea	32 (18)					
	1997	Chukchi Sea	16 (3)					
	1997	Eastern Bering Sea	141 (32)					
	1997	Kuskokwim	ND (ND)					
	1997	Bristol Bay	6 (4)					
Killer whale	1999	Alaska			2	4	Alaska groundfish fisheries	
Dall's porpoise	1999	Alaska			3	4	Alaska groundfish fisheries	
Dall's porpoise	1999	Washington, Oregon and California			1	1	Groundfish trawl fishery	
Short-beaked common dolphin	1999	California/Washington/Oregon			34	191	Swordfish/thresher shark drift gillnet fishery	
Long-beaked common dolphin	1999	California			1	8	Swordfish/thresher shark drift gillnet fishery	
Unidentified common dolphin	1999	California/Washington/Oregon			2	2	Swordfish/thresher shark drift gillnet fishery	
Northern right whale dolphin	1999	California/Washington/Oregon			3	17	Swordfish/thresher shark drift gillnet fishery	
Harbour porpoise	1999	Central California			28	133	Large mesh set gillnet fishery	

Appendix 1

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Annex P

Statements Relating to Agenda Items 19 and 22

ANNEX P1. STATEMENT ON ITEM 22 (WORKING METHODS OF THE COMMITTEE)

T. Smith (verbal), N. Gales, J. Palazzo, S. Childerhouse, M. Donoghue, L. Kell and D. Thiele (associated by)

Some members expressed concern about Japan's unwillingness to support three important aspects of the work of the Scientific Committee:

- (1) refusal to participate in the Intersessional Working Group to review Bryde's whale catch data proposed by the Revised Management Procedure sub-committee (Item 6.4.1), even though the official catch data reported to the IWC for some years in the mid-20th century may have been misreported by whaling companies and even though access to company operational summary charts had been arranged;
- (2) refusal to endorse a Whale Bycatch Workshop, proposed by the Working Group on Estimation of Bycatch and other Human-Induced Mortality (Item 7.2.1), despite the higher reports of western North Pacific minke whale bycatch this year;
- (3) withdrawal from the Fisheries Interaction Modelling Workshop, now to be held in La Jolla, California, of the Standing Working Group on Environmental Concerns (Item 12.3.4), explained in part as conflicts with dates,

even though Japan had agreed the 24-27 June 2002 dates as long ago as November 2001.

The lack of participation of Japanese scientists in these activities, which the full Committee adopted and endorsed, would reduce the Committee's ability to complete work on three tasks that Japan had previously indicated strong interest in. These tasks are:

- (1) Implementation of the RMP for western North Pacific Bryde's whales.
- (2) Implementation of the RMP for western North Pacific minke whales.
- (3) Evaluation of the modelling approaches in use in JARPEN II.

Japan's refusal to participate in the above three activities is impairing the Committee's progress on the three tasks listed. This is impairing the Committee's ability to provide advice to the Commission on these matters, and raises the question of the appropriateness of the high priority that the Committee has continued to give to these tasks for several years.

ANNEX P2. STATEMENT ON ITEM 19 (COMMITTEE PRIORITIES AND INITIAL AGENDA FOR THE 2003 MEETING) AND RESPONSE TO ANNEX P1

M. Komatsu

Japan is deeply concerned that the Scientific Committee is increasingly moving away from its primary objective related to the provision of management advice for the sustainable utilisation of large whales to matters of peripheral interest. This problem has been exacerbated by the unnecessary complication of issues beyond that required for provision of advice on, among other things, stock definition and RMP trials. This has led to the unacceptable situation that despite beginning work to implement the RMP for North Pacific minke whales more than 10 years ago, we are still being asked to provide additional data when the provision of such data simply leads to more unnecessary delays, additional hypotheses and more requests for data.

There has also been an increasing dissociation of the Committee's work from science with the result that much of the discussion on important matters has become little more than inappropriate politically motivated discourse. Japan is

also concerned with the increasing attempts by some members to have the Scientific Committee intervene in matters that are the sole responsibility of sovereign states such as the management of small cetaceans and domestic markets. We regret that the functioning of the Scientific Committee has degenerated in this manner that has produced mistrust among scientists and an atmosphere that impedes rather than encourages the progress of good science. We urge Committee members to examine these matters seriously.

- (1) Concerning participation in the Workshop on Methodological/Modelling Techniques to Examine Interactions between Whales and Fish Stocks, Japan has already noted that the proposed change in venue and timing were problematic. We have already noted our view that the Workshop should be held in either Japan or

Norway since these countries have large datasets that will be required for use in models. The major problem however is that the proposed dates conflict with other obligations for Japanese scientists. We regret that the Scientific Committee did not take these concerns into account, and conclude that this matter should be decided by the Commission since the original decision was made by the Commission.

- (2) With respect to Japan's decision not to participate in the Working Group to examine alleged misreporting of catch data in Japanese whaling operations, we have already explained that we do not have access to data that forms the basis of the allegations. For this reason we see

no merit in participating in the Working Group. Japan will however conduct its own investigation of this matter.

- (3) Japan's decision not to participate in the Scientific Committee discussions of small cetaceans is one of the issues that is the subject of the first paragraph of this statement. Small cetaceans are outside the competence of IWC. While we have provided data on small cetaceans in the past on a voluntary basis, it is our experience that this data has been misused and has resulted in increasing attempts to interfere in the management of these stocks that is the sovereign right of Japan.

ANNEX P3. STATEMENT IN RESPONSE TO ANNEX P1

L. Walløe

It is my serious opinion that the actions taken by the Japanese scientists and criticised by Smith in his intervention, must be understood on the background of what has happened with the RMP *Implementation* for North Pacific Minke Whales during the last five to six years. In the RMP sub-committee I made the following statement, which is only vaguely reflected in one sentence in the sub-committee Report.

The failure of the IWC Scientific Committee to finalise the RMP *Implementation Trials* and complete the *Implementation* for western North Pacific minke whales after 10 years of work is bound to have serious consequences for the credibility of this Scientific Committee. In an earlier intervention in the sub-committee, a well-respected member of the delegation of a non-whaling nation stated that 'the completion of this *Implementation* carries a substantial political baggage'. I agree, but would like to restate the same opinion in a somewhat more blunt language: The failure to complete this *Implementation* is politically motivated, not

scientifically motivated. I also agree with the delegate quoted above that this *Implementation* could and should have been completed five years ago, based on the knowledge available then. It is implicit in scientific work that our knowledge will never be perfect and complete. That is why we should have *Implementation Reviews* every five years or so. If the *Implementation* for western North Pacific minke whales had been completed in 1997, it would have been time for an *Implementation Review* by now, and some of the more recent hypotheses on stock structures could have been explored in the Review.

To me it is especially disturbing that in this case – and I would like to add: in this case only – some of the senior and usually scientifically serious members of the US delegation to the Scientific Committee have taken part in these politically motivated delay operations.

The Japanese regrettable actions must be understood on this background.

Annex Q

Appointment of Chair and Vice-Chair of the Scientific Committee

At this year's meeting, the Scientific Committee must appoint a new Chair and Vice-Chair. This document provides some background on how the process for appointing Chairs and Vice Chairs has been done in the past, and some thoughts/proposals to guide the procedure here in Shimonoseki and at future meetings, including the qualities needed for, responsibilities of, and the time commitment involved in these positions.

Past practice

Until the 51st Annual Meeting in Grenada in 1999, suitable candidates for Chair and Vice-Chair were 'sounded out' by the outgoing Chair and senior members of the Committee and checked for 'acceptability' with the main delegations. During the final plenary, the Chair would propose the candidates who would then be seconded from the floor and duly elected by consensus. This really only applied to the new Vice-Chair as the old Vice-Chair was always, as intended, elevated to Chair. It was a very informal process that worked satisfactorily for many years, although during the selection process at the meeting in 1996, comments were made to the then Chair that the procedure was not sufficiently transparent and democratic. As a result, a different procedure was followed for the appointments made at the meeting in Grenada when all heads of national delegations were consulted and a formal election was held in which votes were cast. The procedure used in Grenada was rather *ad hoc*, with heads of national delegations not being formerly identified or adequately briefed. It would therefore be appropriate to develop a clearer procedure agreed by the Committee that can be more formalised in Rules of Procedure.

Qualities, responsibilities and commitment required Chair

The Chair is primarily a facilitator.

The Chair:

- (1) must be able to chair difficult meetings effectively;
- (2) should understand the work of the Committee and the Commission at least in general terms;
- (3) must be able to present the Committee's work clearly to the Commission — what the Chair presents to the Commission comes straight from the SC report, but he/she must be able to answer questions from the Commissioners;
- (4) must have the trust and support of the Committee — this means he/she must not only be completely fair in chairing and reporting, but must be *perceived* to be fair

and able to be trusted not to favour a particular political position. This requires a person broadly acceptable to all 'shades' of opinion within the Committee.

At least one month each year is taken up by the Scientific Committee and Commission meetings, and the intersessional period involves a lot of e-mail correspondence dealing with the many administrative issues relating to IPs, agenda, etc. and possibly attendance at intersessional meetings. This might take an additional 1-2 months.

Vice-Chair

The Vice-Chair should have, or be expected to develop, the same qualities as the Chair. The time commitment each year is generally less than for the Chair, i.e. usually little intersessional time and only the two-week Scientific Committee meeting to attend, although he/she should attend at least one Commission meeting as an observer if he/she has not previously attended Commission meetings.

The general rule that the Vice-Chair becomes Chair after three years is a good one. It ensures that the new Chair has recent experience in the leadership of the Committee and makes it necessary to choose only one, instead of two new facilitators every three years. There is strong support in the Committee that this tradition should continue unless either the Committee or the Vice-Chair has good reasons to decide otherwise. It is all but essential to choose the Chair from the current or past Convenors group and desirable if the Vice-Chair is also, or has been, a Convenor. Alternatively, he/she should have equivalent experience in other international fora.

Other important considerations

In addition to meeting the qualities described above, it is important that there is balance in the appointment of the Chair and Vice-Chair. As the Committee moves into an era of increased openness in which heads of delegation play more of a role in the business of the Committee, including electing a Chair and Vice-Chair, heads of delegation should consult widely with members of their delegation and with others before nominating candidates. It should be borne in mind that the IWC is an international organisation, and although some may believe that only competence, not citizenship, is important in considering candidates, having a succession of Chairs from the same country (or small number of countries) is not good for the Committee.

The Chair and Vice-Chair should ideally be chosen, after due consultation, by consensus, not by voting.

Meetings of heads of national delegations

As indicated above, it is important that heads of delegations consult widely before nominating candidates for Chair and Vice-Chair. It has been suggested, as part of the move toward increased transparency, that the Chair of the Committee should meet with heads of delegations early in the Annual Meeting, perhaps more than once, to share ideas regarding such matters as Committee structure and workload in any year, and regarding the choice of Chair and Vice-Chair in an election year.

Proposed procedure and amendment to the Rules of Procedure for the Scientific Committee

Given the above, it is proposed that a second paragraph be added to Rule of Procedure C.5 as follows (proposed new text shown in bold italics):

C. Organisation

5. The Committee shall elect from among its members a Chair and Vice-Chair who will normally serve for a period of three years. They shall take office at the conclusion of the annual meeting at which they are elected. The Vice-Chair shall act for the Chair in his/her absence.

The election process shall be undertaken by the heads of national delegations who shall consult widely before nominating candidates. Under normal circumstances, the Vice-Chair will become Chair at the end of his/her term, and a new Vice-Chair will then be elected. If the election of the Chair or Vice-Chair is not by consensus, a vote shall be conducted by the Secretary and verified by the current Chair. A simple majority shall be decisive. In cases where a vote is tied, the Chair shall have the casting vote. If requested by a head of delegation, the vote

shall proceed by secret ballot¹. In these circumstances, the results shall only be reported in terms of which nominee received the most votes, and the vote counts shall not be reported or retained.

In years when elections are required, the Chair will indicate a provisional date for the election in the initial draft agenda circulated to the Scientific Committee.

As it is proposed that the election process be undertaken by the heads of national delegations, it is also proposed that Rule A.1 (Membership and Observers) be amended as follows (proposed new text shown in bold italics):

A. Membership and Observers

1. The Scientific Committee shall be composed of scientists nominated by the Commissioner of each Contracting Government which indicates that it wishes to be represented on that Committee. ***Commissioners shall identify the head of delegation and any alternate(s) when making nominations to the Scientific Committee.*** The Secretary of the Commission and relevant members of the Secretariat shall be ex officio non-voting members of the Scientific Committee.

Amendments to Rules of Procedure should be notified not less than 60 days in advance of the meeting at which the matter is to be discussed. Consequently, any amendments agreed by the Scientific Committee in Shimonoseki could not officially take effect until the 55th meeting next year.

¹ *Secretariat note: The relevant Commission Rule is E.3(d), with the second sentence shown here in bold being of particular note for comparison purposes: 'Votes shall be taken by show of hands, or by roll call, as in the opinion of the Chair, appears to be most suitable. The election of the Chair, Vice-Chair, the appointment of the Secretary of the Commission, and the selection of IWC Annual Meeting venues shall, upon request by a Commissioner, all proceed by secret ballot.'*

Annex R

Statements on the Agenda

ANNEX R1. 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 R2. STATEMENT BY THE JAPANESE DELEGATION CONCERNING SMALL CETACEANS

Resolution 1999-9¹ 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 cooperation 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.

¹ *Ann. Rep. Int. Whal. Commn* 1999:55-56.

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.

ANNEX R3. STATEMENT BY THE JAPANESE AND NORWEGIAN DELEGATION CONCERNING DNA REGISTER SYSTEM

Members of the Scientific Committee and the Commission are aware that the Governments of Norway and Japan 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 Norway and Japan 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 group is inappropriate. For this reason, representatives of the Governments of Norway and Japan and their appointed scientists will not participate in Scientific Committee discussions of this matter. However, the Governments of Japan and Norway will provide additional information on their DNA register systems as they deem appropriate. 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 S

E-mail Correspondence Groups and Terms of Reference

Group Membership	Terms of Reference
(1) Aboriginal Subsistence Whaling Management Procedure (Steering Group) Donovan (Chair), Allison, Breiwick, Butterworth, Cooke, DeMaster, Dereksdottir, George, Givens, Johnston, Punt, Walløe, Witting, Zeh	Continue progress towards development of an AWMP (Item 8).
(2) Performance of Abundance Estimator (Working Group) Palka (Chair), Borchers, Bravington, Butterworth, Cooke, Hakamada, Hammond, Hedley, Kingsley, Okamura, Polacheck, Schweder, Skaug, Smith	Expand the existing set of simulated datasets with the features needed to evaluate the new methods in development to estimate Southern Hemisphere minke whale abundance using IDCR/SOWER data (Item 5.4).
(3) North Pacific Minke Implementation Simulation Trials (Steering Group) Butterworth (Chair), Allison, Cooke, Donovan, Goto, Hatanaka, Kawahara, Kim, Martien, Okamura, Pastene, Polacheck, Punt, Smith, Taylor, Wade, Walløe	TOR for the intersessional meeting: (1) Specify final trials in the light of discussions at the 2002 SC meeting and the result of trials run intersessionally, and decide upon which combinations of <i>Small Area</i> definitions and RMP variants to run the final trials; (2) Initiate discussion on approaches to advise on the relative plausibility of trials and their application in this instance, to facilitate discussion on this matter at the 2003 SC meeting; (3) Specify Terms of Reference for continued work under the intersessional e-mail group until the 2003 meeting (Item 6.1.4).
(4) Conditioning of Trials (Working Group) Allison (Chair), Butterworth, Kawahara, Polacheck, Punt, Wade	Consider the initial results from the conditioning of <i>Baseline-A</i> trials and find a solution to the technical problems experienced (Allison and Punt). Circulate solutions to full Working Group for comments and suggestions (Item 6.1.4).
(5) Bryde's Whale Past Catch Data (Working Group) Brownell (Chair), Kasuya, Smith	Investigate the quality and nature of data provided in the past by requesting data from additional whaling companies, and suggesting methods for its use in the <i>Implementation Trials</i> (Item 6.4.1).
(6) Data availability (Steering Group) Donovan (Chair), Baker, Cooke, Hammond, Hatanaka, Perrin, Smith, Walløe	Continue work to address: (1) data access and safeguards to protect the rights of data providers; and (2) arrangements for analysis (Item 6.5.4).
(7) Plausibility in Relation to RMP Implementation (Steering Group) Smith (Chair), Cooke, Butterworth, Givens, Hatanaka, Kawahara, Taylor, M., Wade	Consider and improve suggested outline (Annex D, Appendix 13) of how plausibility discussions could be structured at SC/55 (Item 6.2).
(8) North Atlantic Minke Implementation Review (Steering Group) Cooke (Chair), Allison, Butterworth, Lyrholm, Martien, Øien, Palka, Schweder, Skaug, Smith, Vikingsson, Witting	Continue preparations for the Review and facilitate accomplishment of the tasks identified in Annex D, Appendix 14.
(9) Bycatch Workshop Feasibility (Steering Group) Berggren (Chair), Cipriano, Donovan, Kasuya, Lento, Perrin, Rojas-Bracho, Taylor, B.	Continue with preparations for this Workshop (Item 7.2.1).
(10) VPA Analysis (Working Group) Polacheck (Chair), Butterworth, Cooke, Leaper, Punt, Smith, Tynan	(1) Request the required summary data following the established data policies; (2) list the concepts that need to be addressed in further analyses (i.e. alter the model structure, incorporate other biological data and stock structure alternatives, and investigate model robustness); (3) coordinate individuals to pursue analyses to address these concerns (Item 10.2.3.7).
(11) Southern Hemisphere Humpbacks (Working Group) Bannister (Chair), Baker, Best, Findlay, Garrigue, Matsuoka, Nishiwaki, Olavarria, Rosenbaum, Zerbini	(1) Summarise current knowledge by population or management area (i.e. abundance and trends, catches and incidental takes, population structure and stock identity, biological parameters, environmental concerns, assessment models); (2) identify any major gaps in knowledge; (3) establish priorities for research to fill these gaps (Item 10.4.4).
(12) In-Depth Assessment of Sperm Whales (Steering Group) Smith (Chair), Best, Childerhouse, Gunnlaugsson, Leaper, Reeves, Rogan, Tynan	Begin collecting information to conduct a future assessment (Item 10.7.2).

Cont.

(13) Testing of Spatial Structure Models (Working Group) Taylor, B. (Chair), Bravington, Goto, Kanda, Martien, Olsen, Pastene, Skaug, [plus Donovan for Intersessional Workshop]	(1) Design simulation models consistent with minke whale biology, that cover several types of population structure. These should eventually include at least: (i) no structure; (ii) stepping stones; (iii) overlapping stepping stones; (iv) isolation-by-distance; and (v) complex two-dimensional structure with behaviour dependent on age, sex, reproductive condition and year-to-year fluctuations; (2) Choose several sampling schemes that replicate the approximate timing and number of existing samples; (3) Distribute simulated datasets to analysts, who will try various methods of estimating/placing biological, management and simulation stock boundaries; (4) Evaluate performance of the different methods in (3) across the range of hypotheses in (1) (Item 11.4).
(14) Ice Data Collection in the Antarctic (ad hoc Working Group) Thiele (Chair), Ensor, Hedley, Moore, Peddemors, Shimada, Tynan	Develop a standardised data collection system from sea-ice observation protocols using the process described in Appendix 3 (Item 12.1.2 and Annex J, Appendix 3).
(15) POLLUTION 2000+ (Steering Group) Reijnders (Chair), Aguilar, Bjørge, Donovan, O'Hara, Rowles, Siebert, Wells	Continue progress with POLLUTION 2000+ (see Item 12.2).
(16) State of Cetacean Environment Report (Working Group) Perry/Stachowitsch (Chairs), Borsani, Clark, E., Clark, C., DeMaster, Findlay, Fossi, Fujise, Gill, Gordon, Krahn, Lauriano, Manzanilla, Moore, Parsons, Reijnders, Rose, Rowles, Simmonds, M., Slooten, Thiele	Continue progress towards submission of a draft SOCER at SC/55 (Item 12.3.1).
(17) Habitat Degradation Workshop (Working Group) Simmonds (Chair), Brownell, Cipriano, Da Silva, Donovan, Fortuna, Fossi, Fujise, Lauriano, Manzanilla, Murase, Nishiwaki, Notarbartolo di Sciara, Parsons, Perry, Reijnders, Reilly, Rose, Slooten, Stachowitsch, Taylor, M., Urban	Continue to plan for this Workshop (Item 12.3.2).
(18) Arctic Issues (Working Group) Moore (Chair), Belikov, Belkovich, Bogoslovskaya, Born, Brownell, DeMaster, Donovan, Friday, Haug, Krahn, Melnikov, O'Hara, Perry, Rojas-Bracho, Rowles, Simmonds, Tynan, Urban	Continue to prepare for review of Arctic research at SC/55 (Annex J, 8.2).
(19) IWC-SO GLOBEC-CCAMLR Collaboration (Steering Group) Thiele (Chair), Borchers, Childerhouse, Donovan, Ensor, Hedley, Kock, Leaper, Moore, Murase, Palka, Rogan	Continue to progress the work associated with these programmes (Items 12.1.1 and 12.1.2).
(20) Mini Symposium on High Latitude Climate Change Effects (Working Group) Thiele (Chair), Ensor, Hedley, Moore, Shimada, Simmonds, M., Suydam, Tynan	Begin preparations for a mini symposium, to be held at SC/55, on high latitude climate change research and the effects of such changes on cetacean populations (Annex J, Item 8.2).
(21) Whalewatching Data Collection (Working Group) Simmonds, M. (Chair), Fulford-Gardiner, Iniguez, Nishiwaki, Oosthuizen, Palazzo, Parsons, Rose, Weinrich, Williams, Yoshida	Review and further develop the Data Recording System (DRS) (Item 14.1.1 and Annex L, Appendix 2).
(22) Whalewatching Management (Working Group) Oosthuizen (Chair), Aguilar, N., Borsani, Carlson, de Lima, Fortuna, Fulford-Gardiner, Lauriano, Palazzo, Parsons, Peddemors, Rose, Simmonds, M., Urban, Wilson, Yoshida	Continue to plan for the Workshop on the development of scientifically-based whale and dolphin watching management (Item 14.1.2), using advice from the Advisory Group (see below).
(23) Whalewatching Management Workshop (Advisory Group) Carlson (Chair), Iniguez, Palazzo, Parsons, Rose, Simmonds, M., Williams	Provide advice on the scientific parameters to be discussed at the whale and dolphin watching management workshop (Item 14.1.2).
(24) Sanctuary Reviews (Steering Group) Zerbini (Chair), Bjørge, Butterworth, Childerhouse, Donovan, Kell, Kock, Manzanilla, Morishita, Thiele, Walløe	Further develop the review process and evaluation criteria. Develop mechanisms by which sanctuary proposals and the review process would benefit including: (1) reviewing IWC sanctuaries in combination when biologically relevant; (2) introducing Marine Protected Area (MPA) scientific concepts into sanctuaries and sanctuary proposals; (3) providing assistance to member countries in developing sanctuary proposals (Item 17.3).
(25) IWC/CCAMLR and SO-GLOBEC cruise data validation (Steering Group) Allison (Chair), Borchers, Donovan, Hedley, Leaper, Murase, Thiele	To advise on and oversee work on validation of the IWC/CCAMLR and SO-GLOBEC cruise data.

**Report of the Workshop on
North Pacific Common
Minke Whale
*Implementation Simulation Trials***

Report of the Workshop on North Pacific Common Minke Whale (*Balaenoptera acutorostrata*) Implementation Simulation Trials

Members: Donovan (Chair), Allison, Butterworth, Goto, Kawahara, Kim, Martien, Miyashita, Ohsumi, Pastene, Polacheck, Punt, Smith, Taylor, Tomita (I), Wade.

1. CONVENOR'S OPENING REMARKS

The Workshop took place from 19-22 January 2002, at the National Marine Mammal Laboratory in Seattle, USA. Butterworth welcomed the participants and reminded the meeting that the Terms of Reference established by the Scientific Committee (SC) for the Workshop were:

- (1) Review results of further analyses of genetic data for sub-areas 7, 8 and 9 to decide what trial modifications may be necessary in consequence, and re-estimation of mixing proportion between 'J' and 'O' stocks in sub-areas 7 and 11.
- (2) Specify final trials in the light of discussions at the 2001 SC meeting and the results of trials run intersessionally, and decide upon which combinations of *Small Area* definitions and RMP variants to run the final trials.
- (3) Initiate discussion on approaches to advise on the relative plausibility of trials and their application in this instance, to facilitate discussion of this matter at the 2002 SC meeting.
- (4) Specify Terms of Reference for continued work under the intersessional e-mail group until the 2002 meeting.

He also highlighted the comment from the last Scientific Committee meeting that the Committee had agreed at its 2001 meeting that the results of the *Implementation Simulation Trials* would be examined at the 2002 meeting with the goal of recommending to the Commission one variant of the RMP irrespective of any further data forthcoming in the interim – this will constitute the end of the *Implementation* (IWC, 2002a, p.100).

2. ELECTION OF CHAIR

Donovan was elected Chair.

3. APPOINTMENT OF RAPORTEURS

Butterworth and Punt acted as rapporteurs with assistance from the Chair.

4. ADOPTION OF AGENDA

The adopted agenda is given as Annex A.

5. REVIEW OF DOCUMENTS

The list of documents is given as Annex B. It was **agreed** that these documents should also be made available to the sub-committee on the RMP at the 2002 SC meeting.

6. GENERAL ISSUES

6.1 Conditioning

Conditioning is the process of selecting the values for the parameters of the operating model so that this model is consistent with the existing data for the species/*Region* under consideration. Each simulation involves: (1) generating a pseudo-dataset based on the information on abundance and mixing of stocks in sub-areas; and (2) estimating the parameter values for the operating model which provide the best fit to the maximum-likelihood value for the objective function.

SC/J02/NP1 outlined a set of diagnostic statistics that could be used to assist in the evaluation of whether the operating model fits the pseudo-datasets adequately and whether the resultant model fits appear realistic. The diagnostic statistics include: histograms of standardised residuals; bivariate plots of these residuals; the time trajectories of 1+ population size with the dataset used for *conditioning* superimposed; the time series of annual catches by stock; the observed and model-predicted mean lengths of the catch; the time-trajectories for the proportion of each stock in each sub-area; and the observed and model-predicted catches of males. Lowering the age-at-recruitment from 4 to 1 was shown in SC/J02/NP1 to lead to better fits to the mean length information.

In considering the value of comparing observed versus predicted mean lengths in the catch as a diagnostic for conditioning, the Workshop **agreed** that this was problematic because of: (1) the general shape of minke whale growth curves; (2) the fact that growth in North Pacific common minke whales remains poorly understood; and (3) the fact that changes in mean length of captured whales over time may be a consequence of operational changes.

It was suggested that basing diagnostic statistics on the fraction mature may be more robust, although maturity information for the catches is not available before the 1970s. Butterworth noted that an inability to mimic the mean length information was not necessarily a concern for the selection of a variant of the RMP because many previous analyses using the Baleen II model suggested that population sizes and trends were insensitive to most specifications regarding mortality and growth. Polacheck noted that changes in mean length could provide information on seasonal movement patterns.

The abundance estimate for sub-area 7¹ in 1990 has been assumed to be a minimum value (of 1,741) when *conditioning* the trials. The operating model population size in that sub-area is therefore constrained not to be less than this estimate. This constraint played a role in determining the values for the operating model parameters for several of the trials because the operating model 1+ population size in sub-area 7 in 1990 frequently equalled the pre-specified minimum value. The abundance estimate for sub-area 7 in 1991 is taken to be unbiased. However, given its CV, some of the abundance estimates generated from this estimate are less than the pre-specified minimum. The Workshop noted that no account was currently taken of the uncertainty associated with the minimum abundance estimate because previous attempts to do this led to a large number of cases in which the generated abundance estimate for 1991 was less than the minimum abundance estimate for 1990². Wade suggested that consideration should be given to defining the minimum population size constraints based on a lower confidence limit for the abundance estimates considered to be minima (see Item 8.5).

The Workshop noted that the trials specified last year (IWC, 2002b) do not explicitly allow for 'additional variance', except through the impact of stochasticity on the catch mixing matrices for the 'J' and 'W' stocks. The evidence for additional variance in the data is the lack of temporal consistency in the abundance estimates for sub-area 9 (see Table 1). There are several possible explanations for the differences in abundance estimates among years other than changes in abundance: for example, variability in the timing of the migration or variability in the spatial distribution of the animals. One reason for the extra-sampling variation for the abundance estimates used previously when conditioning the trials may relate to differences in the assumptions underlying the calculation of the abundance estimates (e.g. the range of Beaufort states considered).

The Workshop requested that two trials be conducted during the meeting to examine issues of conditioning.

¹ See Fig.1 for sub-areas and Table 1 for abundance estimates.

² It was later agreed that the 1990 estimate for sub-area 7 was not suitable for use in the trials – see Item 8.5 and Annex C.

- (1) A trial in which there is a single mixing matrix only for the 'W' stock and the operating model is fitted only to the abundance estimates that were not derived from JARPN (see Table 1). Annex C overviews reasons for the use (or otherwise) of the full set of abundance estimates.
- (2) A trial based on the abundance estimates used in trial 1 plus abundance estimates from the JARPN surveys (see Table 1). The two catch-mixing matrices for the 'W' stock for this trial were randomly selected each year within a simulation from two alternative matrices: one in which all 'W' stock animals are found west of 170°E and another in which a fraction ϕ of these animals is found in this area.

Annex D provides diagnostic plots (histograms of standardised residuals and time-trajectories of population size with the abundance estimates used for conditioning superimposed) for the two trials. The number of simulations on which the plots in Annex D are based is 18 (trial 1) and 30 (trial 2). The 30 simulations for trial 2 are the best 30 in terms of the value of the objective function of the 80 simulations conditioned. The standardised residuals for the abundance estimates for trial 1 are satisfactorily normal while those for trial 2 are not. Even though trial 2 includes stochastic catch mixing matrices for the 'W' stock, the fits to the abundance estimates for sub-areas 8 and 9 are poor. Furthermore, there is evidence from the trajectories of population size of numerical problems when fitting the operating model.

Based on the results in Annex D, the Workshop **agreed** that the final set of trials would be based on the specifications that underlie trial 1 (i.e. no stochastic catch-mixing matrices for the 'W' stock and use of only a subset of the abundance estimates when conditioning). It also **agreed** that an additional factor would be considered in trials to quantify the impact of additional variation i.e. to assume that there is additional variance reflected by a CV of 40%.

6.2 Data availability

During its discussions, the Workshop recognised the importance of data collected by national research programmes (which are not necessarily freely available to all

Table 1
The abundance data used in the two trials (1 and 2) run during the Workshop.

Sub-area	Timing	Areal coverage	Abundance	CV	Used in Trial 1&/or 2?	Survey Type	Estimate also used by CLA ²
Data also used in previous trial specifications							
6	Aug-Sep 1992	56.8	893 ¹	0.67	1 / 2	D	No
7	Aug-Sep 1991	66.5	2,202	0.383	1 / 2	D	Yes
8	Aug-Sep 1990	62.2	1,057	0.706	1 / 2	D	Yes
9	Aug-Sep 1990	35.1	8,264	0.396	1 / 2	D	Yes
9	Jun-Jul 1994	35.0	4,673	0.441	2	J	No
9	Jun-Jul 1995	45.1	2,145	0.315	2	J	No
10	Aug-Sep 1992	30	707 ¹	0.57	1 / 2	D	No
11	Aug-Sep 1990	100.0	2,120	0.449	1 / 2	D	Yes
12SW	Aug-Sep 1990	100.0	5,244	0.320	1 / 2	D	Yes
12NE	Aug-Sep 1990	100.0	10,397	0.171*	1 / 2	D	Yes
12NE	Aug-Sep 1992	89.4	11,544	0.157*	1 / 2	D	Yes
New data							
8	July-Aug 1996	31.3	1,385	0.31	2	J	No
8	May-June 1998	81.6	843	0.541	2	J	No
11	Aug 1996	32.3	608	0.266	2	J	No
11	July 1999	32.3	881	0.338	2	J	No

J: JARPN survey; D: Dedicated survey; * Provisional values, to be recalculated after the meeting. ¹Used as a minimum estimate; ²i.e. Estimate acceptable for calculating catch limits if the Commission decides to implement the RMP.

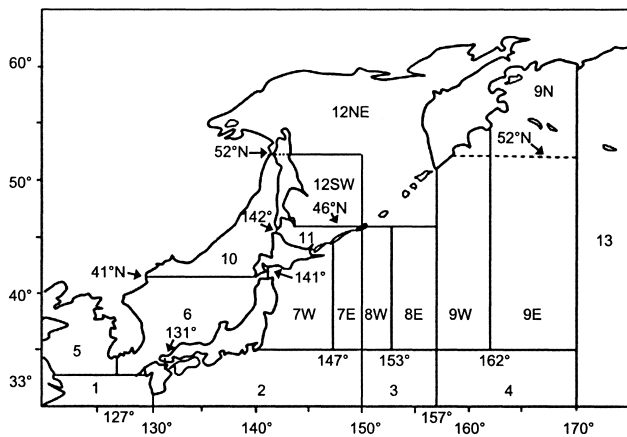


Fig. 1. Map showing the North Pacific region, including the areas and sub-areas relevant to *Implementation Simulation Trials* (see Item 7).

members of the Committee) for the development of the trial process (e.g. the genetics data considered in SC/J02/NP13). It noted that the question of data availability is a complex and sensitive one. A balance must be struck between the needs of the Committee and the rights of the scientists who have invested considerable time and effort in collecting the data. In the past, the Committee spent some time on this general issue when discussing the Guidelines for Surveys and those for Data Collection under the RMP. Although some conflicting views were expressed over this issue, the Workshop agreed that it had neither the time to address the matter thoroughly at the present meeting nor the authority to determine new guidelines. It recognised the great importance of the issue to the working of the Committee in the context of both the development of *Implementation Simulation Trials* and the discussions of the relative plausibility of any such trials. The Workshop strongly **recommends** that the question of data availability/access for the *Implementation* process be considered by the Committee at the 2002 SC meeting.

7. REVIEW OF FURTHER GENETIC ANALYSES RESULTS

Before discussing this item, the Chair reminded the participants that the primary aim of the Workshop was to finalise the *Implementation Simulation Trials* (IWC, 2002a, p.106). In the context of discussions under this item, therefore, he expected to concentrate on whether any of the stock hypotheses put forward were implausible and should not be considered in the *Trials*. Severe time pressure meant that the question of the relative plausibility of the various hypotheses could not be discussed in detail at the Workshop (i.e. in advance of running the trials). He noted that the Workshop report therefore only **briefly explains** the methods used and the hypotheses developed; the **short discussion** sections do **not** represent a detailed critique of these. He expected participants to submit papers to the 2002 SC meeting that performed this function and explained in detail their rationale for weighting the various hypotheses put forward.

7.1 Re-estimation of J-O mixing

This is discussed under Item 8.1

7.2 Methods

Prior to the Workshop, a collaborative meeting had been held in Tokyo between Pastene, Goto, Kanda, Taylor and Martien to discuss available genetic techniques and analyses, and to apply some of these further. These discussions are given in SC/J02/NP13. The Workshop thanked these individuals for their efforts, which assisted in the development of much of the material reported upon in the following sections.

7.2.1 Hypothesis testing

Hypothesis testing is one of the more traditional ways to look at issues of stock identity and it has been the subject of much discussion in the Committee in the past (e.g. IWC, 2001a; b).

SC/J02/NP10 presented results of hypothesis testing based upon a null hypothesis of panmixia, making use of mtDNA data from JARPN I and II (1994-2001). Possible 'J' stock animals are excluded from the comparisons, based upon an 'extreme' genetic criterion. The number of samples by sub-area is (total sample/number of samples after excluding suspected J stock animals): sub-area 7 = 213/173; sub-area 8 = 112/96; sub-area 9 = 233/192 and sub-area 11 = 80/50. A large number of comparisons were performed, leading to the conclusion that the only source of heterogeneity established to the north and east of Japan (sub-areas 7, 8 and 9) could be attributed to whales sampled in the western part of sub-area 9 in 1995, 2000 and 2001 (although sample sizes were low in the last two years). The paper concluded that the results support a one-stock scenario in the sub-areas concerned, except for the possibility of sporadic appearance of another stock in sub-area 9W.

SC/J02/NP11 reported the results of similar hypothesis testing based upon microsatellite data (seven loci) from these sub-areas, again using data from JARPN and JARPN II from 1994-2001 and excluding possible 'J' stock animals. The number of samples by sub-area after the exclusion of suspected J stock animals is as follows: sub-area 7 = 173; sub-area 8 = 96; sub-area 9 = 192 and sub-area 11 = 50. No evidence of heterogeneity was found, except for inter-annual heterogeneity in sub-area 9 which might indicate sporadic intrusion of a further stock into that region.

The Workshop thanked the authors of these two papers for the substantial effort that had been applied to analyse the samples and the data.

7.2.1.1 SHORT DISCUSSION

In discussion, it was reiterated that for a number of reasons (including small sample sizes), failure to detect significant differences in such tests does not necessarily mean an absence of structure.

The approach used to exclude 'J' animals was considered. Some suggested that this might be too conservative (i.e. it would also exclude some non-'J' stock animals). It was suggested that tests should be reported without such exclusions with the resultant larger sample sizes possibly revealing greater discriminatory power.

Some questions over the authors' conclusions regarding temporal variability of structure in sub-area 9W were raised. It was noted that these rested strongly on the inclusion of data from JARPN in 1997, when samples had been collected much earlier in the season.

During the Workshop, AIC-based evaluations of different stock structure models to explain the frequency of haplotype 9 in various sub-areas were carried out. These suggested strong support for a frequency in sub-area 9W that differed

from that in sub-areas 7, 8 and 9E. Evidence for inter-annual variability in 9W was, however, relatively weak. The Workshop **recommends** that these analyses be extended to consider all haplotypes, and to investigate the possibility of temporal variation in sub-areas 7 and 8. It also **recommends**: (1) a general examination of the effect of inclusion of data from past commercial operations in the analyses; and (2) the use of alternative methods for exclusion of 'J' stock animals (e.g. using an 'assignment' method, or using more than simply genetic data).

7.2.2 Bayes and empirical Bayes approaches

SC/J02/NP4 outlined an approach based on Bayesian estimation for comparing single with multiple stock hypotheses. The use of Bayesian methods is arguably preferable to traditional methods because, unlike methods based on hypothesis testing, such methods have the potential to discriminate whether non-rejection of the null hypothesis of a single stock is indeed a reflection of only one stock being present or rather of the low power associated with small sample size. The likelihood of the data in SC/J02/NP4 is assumed to be multinomial and the multivariate prior for the probability of an individual having a particular haplotype is assumed to be of the Dirichlet- β form. The values for the parameters of this prior are either determined using an Empirical Bayes approach or assumed to be distributed according to a log-normal hyper-prior (the 'Full Bayes' approach). The Empirical and Full Bayes methods are examined using simulation. The performance of the Empirical Bayes method is found to be much worse than that of the Full Bayes method. The latter performs adequately if applied to data for two stocks that differ substantially in haplotype frequency, or when sample sizes are large.

7.2.2.1 SHORT DISCUSSION

The Workshop **agreed** that the approach had promise and thanked the authors for their work. However, some concerns were expressed. For example, it appeared unclear how account was being taken of whatever genetic effect size was pertinent to distinction between stocks. It was suggested that this must be effected through the forms of prior distributions specified. The Workshop **agreed** that additional work was required to better clarify the relationship. Taylor noted that this technique requires *a priori* stratification of the data which may have a strong effect on the results.

Application of the approach to mtDNA data for North Pacific common minke whales yielded results broadly consistent with those from hypothesis testing. Some considered that although further development and review of the approach was needed, this was indicative of some support for the hypothesis test results. Others, however, believed that such a view was premature, and that a wider set of comparisons than those reported in SC/J02/NP4 would need to be considered before reaching such a conclusion.

7.2.3 Boundary rank techniques

The boundary rank method is a relatively new approach, developed to generate hypothetical population structures (originally for non-migratory species such as the harbour porpoise and harbour seal). A brief overview of the method is given in Martien and Taylor (SC/J02/NP3). A detailed description is given in Martien and Taylor (2001). The authors' summary of the method is provided as Annex E to this report.

7.2.3.1 SHORT DISCUSSION

The authors were commended for the substantial efforts they had expended and there was an extensive and wide-ranging discussion of these papers and the underlying methodology.

One point raised was that the approach distinguished areas of different haplotype frequencies, rather than biological stocks *per se*. In response, it was pointed out that this applies to all the genetics methods considered. Furthermore, in answer to the assertion that differences detected could reflect overlap between two stocks, rather than a 'hard' boundary with no interchange, it was argued that dispersal rates would be over-estimated in such circumstances, thus compensating (at least in part) for such incorrect inference.

There were a number of comments on the sensitivity of the approach to the initial clusters chosen. The analysis presented to the Workshop had separated clusters of samples spatially, but without consideration of differences in the months or years in which the samples had been taken. However, it was noted that there was little inter-annual overlap in sample positions. The authors advised the Workshop of their desire to examine further the sensitivity of their results to alternative clustering choices. They stated that the short time for which the data were available to them for analysis in Japan (SC/J02/NP13) did not allow them to fully explore the effects of different initial clusters as they would have wished.

Other concerns raised included the sensitivity of boundaries indicated by the method to the specification of connectivity matrices, double use of the data to both formulate and then effectively test hypotheses and the need for expert review of a new technique before using it as a management tool (e.g. by publication in an appropriate scientific journal). These concerns were not shared by all and in particular, some noted their view that the review of a method within the Committee was often more rigorous than the review process in some scientific journals.

The authors concluded that their results provided evidence for two stock boundaries: one in the vicinity of the existing sub-area 8-9 boundary and the other at either 147°E or 153°E, i.e. not only evidence for the classically postulated 'W' stock in sub-area 9, but also for two stocks rather than one in sub-areas 7 and 8. This pattern of results was evident for a number of alternative clustering choices.

Reservations raised about these conclusions (more particularly that of two stocks in sub-areas 7 and 8) generally mirrored concerns raised above about the methodology (at least as applied and interpreted in this instance).

7.3 Stock structure proposals

In discussion, three baseline scenarios were put forward to account for patterns observed in the results from the genetic analyses. Certain features are common across these scenarios, but they also differ in several important respects. It is stressed that inclusion of these scenarios does **not** imply agreement among the Workshop participants that all were equally plausible (or even plausible at all).

It should be noted that Annex G (see Item 7.3.3 below) was written after the meeting. It represents a report of the discussions of a small group (convened by Smith) established by the Chair during the meeting. Smith reported verbally on the deliberations of the small group at the Workshop and their discussions were used in the formulation of *Baseline-D* (below). Participation in that small group meant merely that the individual provided at least technical or biological advice/information – it does not necessarily imply agreement by all participants in the small group that

(a) *Baseline-D* is the most plausible (or even likely); and (b) that other scenarios presented are not plausible. The detailed Annex is included because it documents the basis for a new scenario, not previously discussed by the Scientific Committee and not presented in an authored document to the Workshop.

7.3.1 Baseline-A and Baseline-B

This is a 3-stock scenario ('J', 'O', 'W') with the 'W' stock found only in sub-area 9, and then only sporadically. This interpretation is argued on the basis of the results of hypothesis tests, and particularly that these had provided no significant results (other than those which the scenario reflects) for tests for heterogeneity in sub-areas 7, 8 and 9.

One major concern of those who had reservations to this scenario was that sample sizes may have been too small for such tests to distinguish further stock structure (and see the other comments on the hypothesis testing approach discussed under Item 7.2). As a sensitivity test making some allowance for this concern, a trial is to be conducted that includes some 'W' stock animals in sub-area 8.

Baseline-B (2-stocks) reflects a limiting case of this scenario with no 'W' stock whales present in sub-areas 8, 9 or 12.

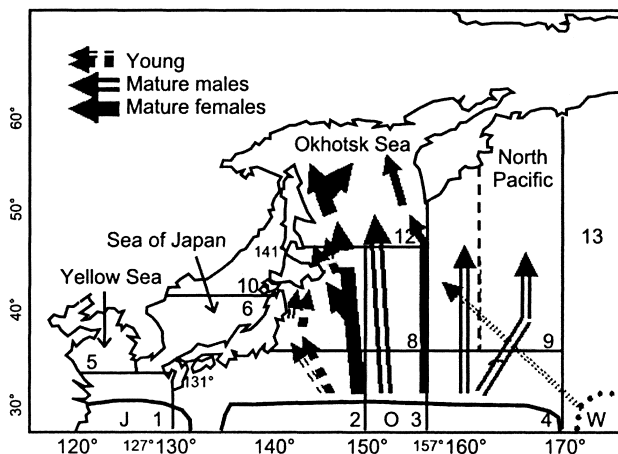


Fig. 2. Illustration of the Baseline-A stock scenario. This is based on a three stocks hypothesis, J, O and W, with the W stock occurring only sporadically in the western part of sub-area 9. This interpretation is based on the results of hypothesis testing heterogeneity in sub-area 7, 8 and 9, except some degree of genetic heterogeneity in the western part of sub-area 9 in three years (although the sample sizes for two years are low). The assumed locations of the unknown breeding grounds for these three stocks are shown. These are not definitive. The possible feeding migration routes of the different sexual classes of the O stock are shown. These are based on the investigation by Hatanaka and Miyashita (1997).

7.3.2 Baseline-C

In this scenario, there are 4 stocks overall, with three ('O_W', 'O_E' and 'W') to the east of Japan. This is motivated by the divisions suggested by the boundary rank method (see Annex E and SC/J02/NP5). The preferred hypothesis is one of no mixing between the stocks, with boundaries at 147°E and 157°E. Variants of this hypothesis first place the 'O_W'/'O_E' boundary at 153°E, then allow 'O_W' and 'O_E' mixing between 147°E and 153°E, further allow intrusion of the 'O_E' stock into sub-area 9E, and finally allow for some mixing of the 'O_W' and 'O_E' stocks throughout sub-areas 7 and 8. Fig. 3 (a-d) illustrate these different hypotheses.

Those who had reservations concerning the above scenario based these largely on the concerns expressed above about the boundary rank method, and, in particular,

whether the haplotype frequency differences this may detect are a sufficient basis to postulate 'hard' inter-stock boundaries. Some members commented that the results were not supported by the hypothesis testing approach. Others believed that in fact the results of the boundary rank method were broadly in agreement with those from hypothesis testing with a strong boundary near the 8-9 line and a weaker boundary near the 7-8 line.

The low proportion of juveniles in sub-area 8 (see SC/J02/NP12) was argued as a basis for rejecting the possibility of a separate 'O_E' stock. In response, counter opinions were offered that these results did not suggest differences in the juvenile proportions in sub-areas 7, 8 and 9 (7W excepted). The Workshop **recommends** that a statistical analysis be conducted to test whether or not these juvenile proportions did differ.

7.3.3 Baseline-D

Those suggesting this scenario presented it as representing one plausible hypothesis based on a synthesis of the implications of the results of the various methods discussed in Item 7.2 and other biological information available (see Annex G). It has 'O' and 'W' stocks to the east of Japan mixing across the area from 147°E to 162°E. The basis of this interpretation is the argument that the genetic data suggest a change in haplotype frequencies as one moves east from Japan, and that this could result from two stocks mixing in proportions that differ by longitude. 'O' stock animals dominate in the west, but become increasingly less prevalent as one moves further east; the reverse is true for 'W' stock whales. This hypothesis is illustrated conceptually in Fig. 4.

Those who had reservations concerning this hypothesis based these largely on the assertion that the genetic data provide insufficient indication of the haplotype frequency change across sub-areas 7 and 8 that this scenario suggests. Some members also noted that there is an apparent contradiction with the results of hypothesis testing in so much as they believed that those results showed that sub-area 9 is genetically closely related to sub-areas 7 and 8.

7.3.4 Distinguishing among the scenarios

The Workshop discussed the possibility of using the JARPN data on sex and size composition of catches by sub-area and time to assist conditioning the trials, and possibly to distinguish between the scenarios above. Concerns were raised about this suggestion, including the fact that there was in any case insufficient time to implement it before the 2002 Scientific Committee meeting. It was suggested, however, that such data might assist in determining the relative plausibilities of the different stock structure scenarios (see Item 11).

8. PROGRESS ON OTHER TRIAL-RELATED ISSUES

8.1 Mixing of the 'J' and 'O' stocks

The fraction of 'J'/'O'/'W' stock animals (of a given sex and age) in a sub-area is determined from the catch mixing matrix. The entries in this matrix consist of pre-specified constants (usually 0, 1, 2 or 4 to reflect qualitative assumptions regarding migration and presence/absence of animals by stock, sex and age) and estimated parameters (the parameters are sometimes multiplied by pre-specified constants to force differences in abundance at different times). The entries for each sex, age and month are normalised within the computer code to determine the

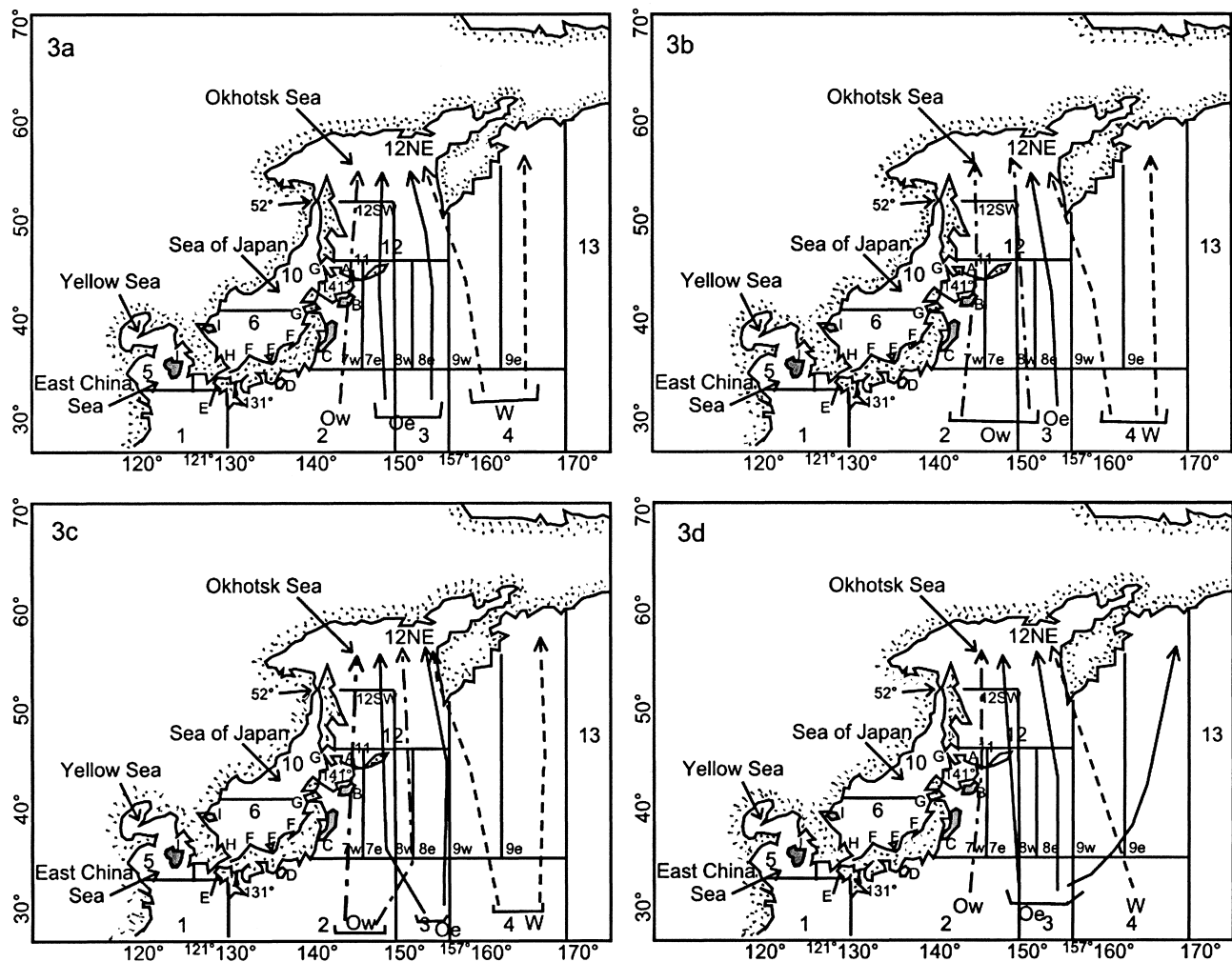


Fig. 3(a-d). Illustration of the proposed Baseline-C and variant hypotheses based on the results of the boundary rank method (see text).

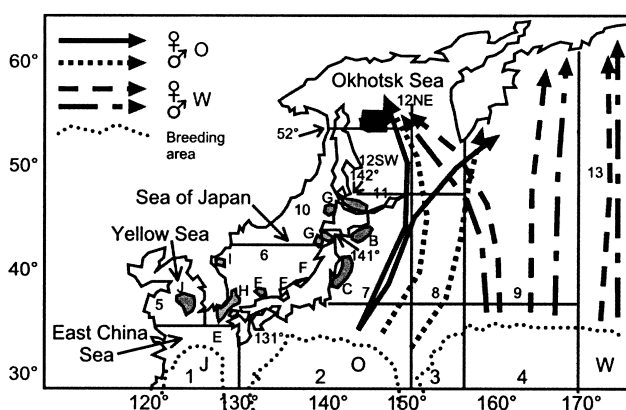


Fig. 4. Illustration of the proposed Baseline-D scenario (see text and Annex G).

fraction of the stock in each sub-area in a particular month. The values for the parameters of the catch-mixing matrix are determined during the conditioning process, primarily based on fitting to data on the fraction of (1+) animals in a sub-area that consist of 'J' stock animals (referred to as the 'J'-O' mixing proportions although, in some trials, these data actually refer to the fraction of 'J' relative to 'O' and 'W' stock animals).

'J' stock animals are known to be found to the north and east as well as to the west of Japan. The information on the fraction of 'J' stock animals in sub-areas 7 and 11 in the trials has been based in the past on analyses of the genetics data for these sub-areas. Last year, the Scientific Committee recommended that the 'J'-O' mixing proportions be based on a mixed-stock analysis of updated mtDNA data (IWC, 2002a). SC/J02/NP9 therefore provided estimates of the 'J'-O' mixing proportions for sub-areas 2, 7 and 11 using mtDNA data and the method of Kishino *et al.* (1994). The information on bycatch in the Sea of Japan was used to define the baseline proportions for the 'J' stock. Mixing proportions were determined for sub-areas 7 and 11 for each month and sex where the data were sufficient to permit estimation. The Workshop thanked the authors of SC/J02/NP9 for their hard work.

The Workshop noted that the standard deviations for the 'J'-O' mixing proportion estimates for some combinations of sub-area, month and sex were very large. Direct use of the information in SC/J02/NP9 in the trial specifications would therefore result in some simulations in which the 'J'-O' mixing proportion was very high for certain combinations of sub-area, month and sex, although the point estimate of the corresponding 'J'-O' mixing proportion is virtually zero. The reason for the high standard deviations for cases in which the point estimate was essentially zero was probably

the consequence of the application of an analytical approach to computing standard errors when the point estimate was equal to its lower bound. The Workshop therefore **agreed** to base the 'J'-'O' mixing proportions on an alternative Bayesian approach (Annex F).

Tables 2a and 2b list the revised 'J'-'O' mixing proportions based on the Bayesian approach. Sensitivity is explored in Table 2b to the choice of the baseline samples for the 'J' stock (bycatch samples or the combination of these samples and the commercial samples from Korea). The Workshop **agreed** that, given the insensitivity of the results to the choice of baseline, the 'J'-'O' mixing proportions for use in the trials would be those based on the bycatch samples only. This choice represented the base-case specification agreed at the 2001 Scientific Committee meeting. Sensitivity to the choice of the baseline sample for the 'O' stock was also examined by estimating mixing proportions using the data for sub-area 8 only, rather than including sub-area 9 as well; this was found to be minor.

The extent of mixing between the 'J' and 'O' stocks in the operating model depends on the specifications for the 'J'-'O' mixing proportions based on the genetics data (the data fitted during the conditioning process) and the structure of the mixing matrix. The Workshop therefore considered whether and how the information in Table 2 should be included in the trials, and the associated underlying trial structure, given the small sample sizes for some combinations of sub-area, month and sex and the hypotheses/information on movement patterns of common minke whales in sub-areas 2, 7 and 11.

The Workshop **agreed** that a single estimable parameter would be included in the catch mixing matrices to determine the proportion of 'J' stock animals in sub-area 2 during April and May. This parameter will be used *inter alia* to determine the split of the bycatch in sub-area 2 between the 'J' and 'O' stocks.

The posterior modal estimates of the 'J'-'O' mixing proportions for sub-area 7 are essentially zero for several of the month-sex combinations, although the corresponding mean values are larger than zero due to the relatively small sample sizes and the fact that the posterior distribution is restricted to the interval [0-1]. No hypotheses based on biological considerations are available to describe the mixing of 'J' stock animals in sub-area 7. The Workshop **agreed** therefore that the data used to condition the simulations would be based on a mixed stock analysis of the data for sub-area 7, in which all samples are pooled (over both month and sex). It also **agreed** that the population dynamics model would include a single parameter in the catch-mixing matrix to allow a low level of 'J' stock mixing in sub-area 7.

Migration patterns into and through sub-area 11 differ by stock and sex. The 'J' stock females are hypothesised to arrive in sub-area 11 before the 'O' stock females, and to migrate north into sub-area 12 before returning to sub-area 11 and migrating south. The estimates of 'J'-'O' mixing rates based on genetics are consistent with this hypothesis. In contrast, between-stock differences in the migration pattern of males are poorly understood. Migration of 'O' stock animals into sub-area 11 in April is probably restricted due to ice coverage in the east of this sub-area.

Based on biological considerations, the Workshop **agreed** that: (1) separate 'J'-'O' mixing proportions would be generated for each month from April to August for females; and (2) different parameters would be included in the catch mixing matrices for each month for females to ensure an adequate fit to the data. There are very few data for sub-area

11 for September. However, it is expected that there would be fewer females in sub-area 11 in September than in August as more should be further south by then. The Workshop **agreed** therefore that a reasonable way to model this was to force the parameter in the catch-mixing matrix for females in sub-area 11 in September to be half of that in August. It also **agreed** that, given the difficulty that 'O' stock animals should have entering sub-area 11 in April, the parameter in the catch-mixing matrix for males in April would be equal to that for females (noting that the total number of females in sub-area 11 in April exceeds that of males).

The sample sizes for males in sub-area 11 in May and June are small. The Workshop **agreed** therefore that the data for these months would be pooled and a parameter common to both months included in the catch-mixing matrix. The mixing proportion for males in July is roughly half that for females, so it was **agreed** that the parameter in the catch mixing matrix for males in July would be fixed to be half of that for females. Separate parameters should be estimated for males and females in the catch-mixing matrix for August. There are two ways to approach specification of the 'J'-'O' mixing proportion for males in September: (1) this should exceed that for August as the male mixing proportions show an increasing trend with month; or (2) this should be less than that for August as the females are leaving and the males should accompany them to some extent. In the absence of data, the Workshop **agreed** that the parameter in the mixing matrix for males in September should equal that for August.

The previous trials were based on the assumption that the mixing proportions were normally distributed when generating the data used for conditioning. However, the posterior distributions for the mixing proportions from the Bayesian approach are better approximated by a beta distribution. The Workshop **agreed** that future trials be based on the assumption that the 'J'-'O' mixing proportions used during conditioning are generated from beta distributions fitted to the posterior distributions from the Bayesian approach of Annex F.

Some of the mixing proportions are based on data from several years. It was **agreed** that the model estimates to which these proportions are fitted during conditioning would be sample size-weighted year-specified proportions.

8.2 Temporal variability in sub-area 9

In the model conditioning process, a simple approach of random choice each year between two alternative mixing matrices specifying different spatial distributions for the 'W' stock was attempted to reconcile the rather different estimates of abundance for sub-area 9 from dedicated surveys around 1990 and from JARPN in 1994 and 1995. The computations possible within the meeting indicated that this was not successful: they might succeed with fits for very many data replicates and a high rejection rate for poor fits, but this would place an impractical time burden on the conditioning exercise. It was accordingly **agreed** not to model temporal variability in sub-area 9 but rather to use only the 1990 abundance estimate in the conditioning process. Although this means discarding the 1994 and 1995 JARPN estimates, they are probably not comparable with that for 1990 because of the different survey methodology in JARPN. It was **agreed** that additional variance should be taken into account when generating simulated abundance estimates for future surveys for the RMP testing process (such additional variance is not added to the sampling variance of estimates input to the RMP itself).

Table 2

'J'-'O' mixing proportion estimates for sub-areas 2, 7 and 11. The baseline sample for the 'J' stock is either (a) the bycatch sample from the Sea of Japan or (b) bycatch sample from the Sea of Japan combined with the historical commercial data off Korea. The rows indicated by asterisks will form the basis for the 'J'-'O' mixing proportions used when conditioning the trials.

Sub-area	Month	Sex	Years	N	Mean	SD	CV	Mode	Beta- α	Beta- β
(a) 'J' stock baseline = bycatch sample from the Sea of Japan										
2*	All	Both	1996-2000	12	0.705	0.120	0.170	0.743	9.4367	3.9409
11*	April	F	1984-87	50	0.623	0.069	0.111	0.629	29.8428	18.0575
11	April	M	1984-87	2	0.743	0.199	0.267	0.999	2.8503	0.9844
11*	May	F	1984-87	39	0.081	0.047	0.586	0.055	2.5963	29.4271
11	May	M	1984-86	9	0.093	0.085	0.912	0.001	0.9963	9.6786
11*	June	F	1984-87	15	0.224	0.101	0.450	0.187	3.6056	12.4940
11	June	M	1984-87	8	0.103	0.093	0.904	0.001	0.9955	8.6701
11*	July	F	1984-87, 1999	20	0.443	0.106	0.239	0.439	9.3355	11.7201
11*	July	M	1986, 1999	26	0.201	0.079	0.392	0.175	5.0063	19.9174
11*	August	F	1986-87, 1996	16	0.087	0.071	0.815	0.009	1.2894	13.5903
11*	August	M	1986-87, 1996	19	0.363	0.109	0.300	0.349	6.6987	11.7522
11*	May-June	M	1984-87	17	0.054	0.051	0.948	0.001	0.9978	17.4243
7	April	F	1984-87	19	0.049	0.047	0.953	0.001	0.9983	19.4338
7	April	M	1983-87	19	0.072	0.060	0.837	0.001	1.2518	16.1376
7	May	F	1983-87, 1998	13	0.133	0.085	0.637	0.077	1.9999	12.9997
7	May	M	1983-87, 1998	62	0.041	0.031	0.766	0.013	1.5957	37.4264
7	June	F	1983-86, 1999	15	0.091	0.074	0.808	0.013	1.3026	13.0068
7	June	M	1983-86, 1997-99	52	0.034	0.029	0.867	0.001	1.2529	35.6562
7	July	F	1986, 1996	12	0.077	0.071	0.925	0.001	1.0006	11.9659
7	July	M	1984-87	14	0.063	0.059	0.939	0.001	1.0001	15.0010
7	August	F	1986, 1996	3	0.215	0.175	0.811	0.001	0.9768	3.5628
7	August	M	1986, 1996	17	0.057	0.053	0.945	0.001	0.9992	16.6735
7	September	F	1986-87, 1996	6	0.125	0.110	0.882	0.001	1.0000	7.0001
7	September	M	1986-87, 1996	28	0.129	0.063	0.494	0.099	3.4454	23.3471
7*	All	Both	1983-87, 1996-99	260	0.028	0.012	0.441	0.023	4.9600	173.5495
(b) 'J' stock baseline = bycatch sample from the Sea of Japan combined with the commercial sample off Korea										
2	All	Both	1996-2000	12	0.709	0.119	0.168	0.745	9.6347	3.9616
11	April	F	1984-87	52	0.636	0.067	0.106	0.641	31.9878	18.3254
11	April	M	1984-87	2	0.746	0.197	0.264	0.999	2.9007	0.9894
11	May	F	1984-87	39	0.081	0.047	0.579	0.055	2.6590	30.3484
11	May	M	1984-86	9	0.093	0.084	0.913	0.001	0.9973	9.7825
11	June	F	1984-87	15	0.227	0.101	0.443	0.191	3.7155	12.6171
11	June	M	1984-87	8	0.102	0.092	0.904	0.001	0.9966	8.7758
11	July	F	1984-87, 1999	20	0.442	0.106	0.240	0.437	9.2539	11.6961
11	July	M	1986, 1999	26	0.194	0.077	0.395	0.167	4.9693	20.6590
11	August	F	1986-87, 1996	16	0.092	0.072	0.778	0.029	1.4083	13.8745
11	August	M	1986-87, 1996	20	0.398	0.106	0.266	0.389	8.0720	12.1854
11	May-June	M	1984-87	17	0.054	0.051	0.948	0.001	0.9985	17.6170
7	April	F	1984-87	19	0.048	0.046	0.953	0.001	0.9989	19.6242
7	April	M	1983-87	19	0.077	0.062	0.800	0.019	1.3656	16.3954
7	May	F	1983-87, 1998	13	0.133	0.085	0.637	0.077	1.9999	12.9997
7	May	M	1983-87, 1998	62	0.050	0.033	0.664	0.031	2.1034	39.7826
7	June	F	1983-86, 1999	15	0.097	0.075	0.771	0.033	1.4236	13.2108
7	June	M	1983-86, 1997-99	52	0.037	0.030	0.812	0.005	1.4243	36.7464
7	July	F	1986, 1996	12	0.075	0.070	0.928	0.001	0.9979	12.2555
7	July	M	1984-87	14	0.063	0.059	0.939	0.001	1.0001	15.0010
7	August	F	1986, 1996	3	0.210	0.171	0.814	0.001	0.9815	3.6878
7	August	M	1986, 1996	17	0.055	0.052	0.947	0.001	0.9980	17.0781
7	September	F	1986-87, 1996	6	0.125	0.110	0.882	0.001	1.0000	7.0001
7	September	M	1986-87, 1996	28	0.130	0.063	0.485	0.101	3.5652	23.9313
7	All	Both	1983-87, 1996-99	260	0.032	0.013	0.403	0.027	5.9135	177.4300

8.3 Incidental catches

The Workshop reviewed the Committee's decision last year (IWC, 2002a, p.101), regarding scenarios for incidental catches off Japan (25 or 75 each year) in the light of the new information provided by the Japanese scientists that, following revision of Japanese reporting laws regarding such catches, a total of 54 common minke whales had been reported incidentally caught during the latter half of 2001. The Workshop consequently **agreed** that option (iv) put forward last year (IWC, 2002a, p.101) should be pursued, i.e.

the baseline levels of 25 and 75 remain as they are, but additional explorative results be obtained for levels of 50 and of 100 whales for one trial in order to test the extent to which interpolation/extrapolation can be achieved reliably.

8.4 Modified method for conditioning

The approach suggested last year (IWC, 2002c, p.143) to deal with temporal variability in sub-area 9 had proved unsatisfactory, and the simpler approach described in Item 8.2 above also failed. Given the consequential decision not to

use the 1994 and 1995 JARPN abundance estimates in the conditioning process, the need for a modification of the original method fell away³.

Procedures to check the adequacy of the conditioning achieved for trials are detailed in Item 12.1 below.

8.5 Abundance estimates

Annex C reviews the results of sighting surveys in the western North Pacific and their acceptability for use in conditioning the trials. The Workshop **agreed** with the recommendations in Annex C, except that the JARPN estimates for sub-area 9 in 1994 and 1995 would not be used in this manner for reasons detailed in Item 8.1 above. It was also **agreed** that if abundance estimates were used as 'minimum' rather than as 'best' estimates for conditioning purposes (often because only a small portion of a sub-area was covered by the survey), the lower bound imposed on the model population should be the estimate in question less one standard error.

Although analysis of the dedicated survey of sub-area 12 in 2000 required further refinement, and so could not be used in the conditioning process, it was agreed that RMP tests would assume that an acceptable estimate from that survey would become available in due course.

Given the decision to split each of sub-areas 7, 8 and 9 into two for stock structure representation purposes (by lines at 147°E, 153°E and 162°E respectively), estimates of abundance are required which are split on this basis. It was **agreed** that the splits for sub-areas 8 and 9 would be *pro rata* by area, but that more care would be needed for sub-area 7 to make allowance for greater densities closer to the coast of Japan. An e-mail group under Miyashita, and including Butterworth and Taylor, would finalise these estimates (see Item 12.1 below). Punt and Allison were requested to finalise other aspects of the trials (such as mixing matrix revisions) necessitated by this splitting of these sub-areas.

Miyashita undertook to report further to the 2002 Scientific Committee meeting on aspects related to the estimation of abundance from the various sighting surveys associated with JARPN and JARPN II.

8.6 Harvesting plans

It is necessary to specify harvesting plans (areas and seasons in which harvesting is proposed to occur or not to occur) in order to fully specify a management option and hence conduct the *Implementation Simulation Trials*. The *Implementation* recommended by the Scientific Committee will be based on one of the management options evaluated (and see Item 10.2). If the actual harvesting plan differs from the management options evaluated, additional trials (in an *Implementation Review*) will have to be conducted.

Kawahara advised that Japan planned future small-type whaling in sub-areas 7 and 11, and pelagic whaling in sub-areas 8, 9 and 12. However, there would be no operations in sub-area 11 in April and July to reduce possible catches of 'J' stock whales.

To investigate whether more stringent spatial closures to further reduce catches of 'J' stock whales would provide any substantial additional benefit, the Workshop **agreed** that as a sensitivity test, the consequences of complete closure of sub-area 11 in all months, together with sub-area 12SW in June, should also be investigated.

8.7 Other

The Workshop considered whether it was necessary to specify that the sex ratio in sub-area 12NE was 50:50 based on data collected by the *Miwa Maru* in the north of this sub-area. Ohsumi explained that imbalance in this ratio was motivated by analogy with the Antarctic, where female whales dominated closer to the ice-edge. The Workshop therefore **agreed** that it would not change the current specification that the density of females exceeds that of males in the Okhotsk Sea.

The Workshop **reconfirmed** decisions reflected in IWC (2002c) regarding 'J' stock depletion, bycatches off Korea and trials with higher *MSYR*. These are reflected in the final trials specified, as listed in Item 10.1 below. The Workshop noted the response given to Hatanaka last year (see IWC, 2002a, p.101) regarding use of *MSYR* values pertinent to the 1+ component of the population, to the effect that such trials could be run during 2002 Scientific Committee meeting if required. Punt and Allison will make the necessary preparations to the able to deal with such a request.

9. RESULTS OF TRIALS CONDUCTED SINCE THE 2001 SC MEETING

The results of the two trials conducted during the Workshop are discussed under Item 6.1.

10. FINAL TRIALS AND RUNNING THEREOF

10.1 Specification of final trials

The Workshop developed a final set of *Implementation Simulation Trials* (see Annex H) in the light of its discussion regarding stock structure hypotheses that are consistent with the available information. In developing these trials, the Workshop noted that account needed to be taken of:

- (1) the time required to: (i) finalise the specifications of the trials; (ii) code them; and (iii) run them;
- (2) whether the trials are likely to be informative regarding the performance of RMP variants; and
- (3) the need for the trials to be appropriately balanced in terms of the factors considered.

The stock structure hypotheses can be divided into three classes:

- (1) those based on the results of hypothesis testing, which primarily imply the possibility of some 'W' stock animals in sub-area 9 but no additional stock structure to the east of Japan (henceforth referred to as '3 stocks with 2 in sub-area 9');
- (2) those based on the results of the boundary rank method, which suggest that there are three stocks ('O_W', 'O_E' and 'W') in addition to the 'J' stock to the east of Japan (henceforth referred to as '4 stocks'); and
- (3) those based on two stocks to the east of Japan (excluding the 'J' stock), which allow mixing of these stocks across most of sub-areas 7-9 during April-September (henceforth referred to as '3 stocks with mixing gradient').

The Workshop **agreed** that all the key factors (e.g. hypotheses regarding the current status of the 'J' stock) to be considered in the trials should be combined with one

³ This does not necessarily mean that substantial inter-annual variability does not exist; rather there are no data to determine its extent.

'baseline trial' from each of three classes. It should be noted, however, that the Workshop did not select these three trials on the basis of plausibility, even within each class. The three 'baseline' trials and their key features are:

- (1) *Baseline-A*: 'W' stock in sub-area 9 each year with 60% probability. In a year when the 'W' stock is in sub-area 9, 50% of the animals in sub-area 9W are from the 'W' stock. The fraction of 1+ non-J stock animals in sub-area 12 in August-September in a pristine state that are from the 'W' stock is determined from the relative abundance of such animals in sub-areas 7, 8 and 9 at that time.
- (2) *Baseline-C*: 4 stock model of which three non-J stocks ('O_W', 'O_E' and 'W') occur to east of Japan. The divisions between the 'O_W' and 'O_E' and 'W' stocks occur at 147°E and 157°E respectively. These boundaries are 'hard' (no mixing across them). The fraction of 1+ non-'J' stock animals in sub-area 12 in August-September in a pristine state that are from the 'W' stock is determined from the relative abundance of such animals in sub-areas 7, 8 and 9 at that time.
- (3) *Baseline-D*: 2 stocks ('O' and 'W') to the east of Japan which mix across the area 147°E to 162°E. The highest densities of 'O' stock animals occur in sub-area 7W and decline to the east, while the highest densities of 'W' stock animals occur in sub-area 9E and decline to the west. Two thirds of the 'W' stock moves into sub-area 12 while all of the 'O' stock does this.

The Workshop **agreed** that all of the 'J' stock animals in sub-areas 12SW+12NE would occur in sub-area 12SW while all of the 'W' stock animals in sub-areas 12SW+12NE would occur in sub-area 12NE. The specification regarding the proportion of 'J' stock animals in sub-area 12SW is based on the analyses of the flipper colour information which indicates a high proportion of 'J' stock animals in that sub-area in June (see Table 2). Previous trials that did not split sub-area 12 into smaller sub-areas, instead reduced this estimate of 'J'-'O' mixing by multiplying it by 0.32 so that it applied to the whole of sub-area 12 (IWC, 1997, p.215).

10.1.1 Changes to previous trials

The Workshop developed the full set of trials by first examining the trials developed last year (IWC, 2002c, p.146; and reproduced here as Table 3). It **agreed** that a number of these could be dropped because the factor on which the trial was based was now a specific part of one of the new stock structure proposals. The trials dropped, and the associated reasons, are as follows.

(1) TRIALS 118 AND 119

These trials specify that no 'J' animals are found in sub-area 12NE while no 'W' stock animals are found in sub-area 12SW. These assumptions are now part of the specifications for all of the trials. The previous 'base-case' assumption that the ratio of the 'J', 'W' and 'O' stocks in 12SW and 12NE is the same has been dropped primarily in the light of the information on the fraction of 'J' stock animals in sub-area 12SW based on the flipper colour information and hypotheses for how 'W' stock animals migrate from sub-areas 9 to 12.

(2) TRIALS 122, 123, 124 AND 125

These trials relate to stochastic mixing of 'W' stock animals from sub-area 9 into the sub-areas to the east of this. These trials have been dropped because they were designed to allow for additional variance in sub-area 9. However, the conditioning analyses conducted during the meeting (see

Item 6.1) suggest that the stochastic mixing approach underlying these trials did not resolve the problem it was designed to address. Furthermore, the abundance estimates for 1994 and 1995 which suggest additional variance in sub-area 9 and which would form the basis for the estimation of the parameters that define stochastic mixing have been omitted from the conditioning process (see Item 6.1).

(3) TRIALS 105, 105A, 112, 112A, 113, 113A, 120 AND 121

These trials modify the specifications for the fraction of 'O' and 'W' whales in sub-areas 8 and 12 to examine sensitivity to the base-case assumptions. The stock structure hypotheses proposed during the meeting provide revised specifications for this fraction as well as revised sensitivity tests.

(4) TRIAL 117

This trial was developed to assess the implications of the sensitivity to the data used to form the baseline for the 'J' stock when computing the 'J'-'O' mixing proportions for sub-areas 7 and 11 by basing a trial on the 'J'/'O' mixing proportions estimated from the new bycatch samples combined with the earlier commercial samples off Korea. However, the results in Table 2 indicate that the 'J'-'O' mixing proportions are insensitive to the choice of baseline for the 'J' stock. All of the trials will be conducted using the 'J'-'O' mixing proportions in Table 2a (i.e. using only the bycatch samples as the baseline for the 'J' stock).

In addition, the Workshop **agreed** to add a new factor to those considered in the trials based on the assumption that the CV supplied to the RMP is negatively biased because there is additional variance with CV of 40%. This factor is required because the catch mixing matrix for the 'W' stock is not stochastic (see Item 6.1), so there is no additional variance associated with the abundance estimates for the sub-areas to the east of Japan due to stochastic mixing of stocks.

10.1.2 Conclusions

The full set of revised trials is given as Table 4. These therefore consist of the base-case trials, the trial variants specified last year, as well as some new variants that examine sensitivity to the now revised stock structure hypotheses and larger incidental catches off Japan. It should be noted that some of the factors that underlie the trials specified last year cannot be combined with some of the stock structure proposals. For example, *Baseline-D* does not include dispersal so the factors 'lower/higher dispersal' cannot be combined with this baseline trial.

The bulk of trials are conducted for $MSYR_{mat} = 1\%$ because it is known that trials in which $MSYR_{mat} = 1\%$ are more informative regarding the risk-related performance of variants of the RMP than trials that involve $MSYR_{mat} = 4\%$.

The full set of trials is based on longitudinal boundaries at 147°E, 150°E, 153°E, 157°E and 162°E although all of the trials merge at least one of the longitudinal sectors defined by these boundaries when defining sub-areas. The Workshop **agreed** that if a trial is specified in terms of a sub-area that is a combination of two of these longitudinal sectors, the relative fraction of each stock in each sector will be the same although the total abundance in each sector may differ as the operating model will be fitted to the information on abundance from surveys for every one of these sectors.

The Workshop **agreed** that it was necessary to check that the conditioning exercise had been successfully achieved. It **recommends** that Allison develop the facility to provide the

Table 3

The set of *Implementation Simulation Trials* for North Pacific common minke whales specified by the 2001 Scientific Committee meeting. All trials to be run using both the J1 and J2 incidental catch options. (P=proportional; C=constant). For details see Allison (2002) and IWC (2002c).

Trial no.	No. of stocks	MSYR Stock J	MSYR Stock O	MSYR Stock W	J stock status in 2000 (see Fc)	% O in sub-area 12 (see Fd)	Prop'n of J in 7&11 (see 1)	Stocks in sub-area 12 (see 2)	O/W in 7,8&9 (see item 3)	Korea catch data (see 6)	Description
Base-cases											
101	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	i)	i)	i): No W in 8	P	Base-case
102	2	1 (A/B)	1 (G1)	-	30% K	-	i)	i)	-	P	2 stock variant
103	3	4 (A/B)	4 (F)	4 (K1)	30% K	30	i)	i)	i): No W in 8	P	NPM-101 + MSYR=4%
104	2	4 (A/B)	4 (G1)	-	30% K	-	i)	i)	-	P	NPM-102 + MSYR=4%
Other											
105	3	1 (A/B)	1 (G)	1 (K1)	30% K	30	i)	i)	iv): 80% O in 9	P	101 + some O in sub-area 9 (80%)
105a	3	4 (A/B)	4 (G)	4 (K1)	30% K	30	i)	i)	iv): 80% O in 9	P	101 + some O in sub-area 9 (80%)
106	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	i)	i)	i): No W in 8	P	101 + lower dispersal rate
106a	3	4 (A/B)	4 (F)	4 (K1)	30% K	30	i)	i)	i): No W in 8	P	101 + lower dispersal rate
107	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	i)	i)	i): No W in 8	P	101 + higher dispersal rate
108	3	1 (A/B)	1 (F)	1 (K1)	15% K	30	i)	i)	i): No W in 8	P	101 + 15% J stock depletion
109	3	1 (A/B)	1 (F)	1 (K1)	50% K	30	i)	i)	i): No W in 8	P	101 + 50% J stock depletion
109a	3	1 (A/B)	1 (F)	1 (K1)	70% K	30	i)	i)	i): No W in 8	P	101 + 70% J stock depletion
109b	3	4 (A/B)	4 (F)	4 (K1)	70% K	30	i)	i)	i): No W in 8	P	103 + 70% J stock depletion
110	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	i)	i)	i): No W in 8	P	101 + 20% J in 12SW (or max. achievable)
111	3	1 (A/B)	1 (F)	1 (K1)	15% K	30	i)	i)	i): No W in 8	P	101 + 15% J stock depletion + 20% J in sub-area 12SW+12NE
112	3	1 (A/B)	1 (F)	1 (K1)	30% K	100	i)	i)	i): No W in 8	P	101 + no W stock in sub-area 12
112a	3	1 (A/B)	1 (F)	1 (K1)	30% K	80	i)	i)	i): No W in 8	P	101 + 80% O in sub-area 12(SW+NE)
113	3	1 (A/B)	1 (F)	1 (K1)	30% K	10	i)	i)	i): No W in 8	P	101 + 10% O in sub-area 12(SW+NE)
113a	3	4 (A/B)	4 (F)	4 (K1)	30% K	10	i)	i)	i): No W in 8	P	101 + 10% O in sub-area 12(SW+NE)
114	3	1 (A/B)	1 (F/H)	1 (K1)	30% K	30	i)	i)	i): No W in 8	P	101 + some O animals in sub-area 10
115	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	i)	i)	i): No W in 8	P	101 + g(0) = 0.5 (see item F.h)
116	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	i)	i)	i): No W in 8	P	101 + misreport Japan incidental catch
117	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	ii)	i)	i): No W in 8	P	101 + different J proportions in 7 & 11
118	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	i)	ii)	i): No W in 8	P	101 + no J in 12NE
119	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	i)	iii)	i): No W in 8	P	101 + no J in 12NE + no W in 12SW
120	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	i)	i)	ii): 1:1 O:W in 8	P	101 + 1:1 O:W in 8
121	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	i)	i)	iii): No O in 8	P	101 + no O in 8
122	3	1 (A/B)	1 (F)	1 (K2)	30% K	30	i)	i)	i): No W in 8	P	101 + different temporal variability (between 9 & 14)
123	2	1 (A/B)	1 (G2)	-	30% K	-	i)	i)	-	P	102 + different temporal variability (between 9 & 14)
124	3	1 (A/B)	1 (F)	1 (K)	30% K	30	i)	i)	i): No W in 8	P	101 + no temporal variability
125	2	1 (A/B)	1 (G)	-	30% K	-	i)	i)	-	P	102 + no temporal variability
126	3	1 (A/B)	1 (F)	1 (K1)	30% K	30	i)	i)	i): No W in 8	C	Different Korean catch data model

plots displayed in Annex D as well as plots that show the time-trajectories of the fraction of each stock in each sub-area for those month/sub-area combinations for which information is available on the 'J'-O' mixing rate. A small group consisting of Butterworth, Kawahara, Polacheck, Punt and Wade was established to work intersessionally with Allison to examine the details of some of the initial conditioning attempts and to develop summary statistics for conditioning.

10.2 Small Areas /RMP variants to be considered

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 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 7W, 7E, 8W, 8E, 9W, 9E, 11, 12SW and 12NE.
- (2) 7+8, 9, 11 and 12 are *Small Areas* and catches are taken from sub-areas 7W, 9W, 11 and 12SW.

- (3) 7+8+11+12 and 9 are *Small Areas* and catches are taken from sub-areas 11 and 9W.
- (4) 7W, 7E+8+12, 9 and 11 are *Small Areas* and catches are taken from sub-areas 7W, 9W, 11 and 12SW.
- (5) 7+8+11+12 and 9 are combination areas and catches are cascaded to the sub-areas within each combination area.
- (6) as (3) except that the catches from the 7+8+11+12 *Small Area* are taken from sub-areas 7W and 11 using catch cascading across those two sub-areas.

Following the advice of Kawahara (see Item 8.6), catch limits will not be set for sub-area 11 in April or July in any of the trials. The Workshop noted that the fraction of 'J' stock animals was not insubstantial in sub-area 12SW in June and in sub-area 11 in all months. Therefore, it **agreed** to conduct two additional RMP variants based on variants (1) and (5). These will be based on the assumption that catches are zero in sub-area 11 in all months and in sub-area 12SW in June.

In cases where a *Small Area* consists of more than one sub-area, the general approach followed above (as in the past) is to assume the extreme that all catches are taken from the sub-area that would lead to the worst performance in terms of risk-related statistics.

Table 4

The revised list of *Implementation Simulation Trials* for the North Pacific common minke whales. All trials will be run using both the J1 and J2 incidental catch options. The detailed version of this table included in Annex H also lists the mixing matrices.

Trial no.	No. of NPM-	stocks	MSYR	'J' stock status in 2000	Description	Old trial equivalent
Base Lines						
A	3	1%+4%	30% K	Base-case 3 stocks with 2 in sub-area 9		NPM-105 ¹
B	2	1% + 4%	30% K	2 stock variant		NPM-102
C	4	1%+4%	30% K	Base-case 4 stocks with hard boundary at 147°		
D	3	1%+4%	30% K	Base-case with mixing gradient {all moving left} (=Annex G)		
Sensitivity trials						
	A	C	D			
1	1%+4%	1%+4%		30% K	+ lower dispersal rate	NPM-106
2	1%	1%		30% K	+ higher dispersal rate	NPM-107
3	1%	1%	1%	15% K	+ 15% 'J' stock depletion	NPM-108
4	1%	1%	1%	50% K	+ 50% 'J' stock depletion	NPM-109
5	1%+4%	1%+4%	1%+4%	70% K	+ 70% 'J' stock depletion	NPM-109a
6	1%	1%	1%	30% K	+ 20% 'J' in 12SW (or max. achievable)	NPM-110
7	1%	1%	1%	15% K	+ 15% 'J' stock depletion + 20% 'J' in 12SW (or max achievable)	NPM-111
8	1%	1%		30% K	Some whales from 9 go east of Kamchatka (162° line)	NPM-112
9	1%	1%		30% K	+ some 'O' animals in sub-area 10 ('O _w ' in 4 stock hypothesis)	NPM-114
10	1%	1%	1%	30% K	+ g(0) = 0.5 (see item F.f of Annex H)	NPM-115
11	1%	1%	1%	30% K	+ mis-report Japan incidental catch	NPM-116
12	1%	1%	1%	30% K	Different Korean bycatch data model	NPM-126
13	1%	1%	1%	30% K	Different Japanese incidental catch level (50 and 100)	
14	1%			30% K	Sensitivity to A: some W in 8	
15		1%		30% K	More 'O _E ' in 12 SW	
16		1%		30% K	Less 'O _E ' in 12 SW	
17		1%		30% K	4 stocks with hard boundary at 153°	
18		1%		30% K	4 stocks with mixing	
19		1%		30% K	4 stocks with intrusion	
20		1%+4%		30% K	4 stocks 'O _E ' mixing. (intrusion with mixing)	
21			1%	30% K	3 stocks with mixing gradient {all moving right}	
22			1%	30% K	3 stocks with stochastic mixing	
23	1%	1%	1%	30% K	40% additional variance in CV supplied to CLA (see item 10.1)	
24	1%	1%	1%	30% K	Sub-area 11 closed in all months + sub-area 12SW closed in June (see item 10.2)	

¹ Note: this is not completely equivalent as it includes a temporal variant.

The Workshop noted that the 'partial cascading' of RMP variant (6) was not in accord with the definition of catch cascading included in the specifications of the RMP because the catch limit is cascaded between two sub-areas rather than among all of the sub-areas in the combination area. The Workshop recalled that this variant arose during discussions among the members of the intersessional Steering Group between the 2000 and 2001 meetings of the Scientific Committee; it was developed because of the fact that it is unrealistic to assume that all of the catches from the 7+8+11+12 *Small Area* would be taken from sub-area 11 only. Rather it implements the specification that the catches from this *Small Area* would be distributed between sub-areas 7W and 11, the two sub-areas in which coastal whaling has occurred in the past.

In discussing this item, it was noted that the approach above is substantially different to that envisaged when the RMP was developed. This is because the RMP was originally developed for baleen whales hunted on their feeding grounds rather than during migration. The Workshop **draws this** to the Committee's attention and **recommends** that it thoroughly reviews the concept of 'partial cascading' and, if deemed appropriate, develops any necessary additions to the explanatory notes to the RMP.

10.3 Methods to examine results including specification of statistics and plots

The Workshop recognised the importance of developing simple and clear approaches to summarise the results of trials to the Scientific Committee (and Commission), but

Table 5
Work plan and timetable.

(1) Finalise the abundance estimates for subdivisions of sub-areas 7, 8 and 9 (Miyashita (Chair), Butterworth and Taylor)	7 February
(2) Finalise adaptations of existing mixing matrices to cater for the subdivisions of sub-areas 7, 8 and 9 (Allison and Punt)	7 February
(3) Check conditioning on an initial set of trials (Allison [Chair], Butterworth, Kawahara, Polacheck, Punt, Wade)	late February
(4) Specify dispersal rates for the 4 stock trials (Taylor and Martien)	end February
(5) Completion of the specification of the trials based '3 stocks with mixing gradient' hypothesis (Smith [Chair], Polacheck, Punt, Ohsumi, Kim)	mid March
(6) Develop format for reporting of results of trials (Smith [Chair], Allison, Butterworth, Kawahara, Taylor)	mid April
(7) Conduct preparatory work to handle a request to conduct trials with <i>MSYR</i> defined in terms of the 1+ component of the population (Allison and Punt)	mid April
(8) Run final trials specified. For practical reasons, these will be coded and run in the order '3 stocks with 2 in sub-area 9', '4 stocks' and the '3 stocks with mixing gradient' (Allison)	late April

unfortunately had insufficient time available to discuss this matter in any detail. It therefore **established** an intersessional correspondence group (led by Smith and including Allison, Butterworth, Kawahara and Taylor) to try and develop such approaches prior to the 2002 Scientific Committee meeting. They would attempt to format simple summaries from the more comprehensive tabulation of results previously prepared by Allison (2002) on the basis of Scientific Committee requests for statistics to be reported. The utility of graphical approaches to facilitate comparison of results for different trials or for different RMP variants was emphasised, for example by use of the software developed by Zeh for this purpose in the AWMP sub-committee.

11. RELATIVE PLAUSIBILITY OF TRIALS

Although there was insufficient time to discuss this item, the Chair reiterated his remarks made under Item 7. In particular, he stressed the need for members to develop papers for the 2002 SC meeting addressing this issue, particularly but not exclusively with respect to the various stock structure hypotheses put forward at this meeting. This should also be the mechanism whereby anyone who had to leave the meeting early can comment on the conclusions reached after their departure.

12. WORK REQUIRED PRIOR TO NEXT SC MEETING

12.1 Schedule

The Schedule of work timetabled before the next Scientific Committee meeting is given in Table 5.

The Workshop recognised that the above work plan was extremely ambitious and that it may not be possible to complete it within the expected timeframe, given the other computing requirements of the Scientific Committee, particularly with respect to the AWMP.

12.2 Terms of Reference for the intersessional group to facilitate conduct of this work

It was **agreed** that the intersessional group established at the 2001 SC meeting should continue to facilitate the conduct of the work identified by the Workshop as required prior to the 2002 SC meeting.

13. ADOPTION OF REPORT

The meeting finished at 11.55pm on its final day without having time to consider a draft report. The Chair thanked the participants for their forbearance and noted his concern that insufficient time had been allocated to cover the extensive agenda. He noted that all members had participated fully in the discussion of complex scientific issues that were important to the satisfactory completion of the

Implementation Trials process. He expressed a general concern that the process of undertaking the *Implementation* exercise required further serious consideration by the Committee outside the pressure of having to complete such an exercise. The Workshop **strongly recommends** that the Scientific Committee thoroughly addresses the question of determining the most appropriate procedure for scheduling and conducting any future RMP *Implementation (Reviews)*, in addition to the discussions held at last year's meeting.

The report was adopted after conclusion of the meeting by means of e-mail correspondence.

14. CLOSURE

The participants thanked: the Chair for his effective and patient handling of this difficult and highly technical meeting; the rapporteurs; and the meeting hosts, the US National Marine Mammal Laboratory, especially Paul Wade.

REFERENCES

- Allison, C. 2002. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 10. The detailed results for trial NPM101-J1. *J. Cetacean Res. Manage. (Suppl.)* 4:123-5.
- Hatanaka, H. and Miyashita, T. 1997. On the feeding migration of Okhotsk Sea-West Pacific stock minke whales, estimates based on length composition data. *Rep. int. Whal. Commn* 47:557-64.
- International Whaling Commission. 1997. Report of the Scientific Committee, Annex J. Report of the Working Group on North Pacific minke whale trials, Appendix 3. Estimates of mixing between J and O stocks. *Rep. int. Whal. Commn* 47:214-5.
- International Whaling Commission. 2001a. Report of the Scientific Committee. Annex I. Report of the Working Group on Stock Definition. *J. Cetacean Res. Manage. (Suppl.)* 3:229-38.
- International Whaling Commission. 2001b. Report of the Workshop to Review the Japanese Whale Research Programme under Special Permit for North Pacific Minke Whales (JARP), Tokyo, 7-10 February 2000. *J. Cetacean Res. Manage. (Suppl.)* 3:375-413.
- International Whaling Commission. 2002a. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. *J. Cetacean Res. Manage. (Suppl.)* 4:93-147.
- International Whaling Commission. 2002b. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 12. Specifications of the North Pacific minke whaling trials. *J. Cetacean Res. Manage. (Suppl.)* 4:127-38.
- International Whaling Commission. 2002c. Report of the Scientific Committee. Annex D. Report of the Sub-Committee on the Revised Management Procedure. Appendix 15. North Pacific minke whale trials Working Group: details of trial modifications. *J. Cetacean Res. Manage. (Suppl.)* 4:140-7.
- Kishino, H., Kitada, S. and Hiramatsu, K. 1994. Sampling scheme for the estimation of the stock composition in the mixed population based on genetic data. *Nippon Suisan Gakkaishi* 60(3):359-64. [In Japanese].
- Martien, K.K. and Taylor, B.L. 2001. A new method of generating hypothesized population structures for continuously distributed species using genetic data. Paper SC/53/SD7 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].

Annex A

Agenda

1. Convenor's opening remarks	8.3 Incidental catches
2. Election of Chair	8.4 Modified method for conditioning
3. Appointment of Rapporteurs	8.5 Abundance estimates
4. Adoption of agenda	8.6 Harvesting plans
	8.7 Other
5. Review of documents and (within-meeting) computing capabilities	9. Results of trials conducted since the 2001 SC meeting
6. General issues	10. Final trials and running thereof
6.1 Conditioning	10.1 Specification of final trials
6.2 Data availability	10.2 Small Areas/RMP variants to be considered
	10.3 Methods to examine results including specification of statistics and plots
7. Review of further genetic analyses results	11. Relative plausibility of trials
7.1 Re-estimation of J-O mixing	12. Work required prior to SC meeting
7.2 Methodologies	12.1 Schedule
7.2.1 Hypothesis testing	12.2 Terms of Reference for the intersessional group to facilitate conduct of this work
7.2.2 Bayes and empirical Bayes approaches	
7.2.3 Boundary rank techniques	
7.3 Stock structure proposals	
8. Progress on other trial-related issues	13. Adoption of report
8.1 Mixing of the 'J' and 'O' stocks	
8.2 Temporal variability in sub-area 9	14. Closure

Annex B

List of Documents

SC/J02/NP

1. PUNT, A.E. On diagnostic statistics to evaluate *conditioning of Implementation Simulation Trials*
 2. TAYLOR, B.L. and MARTIEN, K. Interpretation of Boundary Rank results for North Pacific minke whales.
 3. MARTIEN, K. and TAYLOR, B.L. Estimating the degree of support for population structure hypotheses generated by Boundary Rank.
 4. CUI, G., PUNT, A.E., PASTENE, L.A. and GOTO, M. Bayes and Empirical Bayes approaches to addressing stock structure questions using mtDNA data, with an illustrative application to the North Pacific minke whales.
 5. TAYLOR, B.L. and MARTIEN, K. Proposed trial specifications for four stock scenarios.
 6. TAYLOR, B.L. and MARTIEN, K. What measures of genetic similarity should be used to delineate stocks?
 7. PASTENE, L.A., GOTO, M. and KANDA, N. Proposal on an update to the defaults on stock structure in item 3 of Appendix 15 of Annex D (RMP Sub-Committee Report).
 8. PASTENE, L.A., GOTO, M. and KANDA, N. Scientific background supporting the stock scenarios proposed by Pastene, Goto and Kanda in SC/J02/NP7.
 9. GOTO, M. and PASTENE, L.A. Re-estimations of the mixing proportion of O and J stocks in sub-areas 2, 11 and 7 following the guidelines offered in Appendix 15 of Annex D (RMP Sub-Committee Report).
 10. GOTO, M., KANDA, N. and PASTENE, L.A. Further mtDNA analysis on North Pacific minke whales including JARPN and JARPN II samples from 1994 to 2001.
 11. KANDA, N., GOTO, M. and PASTENE, L.A. Further microsatellite analysis on North Pacific minke whales including JARPN and JARPN II samples from 1994 to 2001.
 12. ZENITANI, R., FUJISE, Y., KAWAHARA, S. and KATO, H. Examination of the distribution and reproductive status of western North Pacific minke whales collected in sub-areas 7, 8 and 9 during JARPN and JARPN II from 1994 to 2001.
 13. Report of the 'Small Drafting Group'.
-

Annex C

Report of the Small Working Group on Abundance Estimates for Use in Conditioning the *Implementation Simulation Trials*

The small Working Group (Wade, Polacheck, Miyashita, Butterworth) reviewed the abundance data available to the Workshop. The purpose of this was to: (1) document the full source and reference for each estimate; (2) determine whether and what kind of extrapolation might have been made to any of the estimates; and (3) re-examine each estimate's suitability for inclusion in the conditioning of the *Implementation Simulation Trials*.

1. DATA USED IN THE 2001 TRIALS

The data used for *Trials* agreed at the last Scientific Committee meeting are shown in Table 1.

1.1 General points

Initially, there was uncertainty about how the values of areal coverage were made, how they were used, and whether extrapolations of the abundance estimates were made. It was confirmed that areal coverage was calculated as the size of the study area divided by the size of the sub-area. Review of IWC reports revealed that a consistent process was used to make abundance estimates for a given sub-area consistent with each other. An abundance estimate was available for all sub-areas in 1990. Therefore, abundance estimates from

other years were scaled to the 1990 abundance by the ratio of areal coverages. Specifically, an abundance estimate from a different year was divided by the ratio of its areal coverage to the areal coverage in 1990. The abundance estimates that appeared in this table have had this areal coverage correction already performed.

1.2 Specific points

Sub-area 6. 1992. Acceptable for use in conditioning.

Covers only the eastern part of sub-area 6 (southern Sea of Japan), therefore it is properly treated as a minimum estimate.

Sub-area 7. 1990. Not acceptable for use in conditioning.

The same data are used again in making the 1991 estimate (which pools 1990, 91, 92). Only goes down to 39°N, whereas sub-area 7 goes down to 35°N, which explains why it was treated as a minimum. Exact source of estimate also needs to be further documented (see discussion of other 1990 estimates).

Sub-area 7. 1991. Acceptable for use in conditioning, needs documentation.

OK, but source needs to be further documented. The estimate of 2,202 comes from pooling data from 1990, 1991 and 1992. The 1990 survey only went to 39°N. The 1991 and 1992 surveys only went to 145°E, whereas sub-area 7 goes to

Table 1
The abundance data upon which the trials specified by the 2001 Scientific Committee are based.

Sub-area	Timing	Areal coverage	Abundance	CV	Type	Use by CLA? ²
6	Aug-Sep 1992	56.8	893 ¹	0.67	D	No
7	Aug-Sep 1990	54.8	1,741	0.655	D	No
7	Aug-Sep 1991	66.5	2,202	0.383	D	Yes
8	Aug-Sep 1990	62.2	1,057	0.706	D	Yes
9	Aug-Sep 1990	35.1	8,264	0.396	D	Yes
9	Jun-Jul 1994	35.0	4,673	0.441	J	No
9	Jun-Jul 1995	45.1	2,145	0.315	J	No
10	Aug-Sep 1992	30	707 ¹	0.57	D	No
11	Aug-Sep 1990	100.0	2,120	0.449	D	Yes
12	Aug-Sep 1990	100.0	15,641	0.363	D	Yes
12	Aug-Sep 1992	91.2	11,948	0.46	D	Yes
12SW	Aug-Sep 1990	100.0	5,244	0.320	D	Yes
12SW	Aug-Sep 1992	100.0	404	0.432	D	No
12NE	Aug-Sep 1990	100.0	10,397	0.171*	D	Yes
12NE	Aug-Sep 1992	89.4	11,544	0.157*	D	Yes

J: JARPN survey; D: Dedicated survey; *Provisional values, to be recalculated after the meeting. ¹Used as a minimum estimate; ²i.e. Estimate acceptable to calculating catch limits if the Commission decides to implement the RMP.

150°E. Therefore, coverage of the entire sub-area is only achieved by combining the surveys. It is believed that the estimate of 2,202 was calculated at an SC meeting by Buckland (and possibly colleagues). It is verbally described as an inverse-variance weighted average of abundance estimates from the area surveyed in common by the three surveys, with other areas added to that estimate.

Sub-area 8. 1990. Acceptable for use in conditioning, needs documentation.

Source needs to be further documented (derivation of Buckland *et al.*, 1992). The estimate of 1,057 comes from Buckland *et al.* (1992). Buckland made estimates for the Sea of Okhotsk and for the NW Pacific, areas that correspond mostly (but not entirely) to sub-areas 11+12 and sub-areas 7+8+9, respectively. The Buckland *et al.* estimates therefore needed to be adjusted to correspond to those areas. First, the Sea of Okhotsk estimate needed to be split between sub-areas 11 and 12. The NW Pacific estimate needed to be divided between sub-areas 7, 8 and 9. Additionally, part of it is allocated to sub-area 12 to account for the SE corner of sub-area 12 that extends SE of the Kurils. It is believed that this division was done just by using areas. Buckland *et al.* (1992) state that their estimate using Beaufort states 0-4 is to be preferred, which is 25,049 (7,909 SE, 0.316 CV). However, the sum of the 1990 estimates in Table 1 for areas 7, 8, 9, 11 and 12 is 28,823. If the allocation to sub-areas had been done solely by using areas, the sum should have been conserved. These numbers first appeared in 1993.

Sub-area 9. 1990. Acceptable for use in conditioning, needs documentation.

Source needs to be further documented (derivation of Buckland *et al.*, 1992), and small discrepancy in sum of numbers needs to be investigated.

Sub-area 9. 1994. Acceptable for use in conditioning, needs documentation.

Source is Miyashita and Fujise (1997), but needs to be further documented. Estimate is based on JARPN SSV (sighting/sampling vessel surveys) data only (there is no dedicated vessel survey data). Numbers in Miyashita and Fujise (1997) do not correspond directly to estimate here of 4,673. Areal coverage of survey is reported as 35.0 in Table 1, but source of this number is unclear. The text from the 1997 report states that this estimate was areal coverage extrapolated to match areal coverage in 1990 (35.1). Given that this was SSV data, the maps in Miyashita and Fujise (1997) showing tracklines were examined to see whether they had provided approximately equal coverage probability throughout the study area. Although not randomly sampled, coverage did occur throughout the study area, and for the purposes of conditioning, it was felt that these estimates could remain.

Sub-area 9. 1995. Acceptable for use in conditioning, needs documentation.

Source is Miyashita and Fujise (1997), but needs to be further documented, and small discrepancy in sum of numbers needs to be investigated (see comments in preceding paragraph).

Sub-area 10. 1992. Acceptable for use in conditioning, needs documentation.

Covers only the eastern part of sub-area 6 (northern Sea of Japan), therefore it is properly treated as a minimum estimate.

Sub-area 11. 1990. Acceptable for use in conditioning, needs documentation.

Source needs to be further documented (derivation of Buckland *et al.*, 1992), and small discrepancy in sum of numbers needs to be investigated.

Sub-area 12. 1990. Acceptable for use in conditioning, needs documentation.

Source needs to be further documented (derivation of Buckland *et al.*, 1992), and small discrepancy in sum of numbers needs to be investigated.

Sub-area 12. 1992. Acceptable for use in conditioning.

The areal coverage was 91.2, compared to 100.0 in 1990. This was due to SE corner of sub-area 12 that is SE of Kurils. Estimate of 10,897 (Miyashita and Shimada, 1994) was divided by 91.2/100.0 to get estimate of 11,948.

Sub-area 12SW and 12NE. 1990 and 1992. Acceptable for use in conditioning, need new CV calculations.

The total estimates for sub-area 12 (15,641 and 11,948, respectively) were divided into the SW and NE sub-divisions, using the observed *n/L* in these areas (this assumes constant effective search width and school size across sub-area). Miyashita reported that this was done using a table of calculated *n/L* by one-degree squares. This necessitated calculating CVs based on one-degree squares as the sampling unit. This differs from the total sub-area 12 estimates, which calculated CVs using daily effort as the sampling unit. It was noted that the one-degree sampling unit calculations led to much lower estimates of the variance compared to using a daily effort sampling unit. It would not be possible to make daily effort variance calculations at the Workshop. Therefore, it was recommended that the variances for the pieces be approximated by allocating the variance for the total estimate calculated from daily effort to the sub-areas 12SW and 12NE estimates using the amount of effort in each sub-area, and using the usual assumption about sample size and expected CV. Even better would be to recalculate the variances using daily effort within the SW and NE sub-areas, which Miyashita indicated could be done, but this was not seen as being necessary.

2. NEW ESTIMATES PRESENTED AT THIS MEETING

A number of new abundance estimates were kindly provided by Japanese scientists to the Workshop. These are summarised in Table 2.

2.1 General points

All of the new estimates were based on JARPN/JARPN II data except for dedicated vessel surveys in 2000 in sub-areas 11 and 12. Areal coverages are provided in the table, but it was confirmed that these had not yet been used. In other words, none of the estimates in the table had been adjusted yet by areal coverage. If they are going to be used in conditioning, the estimates would need to be adjusted to the areal coverage achieved in 1990.

2.2 Specific points

Sub-areas 7 (1999-2000), 8 (1996, 1998), 11 (1996, 1999). Not acceptable for use in conditioning

New estimates in Table 2 for JARPN/JARPN II data from 1996-2000 include both SSV data and dedicated vessel data. Miyashita provided maps of on-effort tracklines for these surveys, but they were pooled across years and stratified by month. This made it impossible to evaluate whether the surveys provided approximately equal coverage probability of a sub-area in a given year. Therefore, the group recommended against using these estimates in the conditioning.

Table 2

Additional abundance estimates.

Sub-area	Timing	Areal coverage	Abundance	CV	Source	Use by CLA?
7	June 1999	13.1	1,663	0.528	J	No
7	May-June 2000	62.6	2,332	2.405	J	No
8	July-Aug 1996	31.3	1,385	0.31	J	No
8	May-June 1998	81.6	843	0.541	J	No
11	Aug 1996	32.3	608	0.266	J	No
11	July 1999	32.3	881	0.338	J	No
11	Aug-Sep 2000	100.0	1,456	0.565	D	Yes
12	Aug-Sep 2000	71.1	12,625	0.317	D	No
12SW	Aug-Sep 2000	100.0	3,259	0.574	D	No
12NE	Aug-Sep 2000	63.8	9,366	0.377	D	No

J: JARPN; D: Dedicated survey.

Sub-area 11. 2000. Acceptable for use in conditioning.

This estimate is reported for the first time in SC/J02/NP4, and was based on dedicated vessel surveys in 1999 and 2000 pooled. These were naked-eye surveys, done in passing mode, using an independent observer. Miyashita noted that the estimates used: (1) 0-3 Beaufort data; and (2) non-duplicate independent observer sightings in the analysis. Although no details of the analysis were available beyond this, the tracklines in the maps indicate roughly equal coverage probability. On this basis, the group agreed that this estimate was acceptable for use in the conditioning. There was 100% areal coverage, so no adjustment of this estimate was necessary, as the 1990 sub-area 11 estimate also had 100% coverage.

Sub-area 12. 2000. Not acceptable for use in conditioning.

This estimate is reported for the first time in SC/J02/NP4, and was based on dedicated vessel surveys in 1999 and 2000 pooled (see further comments under sub-area 11). Examination of the survey tracklines indicated a lack of approximately equal coverage probability, as very little effort was accomplished in the eastern half of the survey area, due to unfortunate problems with bad weather in 1999 and a mechanical breakdown of a vessel in 2000. However, the estimate was calculated in a pooled fashion, and therefore encounter rates in the western half of the survey area were essentially extrapolated to virtually unsurveyed

areas in the eastern half of the survey. The group agreed that a post-stratification into at least two strata (east and west) would be necessary before an estimate from these data would be acceptable.

Sub-area 12SW. 2000. Not acceptable for use in conditioning.

This estimate is reported for the first time in SC/J02/NP4, and was based on dedicated vessel surveys in 1999 and 2000 pooled (see further comments under sub-area 11). Although this survey had 100% survey coverage of this sub-area, examination of the survey tracklines indicated a lack of approximately equal coverage probability. Even though this sub-area was in the SW corner of the study area, this area still had very little effort in the eastern half of the survey area.

REFERENCES

- Buckland, S.T., Cattanach, K.L. and Miyashita, T. 1992. Minke whale abundance in the northwest Pacific and the Okhotsk Sea, estimated from 1989 and 1990 sighting surveys. *Rep. int. Whal. Commn* 42:387-92.
- Miyashita, T. and Fujise, Y. 1997. Abundance estimate of the western North Pacific minke whale in sub-area 9 with notes on the results of dedicated surveys. *Rep. int. Whal. Commn* 47:543-51.
- Miyashita, T. and Shimada, H. 1994. Minke whale abundance in the Okhotsk Sea, the Sea of Japan and off the Pacific coast of Northern Japan estimated from sighting data. Paper SC/46/NP6 presented to the IWC Scientific Committee, May 1994 (unpublished). 9pp. [Paper available from the Office of this Journal].

Annex D

Diagnostic Plots for the Two Trials

Cherry Allison and Andre Punt

Figs. 1–3 on following pages

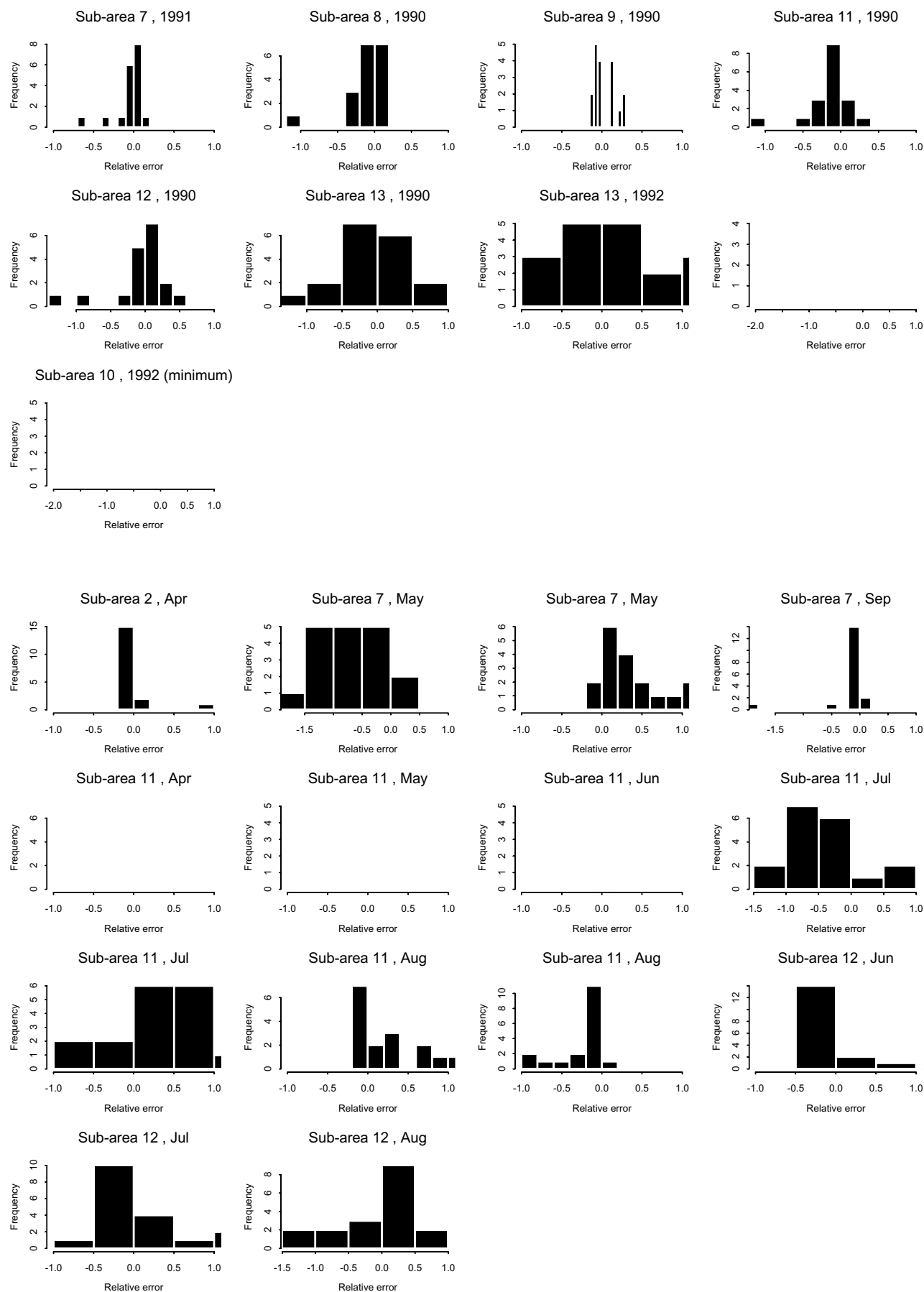


Fig. 1(a). Standardised residuals for the trial 1.

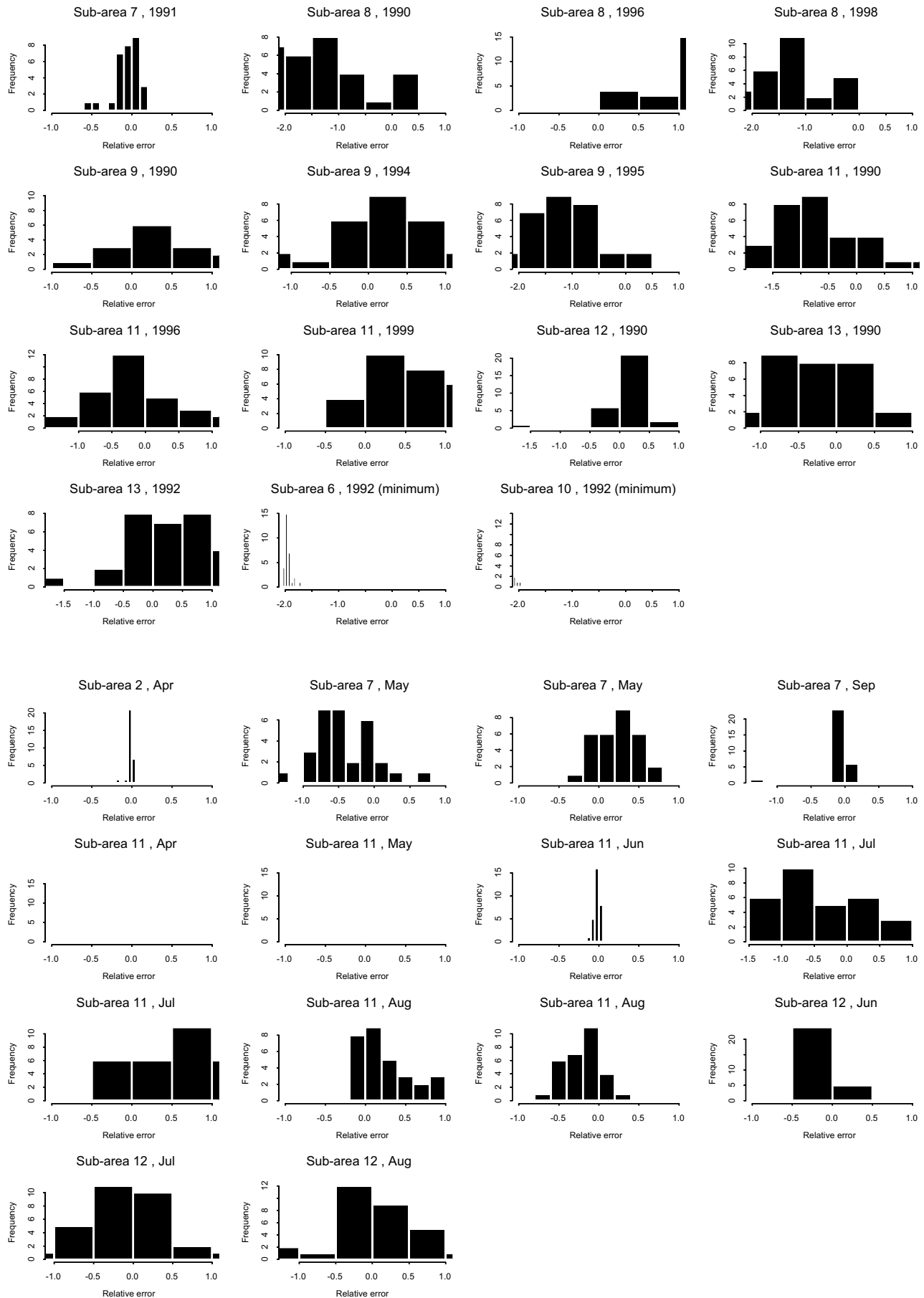


Fig. 1(b). Standardised residuals for trial 2.

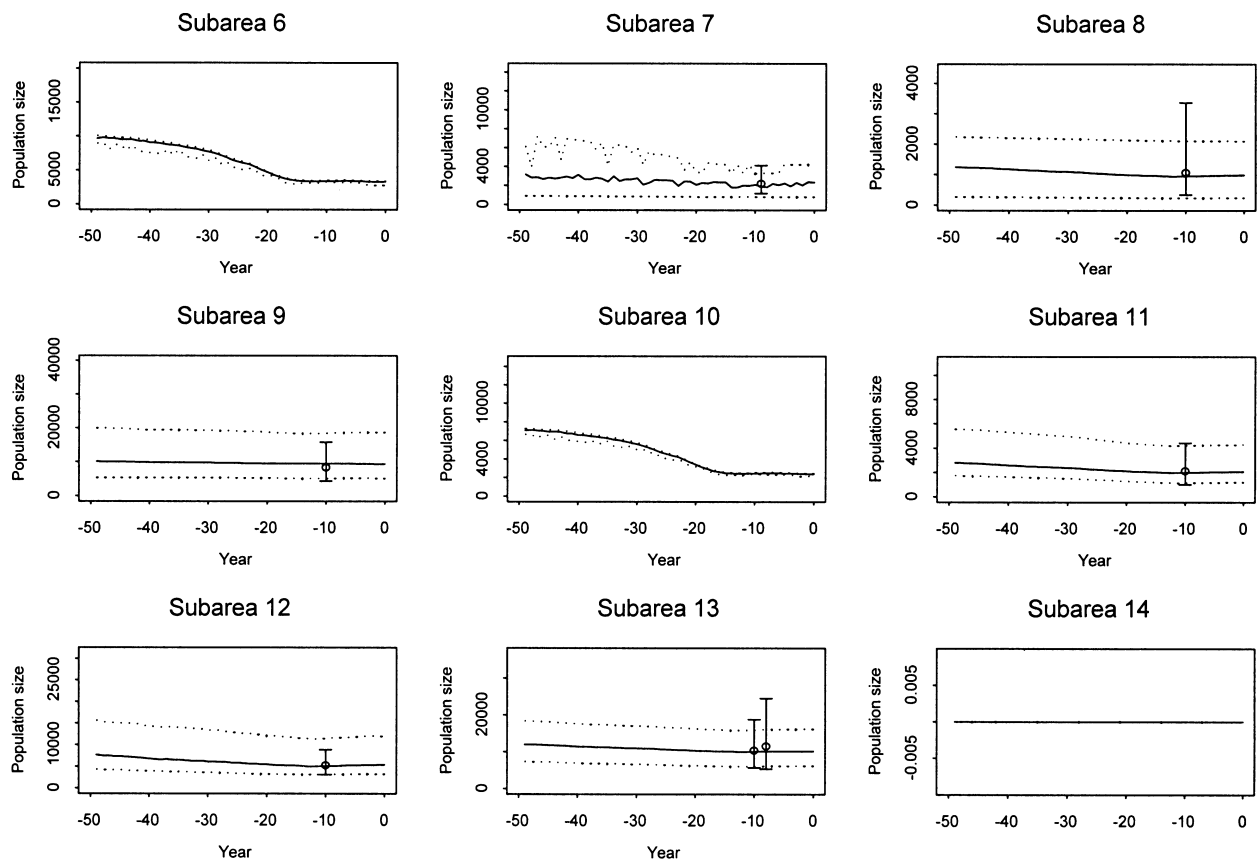


Fig. 2(a). Time-trajectories (medians and 90% intervals) of 1+ population size in August for trial 1. The abundance estimates used when conditioning the simulations are shown by the estimate plus / minus one standard deviation.

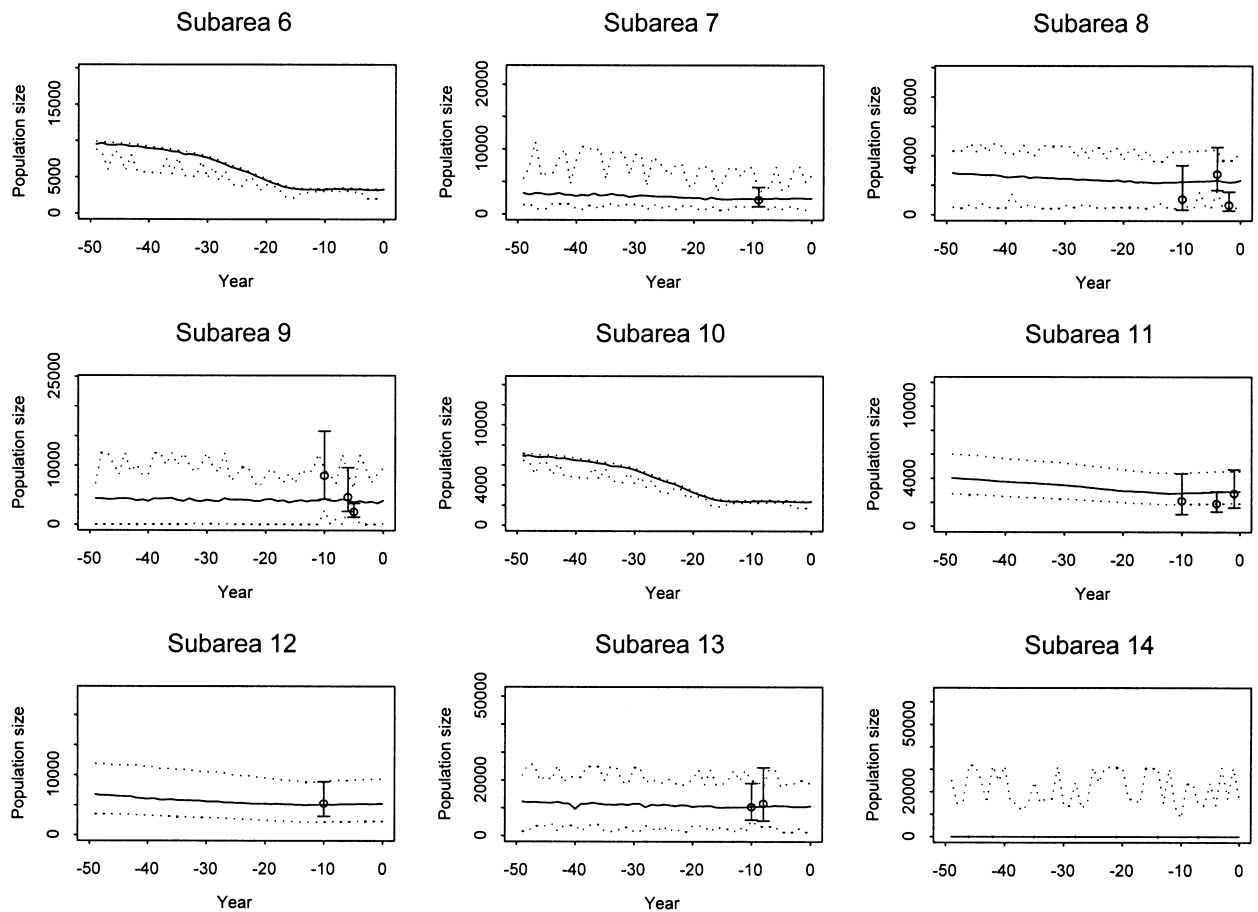


Fig. 2(b). Time-trajectories (medians and 90% intervals) of 1+ population size in August for trial 2. The abundance estimates used when conditioning the simulations are shown by the estimate plus/minus one standard deviation

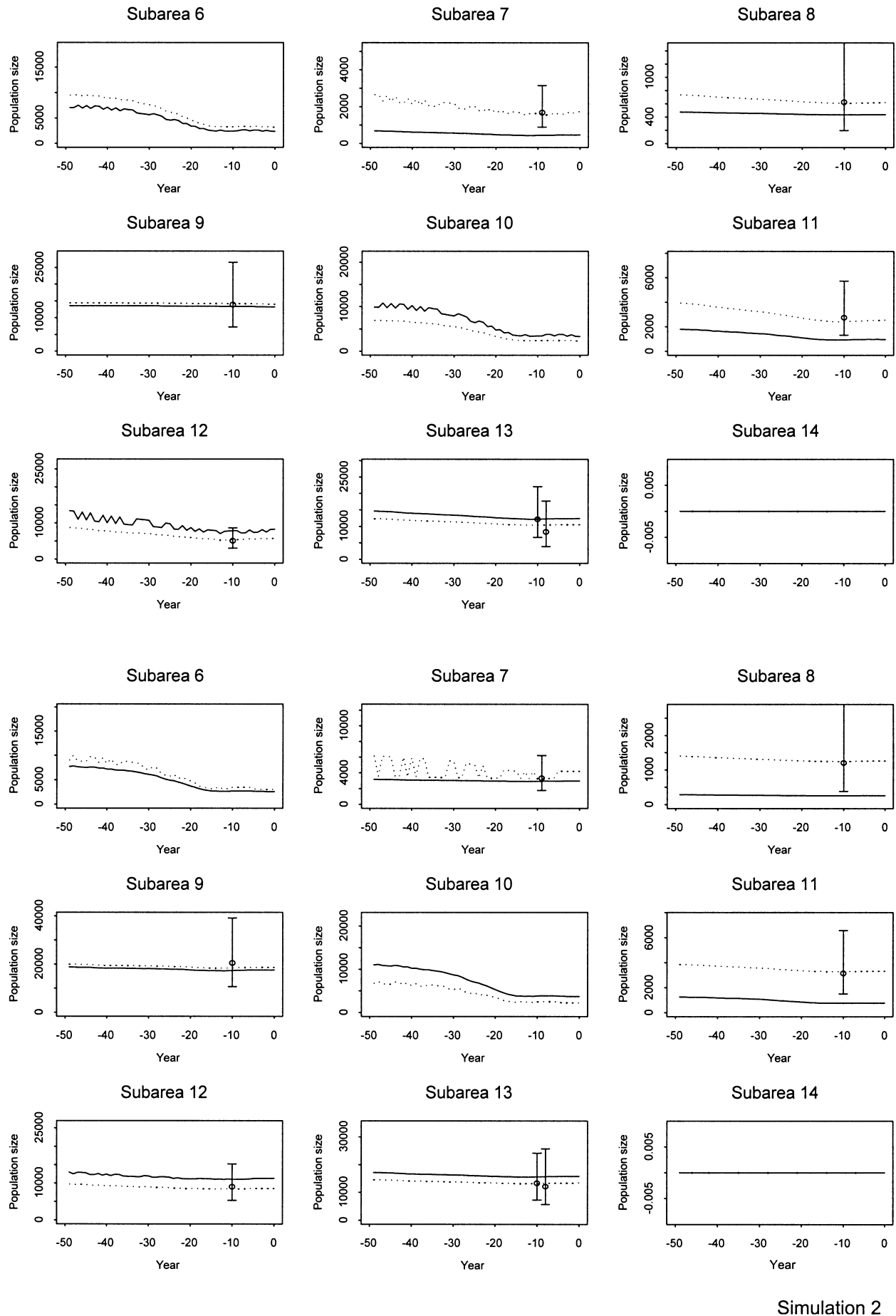
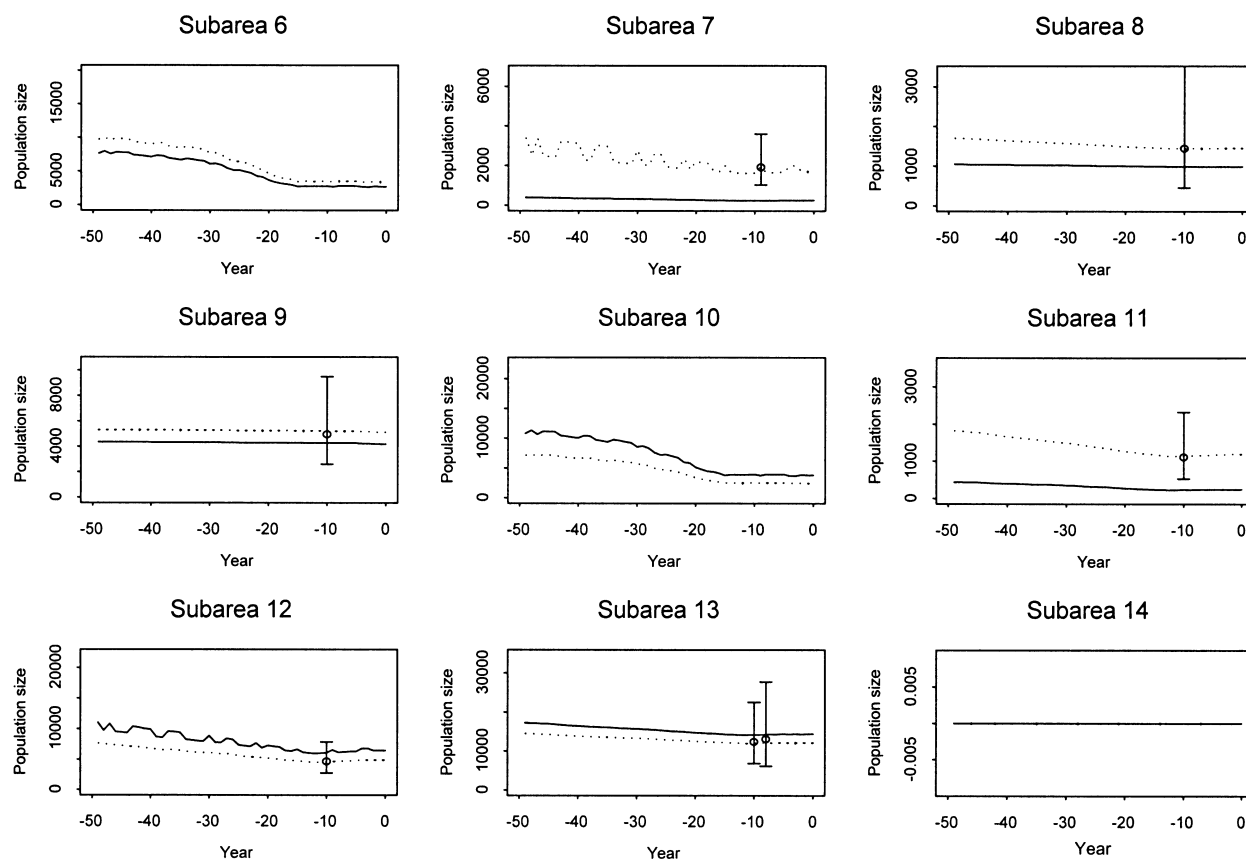


Fig. 3(a). Time-trajectories (May – solid line; August – dotted line) for simulations 1-3 of trial 1. The solid dots denote the abundance estimates used for fitting the selected simulations plus/minus one standard deviation.



Simulation 3

Fig. 3(a) cont.

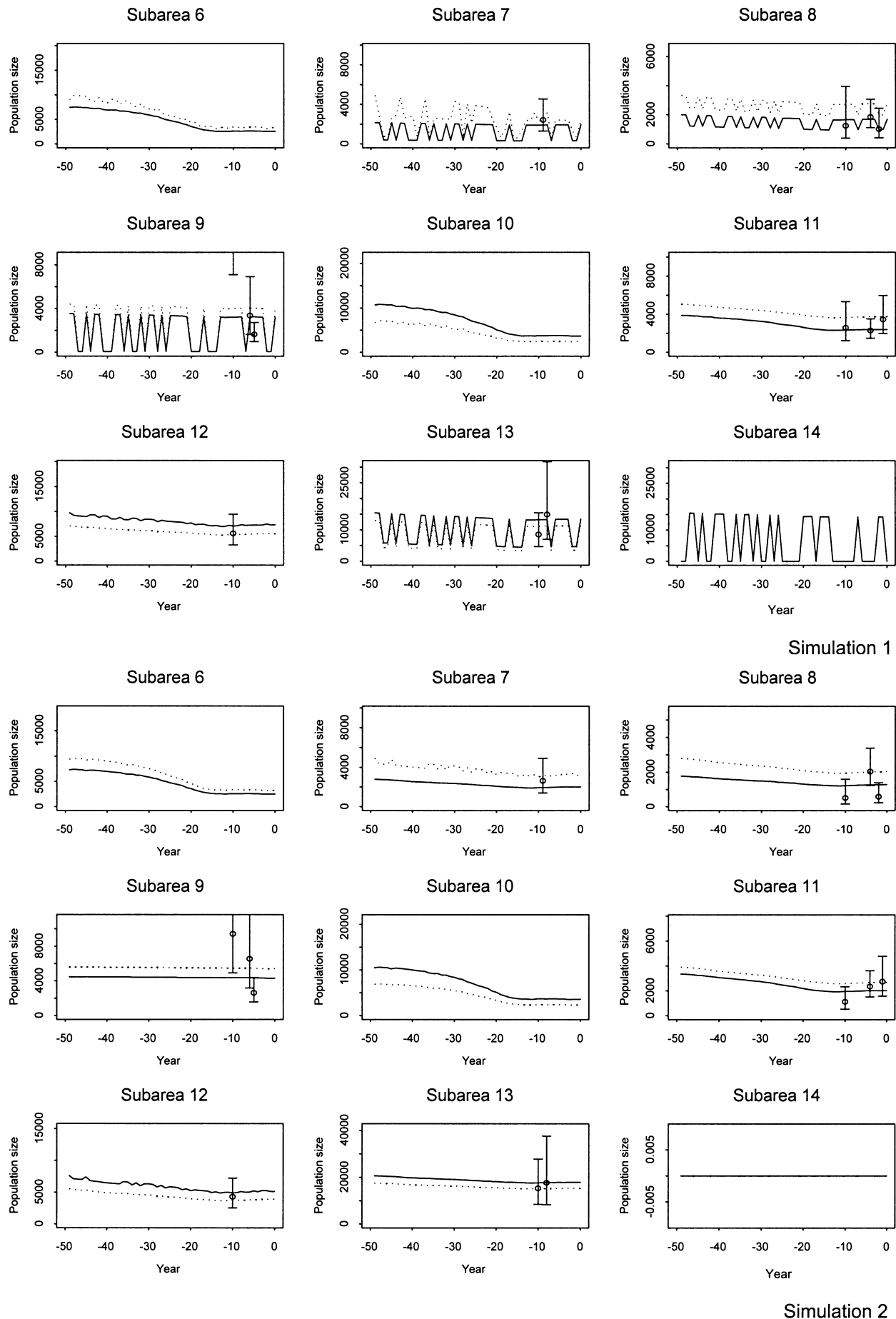
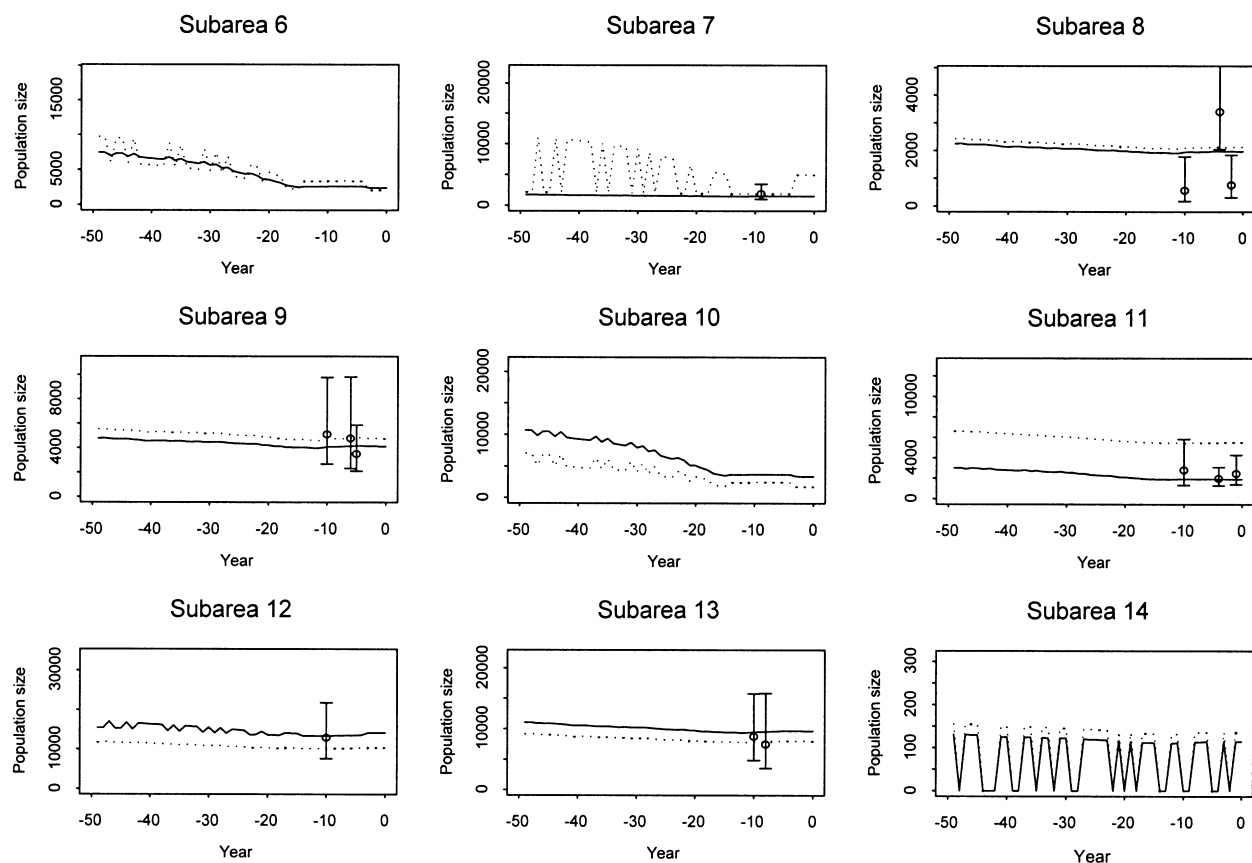


Fig. 3(b). Time-trajectories (May – solid line; August – dotted line) for simulations 1-3 of trial 2. The solid dots denote the abundance estimates used for fitting the selected simulations plus/minus one standard deviation.



Simulation 3

Fig. 3(b) cont.

Annex E

The Boundary Rank Method

B.L. Taylor and K. Martien

The boundary rank method was developed to generate hypothesised population structures that could then be evaluated through parameter estimation by estimating dispersal rates across putative boundaries. A brief overview of the method is given in SC/J02/NP3. A detailed description is in Martien and Taylor (2001). The method begins with the samples already grouped into initial units based on geographical proximity. The units are connected to conform to a hypothesised type of population structure (such as isolation-by-distance) using a connectivity matrix. The genetic similarity of all connected units is calculated and the most similar units are then clustered together to form a new, larger unit. The measure of genetic similarity used by the analysis is the p -value from a χ^2 permutation test. However, no inference regarding statistical significance is made from these p -values. They are simply used as a measure of similarity. The clustering continues, at each step removing the boundary separating the two most similar connected units, until only a single boundary remains. The order in which boundaries are removed and the level of genetic similarity between the units being clustered at each step is recorded. This results in a ranking of the boundaries, with the lowest-ranked boundary being the first one removed, and the highest-ranked boundary being the last boundary removed.

The connectivity matrix constrains the geographical form that stocks defined by the boundary rank method can take. In Bayesian terms, it represents the prior on what we believe is plausible regarding the behavior and movement patterns of the whales (SC/J02/NP2). For this reason, it is important that the connectivity matrix conform to some biologically plausible hypothesis, such as isolation-by-distance or an 'intrusion hypothesis' in which 'W' stock is being caught on migration in the vicinity of sub-area 9W, in the middle of a much more broadly distributed 'O' stock. When the connectivity matrix does not correspond to any biologically plausible hypothesis regarding minke whale population structure, the results will have no biologically meaningful interpretation.

The definition of initial strata for use in the boundary rank method requires careful consideration of the number of samples within each initial stratum. The sample size within the initial strata relative to their haplotypic diversity can have a dramatic impact on any genetic analysis of population structure. When sample size is low relative to haplotypic diversity, the degree of genetic similarity between units (as measured by any frequency based statistic) tends to be biased upward. Since the method combines initial units with the highest genetic similarity, if some units have low sample sizes relative to their diversity, the initial clusterings may be driven more by sample size than by actual biology. In other

words, units with small sample sizes will be combined simply because they have small sample sizes, not because they really are similar. These early clusterings can strongly influence subsequent clusterings and lead to an incorrect result. The diagnostics help us to determine whether the result for a given set of initial units is likely to be strongly influenced by small sample size. The diagnostics list the sample size within each initial unit along with three different measures of haplotypic diversity. The 'prop. Unique' and 'n-#haps' (columns 3 and 5 in the tables at the top of each diagnostic sheet) are both measures of sample size relative to haplotypic diversity. When these two measures are low, the results of any frequency-based genetic analysis, including the boundary rank method, are likely to be strongly influenced by low sample size and are likely not to reflect the true structure of the population.

The measure of genetic similarity between adjacent units is the p -value from a χ^2 permutation test. However, because of the many pairwise comparisons performed by the boundary rank method, it is not appropriate to use the genetic similarity values to evaluate the statistical significance of the boundaries identified by the method. Therefore, a permutation test that can be used to evaluate the strength of boundaries was developed (SC/J02/NP3). This permutation test is used to determine how often the boundary rank method would have detected boundaries with genetic similarity values as low as or lower than those observed if the samples actually came from a single panmictic population. The logic behind the test is that if there is truly only a single population then the strata are completely arbitrary and individuals can be assigned to the different strata randomly. Therefore, we permute the data by randomly assigning individuals to initial units and run boundary rank on the permuted data. This permutation is repeated 500 times and the results obtained from the permuted datasets compared to those observed for the actual data. To ensure that this method is not biased, it was applied to a dataset generated by a computer simulation in which it was known that there was only a single panmictic population. Thus, the null hypothesis of panmixia was correct. When α (the threshold for declaring a p -value to be statistically significant) was set to 0.05, the permutation test falsely rejected the null hypothesis at a rate of 0.058, indicating no bias (SC/J02/NP3).

REFERENCE

- Martien, K.K. and Taylor, B.L. 2001. A new method of generating hypothesized population structures for continuously distributed species using genetic data. Paper SC/53/SD7 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].

Annex F

A Bayesian Approach to Estimating ‘J’-‘O’ Mixing Proportions

Andre E. Punt

The estimate of the fraction of ‘J’ stock animals of a given sex, in a given sub-area during a given month, p , is determined from a Bayesian analysis in which the data are assumed to be multinomially distributed and the prior for p is $U[0,1]$.

The likelihood function is:

$$L \propto \prod_i (\hat{q}_i)^{N_i} \quad (1)$$

where

N_i is the number of animals for the given sub-area, sex and month with haplotype i

$\hat{q}_i$ is the model-estimate for the proportion of animals of the given sub-area, sex and month with haplotype i :

$$\hat{q}_i = p q_i^J + (1 - p)q_i^O \quad (2)$$

q_i^J is the relative frequency of haplotype i in the baseline sample for the ‘J’ stock; and

q_i^O is the relative frequency of haplotype i in the baseline sample for the ‘O’ stock.

The posterior probability assigned to a given value of p is proportional to the likelihood under the assumption of a uniform prior on p . This posterior distribution is summarised by its mean, mode, standard deviation and coefficient of variation. The entire distribution is summarised by a $\text{beta}(\alpha, \beta)$ distribution. Such a distribution could form the basis for the generation of the mixing proportions for the trials. Note that, in some cases, the mixed sample contains haplotypes that are not represented in either of the baseline samples. The data for such haplotypes are ignored.

Annex G

A Three-Breeding-Group Migratory Hypothesis for Common Minke Whales in the Western North Pacific¹

Tim D. Smith

INTRODUCTION

The *Implementation Simulation Trial* (IST) structure that formed the basis for the trials presented to the Scientific Committee in July 2001 did not cover the full range of uncertainties, primarily because new data from JARPN and from recent bycatches off Korea and Japan suggested uncertainties not previously included in the ranges of hypotheses considered. The Committee established a Steering Group to, *inter alia*, 'specify final trials in the light of discussions at the 2001 SC meeting and the results of trials run intersessionally'. During the present Workshop, results of more extensive hypothesis testing and some new spatially based analyses were reviewed.

Those statistical results along with the biological knowledge of this species based on scientific studies of the earlier commercial whaling operations were reviewed in detail. This Annex outlines a hypothesis that three minke whale breeding groups with differential degrees of mixing on migratory and feeding grounds occur in this area – called *Baseline-D* under Item 7.3 of the main report. This hypothesis is consistent with all the available data, and plausible in its biological basis. Further, it is useful in suggesting possible additional observations that might be made to test it. However, it is not the only hypothesis that is consistent with the existing data and uncertainties.

HYPOTHESIS

There are three breeding groups of minke whales in the western North Pacific.

(1) One group (J) occurs primarily in the Sea of Japan (East Sea)

A. Migrating seasonally from unknown southern breeding areas into the Sea of Japan (East Sea) from the south.

B. Migrating out of the Sea of Japan (East Sea):

- (a) as early as April;
- (b) with high relative abundance just north of Japan;

¹ This Annex was written after the meeting. It represents a report of the discussions of a small group (Smith (Chair), Kim, Punt, Ohsumi and Polacheck) established by the Chair during the meeting and initially written by Smith. Smith reported verbally on the deliberations of the small group at the Workshop and their discussions were used in the formulation of *Baseline-D* (Item 7.3), predominantly by Smith and Polacheck. Participation in this group means that the individual provided at least technical or biological advice/information – it does not necessarily imply agreement by all members of the group that (a) *Baseline-D* is the most plausible (or even likely); and (b) that other scenarios presented are not plausible.

- (c) with high relative abundance in the southwest Sea of Okhotsk;
- (d) occurring in Pacific waters near the northern Japanese Islands from April through September in low relative abundance.

C. Additional structure within this breeding group is possible.

(2) A second group (O) is restricted to Pacific waters along and offshore of the coast of Japan

A. Migrating from unknown southern breeding areas north, parallel to the coast of Japan.

B. Migrating into northern feeding areas to:

- (a) the Okhotsk Sea;
- (b) east of the Kamchatka Peninsula.

C. Distributed seaward from the coast of Japan:

- (a) in decreasing abundance with distance;
- (b) differentially by sex and age, with males travelling further offshore;
- (c) with females and younger animals migrating earlier and closer to shore;
- (d) occurring in greater proportion to the Okhotsk Sea;
- (e) with no (or limited) intrusion west into the Sea of Japan.

(3) A third group (W) occurs offshore of the coast of Japan

A. Migrating north from unknown southern breeding areas in the region offshore of the Bonin-Japan Trench.

B. Migrating into northern feeding areas:

- (a) east of the Kamchatka Peninsula;
- (b) in the Okhotsk Sea.

C. Distributed from offshore areas towards the coast of Japan:

- (a) in decreasing abundance with closeness to the shore;
- (b) with females migrating earlier and in greater proportion to the feeding areas.

(4) The spatial overlap between the W, O and J groups differs

A. The J and O groups have limited and seasonal overlap:

- (a) greatest in the SW Okhotsk Sea (sub-areas 11 and 12SW);

(b) less around the Japan Islands.

B. The O and W groups have broad overlap:

- (a) during migration and on the feeding grounds;
- (b) not overlapping west of the Bonin-Japan Trench.

C. The overlap of O and W varies in the feeding grounds with environmental conditions, with both groups being more abundant in the east or in the west in different years.

D. The hypothesis is not specific about the nature of the breeding stock dynamics and would not preclude some overlap corresponding to a spatial gradient structure, some temporary exchange of animals among the O and W breeding grounds or low levels of permanent dispersal of animals.

BASIS OF HYPOTHESIS IN DATA

That minke whales in the western North Pacific are distributed in at least three groups that breed separately is indicated by differences in genetic frequencies. One difference is between whales sampled from the Sea of Japan (East Sea), and seasonally on the Pacific side of Japan, and those sampled from near Japan on the Pacific side. These data are best explained by two breeding groups that overlap at the edges of their distributions seasonally. Morphological differences have been identified that are consistent with these genetic data, and that extend these conclusions into the feeding grounds.

The second difference is in genetic frequencies among animals sampled from near shore and from further offshore in the Pacific. Various spatial and seasonal partitions of the samples have revealed significant differences. Further, agglomerative methods of combining various small pre-defined groupings of the samples have suggested spatial differences in frequencies that are broadly consistent, with one partition around 147°E, and the other around 157°E.

Although neither the multiple hypothesis testing nor the agglomerative clustering methods suggest spatial boundaries between the O and W groups, the genetic frequency differences clearly imply the existence of separate breeding groups. Further, the differences between early and last season samples in the south and the north of the furthest offshore area sampled suggest substantial and possibly variable mixing between the two groups.

Differences in seasonal timing and sex ratios in the earlier commercial catch and in the Japanese research whaling samples are consistent with differential seasonal migration by sex and age. Migrating calves and females are more frequent in samples taken along the coast of Japan than in more offshore waters.

This model is based primarily on the peak season commercial whaling data. However, it should be noted relative to the hypothesised J group migration that some whales have been taken in pre-April season and during winter in areas around Japan and Korea, suggesting that not all J group minke whales are on the hypothesised breeding ground in the winter months. These data need to be examined in greater detail to validate this portion of the hypothesis.

IMPLEMENTING THE THREE GROUP MIGRATORY HYPOTHESIS

We assume that the three groups of minke whales (W, O and J) breed in southern areas during winter months. In the absence of information on the geographic extent of minke whale breeding grounds in any ocean, we assume that these areas are located such that the main locus of spring migrations are into the Sea of Japan (East Sea) for the J group

and along the coast of Japan for the O group. While the locus of migration for the W group does not have to be within the sampled area, substantial numbers of animals relative to O group abundance must occur in that area. Given the lack of information on minke whale breeding areas, the hypothesis is not meant to preclude possible overlaps between the O and W stock breeding areas (e.g. some form of clineal structure). Also, the hypothesis is not meant to exclude the possibility of some temporary exchange or low of dispersal of animals among the O and W breeding grounds. However, in the implementation developed here, no specific allowance is made for such exchanges.

The basic simulation structure that has been previously developed provides an adequate basis for implementing this hypothesis, and below we identify the changes in that model that would be required to accommodate this hypothesis.

The general migratory patterns for the O and W groups postulated in this hypothesis are shown diagrammatically in fig. 4 of the Workshop report. Their movements from the putative southern breeding areas (depicted by bold wavy lines) are depicted with lines with arrow heads, showing differential patterns for the two breeding groups by sex. The bolder solid and dashed lines depict O and W females migrating east of the Kamchatka Peninsula and into the Okhotsk Sea. The finer solid and dashed lines depict O and W males migration, with the change in the lines to include dots denoting that some males do not migrate as far north as do the females.

The proportion of O group animals is assumed to decrease with distance from the coast of Japan, with especially the males spreading east seasonally (and hence latitudinally). We implement this pattern into an analytic framework by assuming that while the abundance of whales varies spatially by season, the proportion of the O and W groups does not. We assume that the migration of the O animals is related to the Bonin-Japan-Kuril Trench (approximated by a line from 140°E, 30°N to 147°E, 47°N, extended north of 47°N along 147°E). To the east of this line, the proportion of O animals decreases exponentially with distance from the line. The proportion of O animals at 155°E is assumed to decline linearly with decreasing latitude from a fixed value at 47°N (p_{47}) to a value of 0.01 at 30°N. The corresponding exponential rates for each latitude are computed to achieve that specified proportion at 155°E (Appendix 1).

We allow the proportion O animals at 155°E and 47°N, p_{47} , to range from 0.60 to 0.20 (Figs 1a-c). The amount of spreading eastward decreases as p_{47} decreases. We account for the differences in migration of males and females by assuming different values of p_{47} , with that for females being always lower than that for males. The proportion of W animals in each sub-area is computed the complement of the proportion of O group whales in that area. This latter is computed to account for the differential migration and longitudinal spreading of the sexes by computing the sex specific abundance weighted average of the modelled proportions. The sex distribution of the W animals on the feeding grounds is assumed to be the same as for the O group animals.

Plausible seasonal distributions of O group males, females and juveniles are shown in Table 1 in terms of proportions of the total of each group located in each of three regions by month over the summer migratory period. Thus males, females and juveniles are assumed to be equally abundant in sub-areas '2' and '3' before April and after September. Females and juveniles are assumed to become less abundant more rapidly than males in sub-areas 2 and 3, and to show up first in the 7-9 sub-areas and then in the 12 sub-area and the

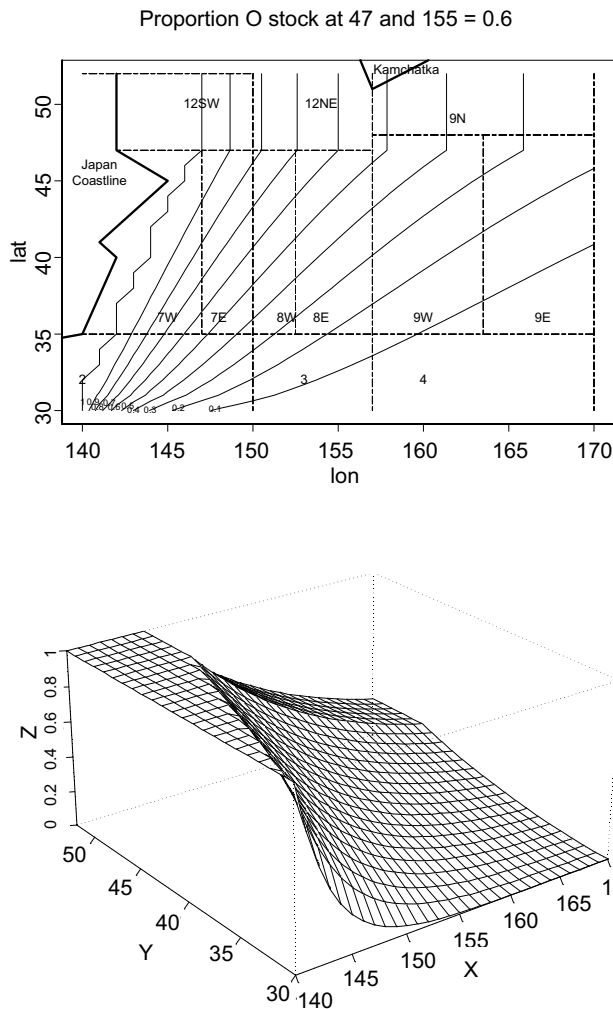


Fig. 1a. Model of proportion of 'O' group minke whales over space on migration route with $p_{47} = 0.60$.

northern portion of sub-area 9 (9N). Females maintain their numerical advantage in the feeding grounds and males occur in greater numbers in sub-areas 7-9 throughout the season. The values in Table 1 are scaled by introducing three estimable parameters multiplying the relative abundance for males, females and juveniles in the 7-9 sub-areas (Table 2).

Abundance of whales in the sub-areas 7-9 is allocated among the sub-areas 7W, 7E, 8W, 8E, 9W and 9E by integrating the equation defining the spatial distribution across each sub-area and using the results to pro-rata total abundance to each of the smaller areas. Similarly, the abundance in 12 and 9N is allocated among sub-areas 12SW, 12NE and 9N in a similar manner. Thus, the spatial distribution function would be numerically integrated for a sufficiently fine spatial grid for each sub-area 7W to 9E and 12 and 9N. Table 2 would then be expanded to a full catch-mixing matrix using the relative abundance in 7W to 9E, while the relative abundance in 12SW and 12NE and 9N would define the differential between those latter areas. In this, W breeding group animals would not occur in 12SW while the split of O breeding group animals would be estimated. This allows the allocation to be computed once the value for p_{47} is specified, rather than as part of the conditioning process.

We assume two scenarios relative to the distribution by sex and breeding group. In the first, the Okhotsk Sea is assumed to be the more desirable and hence the parameter p_{47} is 0.20 for females and 0.40 for males. This is referred to

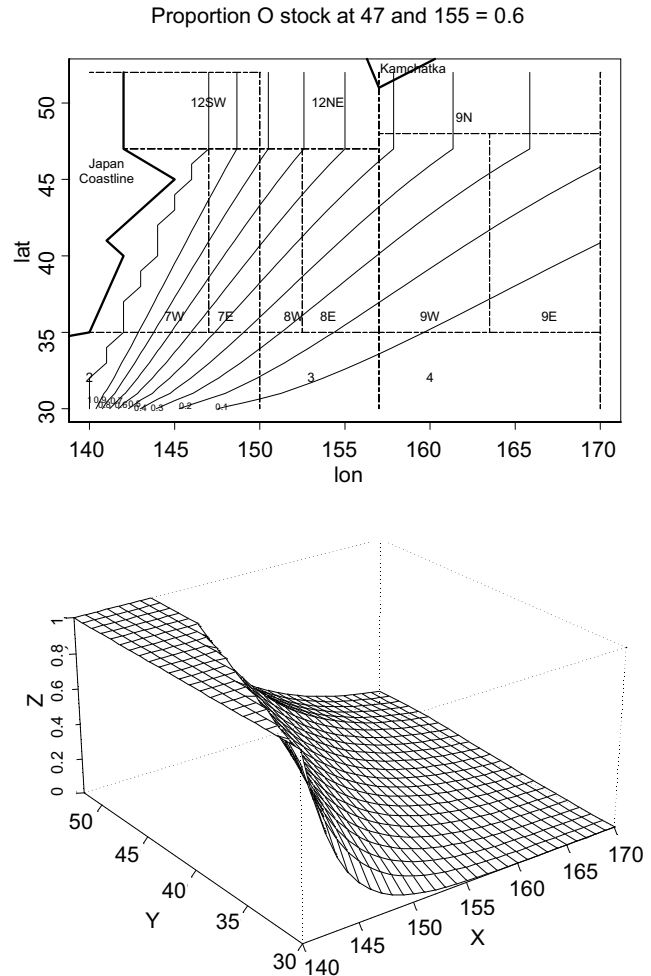


Fig. 1b. Model of proportion of 'O' group minke whales over space on migration route with $p_{47} = 0.40$.

as 'leaning west' toward the assumed better habitat. The second is where that area is less desirable, and p_{47} taking on the values 0.40 for females and 0.60 for males i.e. 'leaning east'. These two scenarios are combined in three ways. The first is to assume that the habitat is consistently better in the west ('leaning west') and second that it is better in the east ('leaning east'). The third is that the habitat quality varies stochastically with probability one half from year to year, and the animals respond to this without lag.

This specification of how to implement this hypothesis is tentative given its spatial complexity, and more flexibility is likely needed than allowed for here. One area is in the assumption that the proportion of O and W groups does not vary seasonally. Another is in how to treat lack of fit to abundance data, either as something to be reparameterised for or as additional variance. Further, the assumption about habitat quality differences should imply greater numbers of whales in the better habitat, and parameterisations must ensure for example that when the habitat is better in the west, O group animals drawn into the Okhotsk Sea do not 'displace' W group animals to the east.

CONCLUSIONS

The three breeding group hypothesis suggested here is consistent with the available data, and the implementation suggested is plausible biologically. We suggest that the performance of the RMP should be tested assuming a three breeding group migratory model to ensure the RMP's

Proportion O stock at 47 and 155 = 0.2

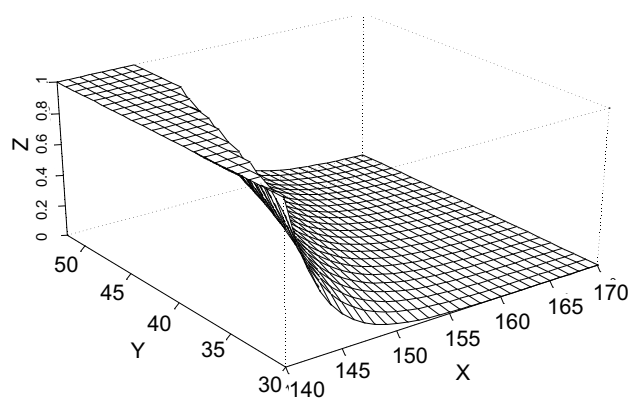
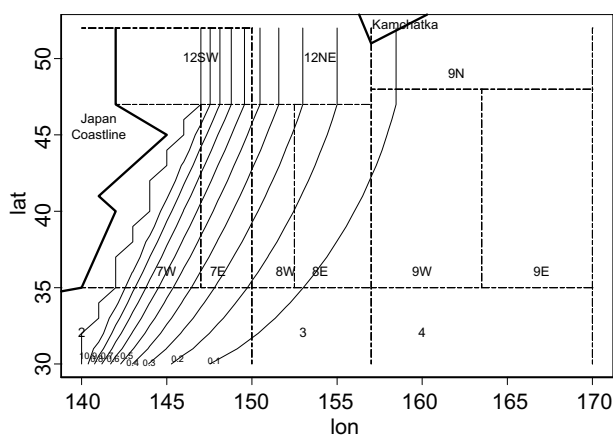
Fig. 1c. Model of proportion of 'O' group minke whales over space on migration route with $p_{47} = 0.20$.

Table 1

Relative abundance of O group whales by area and month for mature males (M) and females (F), and for juveniles (age <5, J). The row entries sum to 1.0 for males, females and juveniles, separately.

Month	2 & 3			7-9			12 & 9N		
	M	F	J	M	F	J	M	F	J
Pre	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Apr	0.8	0.7	0.7	0.2	0.1	0.2	0.0	0.2	0.1
May	0.5	0.1	0.3	0.3	0.3	0.4	0.2	0.6	0.3
Jun	0.0	0.0	0.0	0.7	0.2	0.4	0.3	0.8	0.6
Jul	0.0	0.0	0.0	0.7	0.2	0.2	0.3	0.8	0.8
Aug	0.0	0.0	0.0	0.8	0.3	0.3	0.2	0.7	0.7
Sep	0.1	0.1	0.1	0.8	0.3	0.4	0.1	0.6	0.5
Post	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0

performance when it is applied to whales on the migratory route. It should be noted that the hypothesis developed here is not necessarily the only plausible hypothesis that is consistent with the available data.

Our model could be tested further by additional observations both in the areas that have been sampled previously and in areas further north. For example, observations on relative abundance of minke whales in the Okhotsk Sea and east of the Kamchatka Peninsula would allow the feeding area spatial distribution to be validated. Similarly, additional observations on genetic frequencies

Table 2a

Generic catch mixing matrices for the 'O' stock. Distribution pattern are provided for mature males (age 10 and older), mature female (age 10 and older), and juveniles (age 4 and younger). The catch mixing matrices for animals aged 5-9 are determined by linear interpolation.

Month	2-3			7-9			12 & 9N		
	M	F	J	M	F	J	M	F	J
Pre	1.0	1.0	1.0	-	-	-	-	-	-
Apr	0.8	0.7	0.7	$0.2\gamma_1$	$0.1\gamma_1$	$0.2\gamma_1$	-	$0.2\gamma_2$	$0.1\gamma_2$
May	0.5	0.1	0.3	$0.3\gamma_1$	$0.3\gamma_1$	$0.4\gamma_1$	$0.2\gamma_2$	$0.6\gamma_2$	$0.3\gamma_2$
Jun	-	-	-	$0.7\gamma_1$	$0.2\gamma_1$	$0.4\gamma_1$	$0.3\gamma_2$	$0.8\gamma_2$	$0.6\gamma_2$
Jul	-	-	-	$0.7\gamma_1$	$0.2\gamma_1$	$0.2\gamma_1$	$0.3\gamma_2$	$0.8\gamma_2$	$0.8\gamma_2$
Aug	-	-	-	$0.8\gamma_1$	$0.3\gamma_1$	$0.3\gamma_1$	$0.2\gamma_2$	$0.7\gamma_2$	$0.7\gamma_2$
Sep	0.1	0.1	0.1	$0.8\gamma_1$	$0.3\gamma_1$	$0.4\gamma_1$	$0.1\gamma_2$	$0.6\gamma_2$	$0.5\gamma_2$
Post	1.0	1.0	1.0	-	-	-	-	-	-

Table 2b

Generic catch mixing matrices for the 'W' stock. Distribution pattern are provided for mature males (age 10 and older), mature female (age 10 and older), and juveniles (age 4 and younger). The catch mixing matrices for animals aged 5-9 are determined by linear interpolation.

Month	2-3			7-9			12 & 9N		
	M	F	J	M	F	J	M	F	J
Pre	1.0	1.0	1.0	-	-	-	-	-	-
Apr	0.8	0.7	0.7	$0.2\gamma_3$	$0.1\gamma_3$	$0.2\gamma_3$	-	$0.2\gamma_4$	$0.1\gamma_4$
May	0.5	0.1	0.3	$0.3\gamma_3$	$0.3\gamma_3$	$0.4\gamma_3$	$0.2\gamma_4$	$0.6\gamma_4$	$0.3\gamma_4$
Jun	-	-	-	$0.7\gamma_3$	$0.2\gamma_3$	$0.4\gamma_3$	$0.3\gamma_4$	$0.8\gamma_4$	$0.6\gamma_4$
Jul	-	-	-	$0.7\gamma_3$	$0.2\gamma_3$	$0.2\gamma_3$	$0.3\gamma_4$	$0.8\gamma_4$	$0.8\gamma_4$
Aug	-	-	-	$0.8\gamma_3$	$0.3\gamma_3$	$0.3\gamma_3$	$0.2\gamma_4$	$0.7\gamma_4$	$0.7\gamma_4$
Sep	0.1	0.1	0.1	$0.8\gamma_3$	$0.3\gamma_3$	$0.4\gamma_3$	$0.1\gamma_4$	$0.6\gamma_4$	$0.5\gamma_4$
Post	1.0	1.0	1.0	-	-	-	-	-	-

throughout the 7-9 sub-areas may possibly help to further clarify the degree of mixing between the two suggested breeding groups.

Observations on winter distribution patterns, and on movements when leaving the feeding areas, such as might be obtained from multi-month satellite tagging data would help clarify the location and possible discreteness of breeding areas. Similarly, multi-monthly satellite tagging of individuals across the longitudinal range early in the year would provide important information on the extent to movement and mixing of animals across the feeding grounds.

This migration model would be consistent with the possibility their being only three breeding groups in across the entire Pacific, and the low frequency of calves in offshore waters being explained by calves migrating near the coasts of Japan on the west and North America on the east. Observations about minke whales in other areas of the Pacific could help resolve these questions. However, the available data are also consistent with a number of other hypotheses about the unsampled area that are less extreme, including additional breeding groups. However, given the potential for low levels of exchange of individuals between the two breeding grounds combined with temporal variability in the annual migration, the power of further genetic sampling to determine the level of mixing may be low.

Appendix 1

MODEL FOR THE SPATIAL DISTRIBUTION OF THE O GROUP

The proportion of O group animals (p_o) varies with latitude and longitude seasonally according to the following equations, where functions are shown in bold. The function $\forall$ (lat) determines the value of the exponential parameter that will ensure the proportion of O animals at longitude 155°E is as specified by the function p_{155} (lat). This latter function specifies a linear reduction in the proportion of O group animals from the parameter value p_{47} (0.20, 0.40, 0.60) at 47°N to 0.01 at 30°N. The function $\forall$ (lat) also depends on the longitude of the Bonin-Japan-Kuril Trench, which approximated by a line from 140°E, 30°N to 147°E, 47°N,

and extending north of 47°N along 147°E. This longitude is specified by the function lon_{tr} (lat).

$$p_o(\text{lat}, \text{lon}) = \min(1, \exp((\forall(\text{lat}) * (\text{lon} - lon_{tr}(\text{lat}))))$$

where:

$$\forall(\text{lat}) = \log(p_{155}(\text{lat}) / (155 - lon_{tr}(\text{lat})))$$

$$p_{155}(\text{lat}) = \begin{cases} p_{47} & \text{if lat} > 47^\circ \text{ N} \\ 0 & \text{if lat} < 30^\circ \text{ N} \\ 0.01 + ((p_{47} - 0.01) / (47 - 30)) * (\text{lat} - 30) & \text{otherwise} \end{cases}$$

$$lon_{tr}(\text{lat}) = 30 + (47 - 30) / (147 - 140) * (\text{lat} - 30)$$

Annex H

Final Specifications of the North Pacific Minke Whaling Trials

[See Scientific Committee Report, Annex D, Appendix 10 this volume, pp. 133-149]

**Report of the Fourth Workshop
on the Development of an
Aboriginal Subsistence Whaling
Management Procedure (AWMP)**

Report of the Fourth Workshop on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP)

Members: Donovan (Chair), Allison, Borodin, Breiwick, Butterworth, Dereksdottir, Etylina (I), Fay (local scientist), George, Givens, Magnússon, Mikhno, Punt, Wade, Witting, Zeh.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks

The Workshop took place in Seattle from 23-26 January 2002. Donovan convened the meeting and thanked the National Marine Mammal Laboratory, Jeff Breiwick and Doug DeMaster for hosting the meeting. He noted that the primary objectives of this meeting were to: complete discussions of the gray whale trial structure; review progress on the process to determine a recommended SLA for the bowhead whale; consider how to present the recommended SLA to the Scientific Committee and the Commission; continue discussion of scientific aspects of an aboriginal subsistence whaling scheme in the light of comments received from the Commission at the 2001 Commission meeting; and determine a work plan for the intersessional period up to the 2002 Scientific Committee meeting.

1.2 Election of Chair

Donovan was elected as Chair.

1.3 Appointment of rapporteurs

Allison, George and Givens were appointed as rapporteurs.

1.4 Adoption of agenda

The agenda adopted is given in Annex A.

1.5 Review of documents

SC/J02/AWMP1-3 (Annex B), Witting (2001), Punt and Breiwick (2002) and a collection of past reports were available for discussion and review.

2. GRAY WHALE TRIALS STRUCTURE

2.1 Review of trial specifications

The SWG reviewed the specifications for the gray whale trials. The revised specifications are given as Annex C. Details and rationale for changes are given below.

2.1.1 Model related issues

Witting (2001) noted that the density-regulated BALEEN II model (Punt, 1999), which forms the basis for the bowhead trials, cannot reconcile the catch history and the abundance

data for the eastern North Pacific gray whales unless the catches are assumed to have been severely under-reported or the carrying capacity is assumed to have increased substantially (Butterworth *et al.*, 2002). Witting (2001) used an alternative model based on inertial dynamics to calculate population trajectories over the past 150 years that are able to reconcile all of the data and that are also consistent with an independent abundance estimate for 1885. The inertia model predicts over-compensation and that the population has increased steadily above the equilibrium abundance level for the last three to four decades.

The SWG welcomed this work, particularly as it incorporates regime shifts, which have been postulated. Oscillations in population size, which are damped over time, are a feature of the inertia model and are caused by the assumption that there is an 'intrinsic' birth rate which is determined at birth and does not change over time.

Moore summarised the current information on the productivity of gray whale feeding areas as it relates to possible changes in gray whale carrying capacity. Gray whales migrate north towards the Cherkov Basin of the Bering Sea. Benthic sampling in this area indicates that prey density was decreasing in the 1980s (Highsmith and Coyle, 1990; 1992) and decreases in prey density were also noted along the Bering Sea Shelf (Grebmeier and Harrison, 1992). Additional sampling will be conducted in the same areas by the same researchers this year. The Arctic Oscillation (which is computed from the relative strength of barometric pressure fields near Arctic North America), was considered as a possible cause for the changes in prey density. The North Pacific region may be shifting out of the warmer, less productive regime, to a cooler, more productive regime. In the favourable phase of the Arctic Oscillation, a larger proportion of the production from along the shelf break is advected north into the Cherkov Basin and Bering Strait which may improve feeding opportunities for gray whales. During the last few years, several hundred gray whales have been noted to feed near Kodiak Island in the Gulf of Alaska. This appears to be a new phenomenon, and suggests that gray whales can feed in a more opportunistic way than previously thought.

The oscillatory population trajectories from the inertia model are due to the structure of how birth rate is modelled. Hence they differ from variation in population size due to external factors such as environmental change. The latter can be mimicked in the trials by imposing sinusoidal time trajectories for carrying capacity. It will be difficult to find empirical support for the inertia model, however, because there are few large mammals, the dynamics of which have not been profoundly impacted by human activities. It was suggested, however, that there might be value in examining

data for Canadian Arctic caribou as there are few human-related constraints on them, data are available for many years and there is evidence for large oscillations in population size.

The SWG **agreed** that the different dynamics provided by the inertia model meant that this model should be included in the trials but that the model needed to be examined in more detail before it was used as the basis for many trials. A fundamental assumption to the inertia model is that fecundity is stable for the whole life of an animal. A possible extension to the model might be to add a factor allowing the fecundity memory to decay over time. This is, however, likely to be a second-order effect. In addition, the fecundity rate and juvenile survival rate could be separated so that survival rather than fecundity are considered intrinsic.

The robustness of the future predictions of the inertia model was questioned, *inter alia* because the model may be sensitive to perturbations to its initial conditions. For example, Witting (2001) assumes that the population was at its equilibrium level in 1846; starting the population projections in 1600 and including the aboriginal catches from that date might lead to different future trajectories of population size. Many of the population trajectories in Witting (2001) show steep declines in population size in the future. The SWG **agreed** that such declines in population size were not implausible and agreed to include some inertia model based trials to ensure that the full range of plausible hypotheses was included in the trials.

The SWG noted that the statistics used to evaluate the performance of candidate SLAs may need to be revised for use with the inertia model. However, it was **agreed** that the present statistics that compare the population levels with and without catch might be suitable and should continue to be used. This matter will be reviewed at the next meeting of the SWG.

The current control program incorporates a version of the inertia model and this has been used in some of the bowhead trials. This implementation uses the traditional Pella-Tomlinson form of density-dependence in combination with the inertia model. It was noted that the formulation of the Pella-Tomlinson model in the control program does not constrain the birth rate to be larger than zero when the population is above K , which can lead to time trajectories of population size that exhibit rapid short-term fluctuations. It was agreed to modify the behaviour of the model at high population levels to eliminate this problem. Initial runs of the inertia model indicate that it was possible to obtain good fits to the recent abundance data, but with population trajectories that are at very high levels in the late 1800s. To overcome this problem, a constraint would be added to the population size during this period.

2.1.1.1 NEW TRIALS

The SWG **agreed** to add three trials using the inertia model to the previously agreed set of trials (see Table 1). The three trials can be classified as having fast, medium and slow dynamics. The inertia model would be that used in the bowhead BE24 trial (i.e. including a Pella-Tomlinson density-dependence function) but with a restriction on the birth rate at population levels above K and with an additional constraint to ensure that the population between 1880 and 1920 is less than 5,000. There is no obvious definition of 'fast, medium and slow' dynamics. The SWG **agreed** therefore that Allison should conduct analyses based on defining 'fast, medium and slow' according to five alternatives:

- (1) Slope: the slope from the first maximum population size after year 0 (= actual year 2003) to the first minimum population size or the slope from year 0 to year 50 if the population size increases monotonically over the entire 50 year period.
- (2) F_{MSY} : the constant exploitation rate that, over the next 1,000 years, maximises the average future catch (range 0 to 10% in steps of 0.5%).
- (3) F_{ext} : the constant exploitation rate that, over the next 1,000 years, keeps the 1+ population size above 1,000 animals.
- (4) Population change: the ratio of the population size in year 50 to that in year 0.
- (5) High Low ratio: the ratio of the lowest to the highest population size over years 0 to 50.

The 'slope', 'population change' and 'high low ratio' statistics are based on population projections after 2003 in which the catch is assumed to be zero. To select parameter sets for a simulation trial, the draws from the prior distributions will be divided into three groups based on the values for each of these statistics, a subset of draws for each group will be selected by sampling with replacement and proportional to the likelihood within each group, and the resulting trajectories will be plotted for each group. The e-mail correspondence group will examine the trajectory plots to see which of the five statistics can be best used to define 'fast, medium and slow' dynamics.

2.1.2 CVs

The last two historic estimates of abundance (1995/6 and 1997/8) have both incorporated allowance for covariance between errors in school size estimation and correction for mixed groups. Last year (IWC, 2002b), the SWG agreed that the overall CV associated with the abundance estimates of gray whales would be modelled as the sum of three components: estimation error from factors considered historically (CV_{est}); estimation error in mean school size estimation (CV_{sch}); and additional variance (CV_{add}). As for the bowhead trials, CV_{est} is modelled as a chi square distribution with 19 degrees of freedom, and it was suggested that CV_{sch} also be modelled as a chi square distribution with 10 degrees of freedom. The SWG reviewed the intention of the specifications and agreed that: (1) the expectation of the distribution should match the average observed value; and (2) that the CV of the CVs should be constant and match the observed value of the CV of the CVs. Some concern was expressed that the equation for likelihood assumed independence between the observed estimates and the CV_{sch} but as only two estimates have incorporated this allowance, it was **agreed** that the approximation was sufficient for the trials.

2.1.3 Other

The trials agreed previously use a value of 124 whales for the lowest need value, based on the present catch limits (a total of 620 landed during the five-year period 1998-2002, with a maximum of 140 in any one year). However, it was noted that (a) the *Schedule* referred to takes not strikes; and (b) it was also noted that when the Russian Federation had submitted its need statement in 1997 it had noted that its real need was for up to 340 gray whales but that at that time only up to 140 per year could be realistically harvested (IWC, 1998, p.28). In addition, the USA had at that time submitted a request for up to five gray whales. The Workshop therefore

Table 1
Revised GE trials.

Trial	Description	Model	$MSYR_{1+}$	$MSYL_{1+}$	Final Need	Survey frequency	Historical survey bias	Future survey bias	Future Survey CV
GE01	Base case	D	3.5%	0.6	340	10	1	1	Base
GE02	Low need i.e. constant need	D	3.5%	0.6	150	10	1	1	Base
GE03	Future +ve bias	D	3.5%	0.6	340	6	1	1→1.5 in yr 25	Base
GE04	Future -ve bias	D	3.5%	0.6	340	6	1	1→0.5 in yr 25	Base
GE05	Underestimated CVs	D	3.5%	0.6	340	10	1	1	½ CV _{est}
GE07	$MSYL_{1+} = 0.8$	D	3.5%	0.8	340	10	1	1	Base
GE08	6 year surveys	D	3.5%	0.6	340	6	1	1	Base
GE09	$MSYR_{1+} = 1.5\%$	D	1.5%	0.6	340	10	0.5 → 1	1	Base
GE10	$MSYR_{1+} = 5.5\%$	D	5.5%	0.6	340	10	1	1	Base
GE11	Bad data	D	3.5%	0.6	340	10	1	1→1.5 in yr 25	½ CV _{est}
GE12	Difficult 1.5%	D	1.5%	0.6	340	10	0.5 → 1	1→1.5 in yr 25	½ CV _{est}
GE12a	Difficult 1.5%	D	1.5%	0.6	340	6	0.5 → 1	1→1.5 in yr 25	½ CV _{est}
GE14	High need	D	3.5%	0.6	530	10	1	1	Base
GE14a	High need	D	3.5%	0.6	530	6	1	1	Base
GE16	$MSYR_{1+} = 1.5\%$; high need	D	1.5%	0.6	530	10	0.5 → 1	1	Base
GE20	$MSYR_{1+} = 5.5\%$; high need	D	5.5%	0.6	530	6	1	1	Base
GE21	Integrated	D	U [1.5,5.5%]	U [4-.8]	340	10	1	1	Base
GE21a	Integrated	D	U [1.5,5.5%]	U [4-.8]	340	6	1	1	Base
GE23	Strategic surveys; high need	D	3.5%	0.6	530	5	1	1	CV _{true} =0.1+ base case value
GE24	Inertia Model – medium	I		0.6	340	10	1	1	Base
GE25	Inertia Model – slow	I		0.6	340	10	1	1	Base
GE26	Inertia Model – fast	I		0.6	340	10	1	1	Base

agreed that it was appropriate to increase the lower value to 150 whales for the purposes of the trials; the base case value is 340.

The previous specifications for the gray whale trials (IWC, 2002b) have assumed that the *SLA* is provided with estimates of abundance every five years. However, the group recognised that 5-yearly estimates may not be available in practise. Surveys have been performed regularly over the past 30 years, but as surveys are costly this pattern may change once the Aboriginal Whaling Scheme is in place. In addition, circumstances may prevent completion of a successful survey. For example, weather and ice conditions have frequently prevented the completion of a successful bowhead abundance survey. In the light of this, the SWG agreed that a base-case value of 10-yearly survey intervals would be used. However, the SWG recognised that there might be a trade off between data availability and need satisfaction so it agreed that a few trials (GE12, 14, 20 and 21) be tested with 6-year surveys for comparison. Trials with future biased data (GE03 and GE04) would be performed with 6-yearly surveys as more data may cause the *SLA* more problems in these cases. The revised list of trials is given in Table 1. The robustness trials should continue to include some 15-year surveys.

3. BOWHEAD WHALES AND THE SELECTION OF AN *SLA*

3.1 Review of trial structure

In light of considerations discussed under Item 4, the Workshop **agreed** that the bowhead *Evaluation Trials* should be changed to assume a 10-year survey frequency. Trial BE08 should be changed to a 5-year interval, and trials BE04, BE09, BE10 and BE12 should be run with both 5-year and 10-year survey intervals. It was **agreed** that Allison should adjust the *Robustness Trials* to account for this. The Workshop **agreed** that the strategic survey trials (BE23 and BR05) should retain a 5-year nominal survey interval.

Punt noted that there were two trials not run in Hammersmith due to lack of time (BR16e-9s and BR11a), and two were revised (BR06b-1 and BR11a). The SWG

agreed that these should be run and the results circulated to the group via e-mail.

Item 5.4 of IWC (2002a, p.154) describes a trial designed to test sensitivity of *SLAs* to a sharp decline in abundance (to 2,000 whales). The Workshop reviewed this scenario and **agreed** that it should be implemented for trials BE01 and BE16. It reiterated, however, that such a scenario is not even remotely plausible and should not be considered an *Evaluation* or *Robustness Trial*. It is rather being used to assess the relative speed at which the *SLAs* react to large changes in population size. However, it recognised that the interpretation of the results will be difficult since there are both positive and negative aspects of reacting quickly to such a change.

The G-G and D-M *SLAs* were subjected to these trials but a technical problem (underflow error) prevented the results of some of the trials being available during the meeting. The Workshop **agreed** that these trials should be run and all the results considered at the 2002 Committee meeting.

Magnússon reviewed the roles of the *Cross-validation* and *Robustness* trials, and considered whether extrapolatory cross-validation of *SLAs* had been sufficient. The SWG noted that it had increased the number of *Cross-validation* trials last year and that the roughly 100 *Robustness Trials* had been designed to constitute a diverse and challenging set of extrapolatory *Cross-validation Trials*. The SWG **agreed** that all necessary trials should be set at the present meeting. After further consideration, Magnússon indicated that his concerns were sufficiently addressed by the existing trial structure and the long-standing agreement that *Implementation Reviews* must be carried out if any implementation appeared to move outside the scenario space tested by the SWG.

Tables 2 and 3 show the agreed set of bowhead *Evaluation* and *Robustness Trials*.

3.2 Intersessional progress

SC/J02/AWMP1 presented some further developments and explorations of the D-M procedure. The following changes were investigated.

Table 2

The *Evaluation Trials* for the Bering-Chukchi-Beaufort Seas stock of bowhead whales (10 year surveys unless specified).

Trial No.	Description	Model	MSYR ₁₊	MSYL ₁₊	Final need	Historical survey bias	Future survey bias	Survey CV (true, est)	Age data [#]	Other
BE01*	Base case	D, S _E	2.5%	0.6	134	1	1	0.25, 0.25	Good	
BE02	Constant need	D	2.5%	0.6	67	1	1	0.25, 0.25	Good	
BE03	Future +ve bias	D, S _E	2.5%	0.6	134	1	1→1.5 in yr 25	0.25, 0.25	Good	
BE04	Future -ve bias	D	2.5%	0.6	134	1	1→.67 in yr 25	0.25, 0.25	Good	
BE04a	Future -ve bias	D	2.5%	0.6	134	1	1→.67 in yr 25	0.25, 0.25	Good	5yr surveys
BE05	Underestimated CVs	D	2.5%	0.6	134	1	1	0.25, 0.10	Good	
BE07*	MSYL ₁₊ = 0.8	D, S _E	2.5%	0.8	134	1	1	0.25, 0.25	Good	
BE08	5 yr surveys	D	2.5%	0.6	134	1	1	0.25, 0.25	Good	5yr surveys
BE09*	MSYR ₁₊ = 1%	D, S _E	1%	0.6	134	0.67 → 1	1	0.25, 0.25	Good	
BE09a	MSYR ₁₊ = 1%	D	1%	0.6	134	0.67 → 1	1	0.25, 0.25	Good	5yr surveys
BE10*	MSYR ₁₊ = 4%	D	4%	0.8	134	1	1	0.25, 0.25	Good	
BE10a	MSYR ₁₊ = 4%	D	4%	0.8	134	1	1	0.25, 0.25	Good	5yr surveys
BE11	Bad data	D	2.5%	0.6	134	1	1→1.5 in yr 25	0.25, 0.10	Poor	
BE12*	Difficult 1%	D, S _E	1%	0.6	134	1 → 1.5	1.5	0.25, 0.10	Poor	
BE12a	Difficult 1%	D	1%	0.6	134	1 → 1.5	1.5	0.25, 0.10	Poor	5yr surveys
BE13	Difficult 1%; constant need	D	1%	0.6	67	1 → 1.5	1.5	0.25, 0.10	Poor	
BE14	Need increases to 201	D	2.5%	0.6	201	1	1	0.25, 0.25	Good	
BE16	MSYR ₁₊ = 1%; 201 need	D, S _E	1%	0.6	201	0.67 → 1	1	0.25, 0.25	Good	
BE20	MSYR ₁₊ = 4%; 201 need	D	4%	0.8	201	1	1	0.25, 0.25	Good	
BE21*	Integrated	D	U[1,4%]	U[.4-.8]	134	1	1	0.25, 0.25	Good	
BE22*	20yr time lag	D, S _E	2.5%	0.6	134	1	1	0.25, 0.25	Good	20yr lag
BE23	Strategic surveys;	D	2.5%	0.6	201	1	1	0.25, 0.25	Good	Strategic surveys
BE24*	Inertia Model	D	0.6% [§]	0.6	134	1	1	0.25, 0.25	Good	Inertia model

* Requires conditioning. # Age data: Good (no bias or extra variance): $\gamma_{12.9} = 0$, $\lambda_{12.9} = 1$; poor: $\gamma_{12.9} = 2$, $\lambda_{12.9} = 1.5$.§ MSYR₁₊ here refers to MSYR in the absence of inertia dynamics. The value of 0.6% was set interessionally by the E-mail correspondence group following inspection of trajectories.

Incorporation of the snap-to-need feature: this feature, employed in the G-G procedure, adjusts the strike limit upwards to meet 100% of need if it is nominally above 95% of need.

Using of a finer grid of MSYR values: the previous version of the D-M SLA had four different MSYR values which gave a cumulative distribution function for strike limits that is a step function with four levels corresponding to the four MSYR values. In order to reduce the heights of the steps and produce a smoother cumulative distribution, a finer grid of MSYR filters was used. The seven values of 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4% MSYR were used. Adopting an even finer grid is desirable but was not done in this instance for computational reasons. A retuning of the SLA is required if a finer grid is used.

Exploring a variety of different catch control laws: the previous version of the D-M SLA used the 'H' rule given in IWC (2001, p.150) to determine strike limits, conditional on values of (*K*, MSYR). The variants considered in SC/J02/AWMP1 replaced the 'H' strike limit of 0.8RY for stocks between 2,000 whales and MSYL with several intermediate steps so that a lower percentage of RY is caught for low stock sizes. These results showed some promise, in particular they showed increased ability to protect the stock in low MSYR trials without severely lowering need satisfaction in trials where productivity is higher. Furthermore, the tunability of the procedure was increased.

In discussion, it was noted that the tuning parameter in the D-M procedure was sensitive to the number of filters chosen. While sensitivity is to be expected, the view was expressed that similar sensitivity was considered problematic during the development of the RMP. If the number of filters was adjusted *post hoc* (e.g. to 'improve the integration over MSYR'), performance of the procedure might be affected sufficiently to require new tuning. However, it was argued

that the estimation technique in the D-M procedure should be viewed as a weighting of a discrete list of choices, rather than as a Monte Carlo approximation to an integral. From that viewpoint, there is little justification for *post hoc* improvements such as those required for the RMP.

The filters used in the D-M procedure are evenly spaced over 131 values of *K* and 4 or 7 values of MSYR. Some suggestions for changing the array of filters were made in discussion. These included: reducing the number of *K* filters to allow a greater number of MSYR filters; spacing the *K* filters unevenly; and eliminating some filters whose (*K*, MSYR) combinations virtually always assured simulated population extinction. The developers of the D-M procedure noted these ideas and indicated that they might investigate several options.

SC/J02/AWMP2 presented results from several pilot studies implementing suggestions the SWG offered for the G-G SLA last year. First, transitions to 30% and 50% protection levels (i.e. reductions of the strike limit by those amounts) were made continuous with respect to surveyed abundance. This was done by estimating the range spanned by the quantity triggering such protections when surveyed abundance changed by four standard deviations. The transitions between protection levels were then continuously interpolated over this range. Other SWG suggestions involved removing certain discontinuities with respect to time. SC/J02/AWMP2 noted that SLAs are inherently discontinuous with respect to time and that there were practical barriers related to survey timing that prevented meaningful discrete intermediate steps. Furthermore, these discontinuities were internal to the SLA; they did not cause a situation where any quantity estimated by the hunters (e.g. survey abundance) would change the strike limit discontinuously. Nevertheless, one discontinuity with respect to time was changed from a single step to six smoother steps, to investigate this SWG concern. All these

Table 3
The *Robustness Trials* for the Bering-Chukchi-Beaufort Seas stock of bowhead whales.

Trial	Factor	Basic trials (Table 2)	Factor Level
BR01	A: Density-dependence	1, 1 ^S , 9, 9 ^S	Density-dependence on mature (BE trials use 1+).
BR02	B1: Stochastic dynamics	8 ^S , 13 ^S	Stochastic dynamics (with serially-correlated environmental variation).
BR04	E: Survey frequency	9, 13, 14, 16, 20 16, 20	a) 15 yrs b) 5 yrs
BR05	F: Strategic surveys	9 9	a) Yes + CV = (0.25, 0.25) b) Yes + CV = (0.34, 0.25)
BR06	G: Survey bias time dependence	1 1 9, 9 ^S 12, 12 ^S 14	a) Historic bias (1978-2002): 1.5 constant; Future bias: decreasing (1.5→1) b) Historic bias (1978-2002): 0.67 constant; Future bias: increasing (0.67→1) c) Future bias: sinusoidal from base value in yr 0 to maximum of 150% in yr 40 d) Future bias: decreasing (1.5→1) from year 0 to 100 e) Future bias: increasing from 1→1.5 in year 25 and constant thereafter
BR07	H: Future survey CV	1 1 ^S 9	a) CV = (0.1, 0.1) b) CV = (0.34, 0.25) c) (0.1, 0.1) + sinusoidal survey bias
BR08	I: Historic catch bias	14, 16 ^S 14, 16, 16 ^S	a) 0.5 bias from 1848-1914 b) 1.5 bias from 1848-1914
BR09	K: Time dependence in <i>K</i>	1, 9, 10 1, 9, 10 1 1, 21 1, 9	a) <i>K</i> halves linearly over 100 years b) <i>K</i> doubles linearly over 100 years c) <i>K</i> sinusoidal from base value in year 0 to maximum of 150% in year 40 d) Tent <i>K</i> : <i>K</i> doubles linearly from years -50 to 0 and halves from years 0 to 50 e) <i>K</i> halves linearly over 100 years + strategic surveys
BR10	L: Time dependence in <i>MSYR</i>	10 9 1, 8 1, 8 1 1, 21	a) Resilience (<i>A</i>) halves linearly over 100 years, b) Resilience (<i>A</i>) doubles linearly over 100 years c) Resilience steps 2½%→1%→2½% every 33 yrs over 100 years d) Resilience steps 2½%→1%→2½% every 33 yrs over 100 years in sync with <i>M</i> (compute <i>MSYR</i> first) – if it is practical halve <i>M</i> for each age class e) <i>K</i> and <i>A</i> halve linearly over 100 years f) <i>K</i> and <i>A</i> vary as tent (see BR09)
BR11	M: Time dependence in <i>M</i>	1, 9, 10 1, 9, 10	a) Natural mortality <i>M</i> halves linearly over 100 years (and calculate resulting <i>MSYR</i>) b) <i>M</i> doubles linearly over 100 years
BR12	N: Episodic events	1, 1 ^S , 9, 9 ^S	2 events occur, between years 1-50, in which 20% of animals die
BR13	O: Integrated	1, 11, 14 11, 14 1, 1 ^S , 11, 11 ^S , 14 1 ^S , 11 ^S	a) $MSYR_{1+} \sim U[0.01, 0.04]$; fixed $MSYL_{1+}=0.6$ b) $MSYR_{1+} \sim U[0.01, 0.04]$; $MSYL_{1+} \sim U[0.4, 0.8]$ c) $MSYR_{1+} \sim U[0.01, 0.04]$; $MSYL_{1+} \sim U[0.4, 0.8]$; historical catch bias $\sim U[0.5, 1.5]$; Serial correlation $\sim U[0.47, 0.95]$ d) $MSYR_{1+} \sim U[0.01, 0.04]$; $MSYL_{1+} \sim U[0.4, 0.8]$; historical catch bias $\sim U[0.5, 1.5]$; Serial correlation $\rho \sim U[0.47, 0.95]$, time delay in density-dependence $\sim U[0, 30]$
BR14	P: 1 st year of population projection	1, 9	1940 (reference or base case level is 1848 or 1748 for stochastic trials)
BR15	$MSYL_{1+}=0.9$	1, 9, 10	
BR16	B2: Different stochastic parameters	1 ^S 1 ^S 1 ^S , 9 ^S , 10 ^S 1 ^S 9 ^S	a) Negative correlation in recruitment $\rho = -0.75$ b) High correlation in recruitment $\rho = 0.9$ c) High correlation in recruitment $\rho = 0.9$; + Episodic events d) Change σ_e^2 to give 3* variation in population size at equilibrium e) $\rho = 0.9$ + change σ_e^2 to give 3*equilibrium variation +episodic events

experimental changes described in SC/J02/AWMP2 resulted in very small and predictable effects on strike limits and performance.

The Workshop discussed a number of technical points regarding the design of the G-G *SLA* and the discontinuities therein. It believed the approaches illustrated in SC/J02/AWMP2 were suitable strategies for responding to SWG suggestions. It **agreed** with the author that discontinuities with respect to survey abundance were qualitatively different and of much greater concern than discontinuities with respect to time or similar quantities. The SWG also endorsed the choice of roughly 100 whales as the span over which continuous protection level transitions were made in SC/J02/AWMP2 to address the discontinuity with respect to survey abundance. The SWG believed that the

removal of other discontinuities might be investigated to the extent that this does not deteriorate performance of the algorithm, but did not view this to be essential.

3.2.1 Selection of preferred *SLA*(s)

The difficulty in selecting a final *SLA* from the two excellent procedures had been noted at the last meeting.

During the Workshop, Givens suggested that a candidate *SLA* that took the simple mean of the G-G and D-M block strike limits would perform extremely well. Furthermore, this would provide a procedure with a built-in check-and-balance system because if one *SLA* behaved somewhat erratically in one instance, the effect would likely be muted by the better performance of the other *SLA*. Adoption of this averaged *SLA* (hereafter termed GUP – the

Grand Unified Procedure) would prevent the SWG from being forced to select between two very different yet highly desirable *SLAs* on the basis of small performance differences that are partially obscured by random variation. The Workshop **agreed** that such an approach was extremely desirable and should be pursued. It was noted that it would be possible to overlay a snap-to-need feature on such an averaged *SLA* in order to retain this feature, which would otherwise be eliminated by averaging. A number of snap-to-need overlay methods were discussed, and the SWG **agreed** that a suitable choice could easily be made.

The developers agreed to separate out the snap-to-need features in their *SLAs* so that the raw catch limits from each would be available to the GUP *SLA*; the snap-to-need feature can then be applied after the averaging.

3.2.2 Review of Guidelines for Developers after the 2001 meeting

Last year, the SWG developed a list of instructions about the changes to each *SLA* either sought or forbidden by the SWG (see Annex D). After reviewing these decisions, the SWG **agreed** that those instructions were still relevant, although its interest in time-continuity had weakened. Magnússon sought clarification regarding what constituted a substantial change in a *SLA*. The SWG **agreed** that changes which compelled a re-examination of most trial results would be substantial. For example, adding bias filters to the D-M procedure would probably comprise a substantial change. The SWG noted that in SC/J02/AWMP1 the changed catch control law 'H' was at the upper end of what would be considered an acceptable change; any greater change would be a matter of concern. The Workshop **instructed** the *SLA* developers that if they were in doubt about whether any planned change would be acceptable or not, they should contact the SWG via e-mail to seek advice before proceeding.

3.3 Presentation of results for the SWG

In consideration of its concerns about avoiding substantial modifications to *SLAs* at this point, the Workshop requested that developers provide the following scatter plot to compare new and old versions of their procedures. The horizontal axis should show the original block strike limits. The vertical axis should show the new block strike limits. The figure should contain 2,000 points (100 replicates with 20 block quotas each) if it is based on one trial (e.g. BE01). The selection of trials to examine was left to the developers to provide. The possible advantage of pooling the results from several trials in one scatter plot should be considered. The $x=y$ line should be added for reference. Supplemental plots designed by developers to aid in the comparison of their original and revised *SLAs* are also welcome.

Next, the SWG considered how to organise the voluminous tabular and graphical results that would be generated to compare the G-G, D-M and GUP (Grand Unified Procedure) *SLAs*. The SWG was satisfied overall with the presentation of results last year. Revisions and additions suggested by the SWG were as follows. The plots of 100 strike limit trajectories for each trial (*Evaluation* and *Robustness*) should be constructed. The plots in figure 6i-iii of IWC (2002a, p.171) should be constructed by Allison. The plots in figures 7i and 7ii of IWC (2002a, pp.172-173) are unnecessary.

All tables and results will be compiled in a 'book' to be made available to the SWG. All tables and results for *Evaluation Trials*, and selected tables and results for *Robustness Trials*, will be distributed to each SWG member.

The SWG **agreed** that a small group consisting of Dereksdottir, Givens, Magnússon and Punt would sort through the complete tables and results in order to select which *Robustness Trial* results should be distributed. The standard for selection would be whether any member of that small group believed that the item conveyed useful information. The small group might also construct a summary of which items from the *Evaluation Trials* are most important, based on the same standard. In addition to this summary, all *Evaluation Trial* results should be distributed.

3.4 Presentation of results to the Scientific Committee

The SWG **agreed** that its presentation of results to the Scientific Committee should not differ substantially from that for the Commission. For reasons of clarity, results from procedures not preferred by the SWG should not be provided to the Scientific Committee.

3.5 Tuning

SC/J02/AWMP2 discussed several issues related to potential tuning of *SLAs*. In the most plausible trials, the G-G and D-M *SLAs* do an excellent job in satisfying nearly all aboriginal need while leaving the stock above MSYL. To seek an alternate tuning with higher catch might risk severely diminishing returns because fulfilling the last few percentage points of need satisfaction on plausible trials would probably require significant performance sacrifices on other trials. Conversely, it is also unreasonable to seek an alternate tuning with lower risk because this amounts to asking the developer to create an *SLA* that is inferior to the original tuning in the sense that it provides less catch at equal practical risk to the stock (namely none).

Furthermore, SC/J02/AWMP2 noted that the SWG has received explicit and precise performance goals from the Commission, and — on plausible trials — meeting these goals allows very little room for tuning freedom. It is only on less plausible trials where a range of tunings can provide a range of catch/risk tradeoffs.

The SWG also noted that the GUP *SLA* (see Item 3.2) reduces the relevance of equivalence tuning. It would no longer be necessary to tune two competing *SLAs* for a fair comparison by matching their performances on some key statistic.

The SWG **agreed** that it was not necessary to establish precise tuning goals to which *SLA* developers must adhere. After reviewing some simulation results for various tunings of the G-G and D-M *SLAs* from last year and for alternative tunings of D-M given in SC/J02/AWMP1, the SWG **agreed** that the range of tunings seen thus far was not outside the range of trade-offs it deemed reasonable. The SWG **agreed** that each developer should bring between two and three tunings of their procedure. It advised that at least one tuning should provide median D_{10} value on BE12 of 1.0 or greater.

Given that there is essentially no tuning freedom if an *SLA* is to best meet the Commission's objectives on plausible trials, the SWG **agreed** that it would consider presenting only a single tuning of the preferred procedure to the Commission and the Scientific Committee. Along with this, it would present illustrative data on how performance would suffer on plausible trials if the procedure were retuned to alter the catch/risk trade-off on less plausible trials.

It was **agreed** that the GUP *SLA* will be based on the developers preferred tunings only.

4. ABORIGINAL WHALING MANAGEMENT SCHEME

4.1 Rules

4.1.1 Carry-over

The concept of carry-over is intended to address the problems associated with variability in hunting conditions in a harsh environment. Last year, the Committee presented the Commission with the following illustration:

For the purposes of illustration only it is assumed that the block is 5 years, that the total strike limit over the 5 year period is 500, and that an inter-annual carry over allowance of 50% is permitted. The block length and the percentage inter-annual carryover allowance are numbers for which explicit advice is required from the Commission. The total block quota is then divided by the number of years to provide an average annual quota.

In response the Commission agreed:

...that blocks of five years with an inter-annual variation for fifty percent were satisfactory in terms of allowing for the likely variability in hunting conditions. It therefore agreed that these values are appropriate for use in trials. It was recognised that this does not commit the Commission to these values in any final aboriginal whaling management procedure.

In order to allow the Commission to consider this further, the Workshop notes that if under a recommended *SLA*, current need is met (and there is no indication from the present results that this will not be the case), then a revised *Schedule* paragraph for bowhead whales might look something like:

For the years [2003-2007] inclusive, the total number of strikes shall not exceed [330]. The Strike Limit in any one year shall not exceed [100].

4.1.2 Survey interval and related issues

Phase-out is the process by which catch limits are reduced in the absence of new abundance data. Donovan noted that when he presented the Committee's discussion of this to the Commission (and representatives of the AEW — the Alaska Eskimo Whaling Commission) at the Commission meeting last year, this concept was the most contentious.

George presented a brief summary of the AEW concerns regarding phase-out. In essence, the AEW felt that the phase-out concept should apply only to commercial whaling and is overly harsh, and even suggests mistrust of aboriginal whalers and hunters. The AEW further stated that the AWMP 'rules' should provide hunters with as much freedom as possible to cope with environmental variability, since it has such a significant effect on surveys and hunting success.

The Workshop noted the concerns of the AEW. It referred to its earlier discussions of the difficulties in carrying out successful censuses¹ (and hunting) in the Arctic environment and its efforts to take this into account both by using a survey interval of 10 years and in the carryover provision described above. However, it noted that it was not possible to successfully manage in the absence of data; the Workshop did not believe that it was acceptable for catches to be allowed to continue at level of need if there was no new abundance information for long periods. This does not imply mistrust of hunters and the cooperation of the AEW in the census effort is well recognised and greatly appreciated. Whilst it is hoped and expected that any phase-out rule will never need to be utilised, it is important that any comprehensive management procedure includes rules for such an eventuality.

¹ Weather and ice conditions often prevent the completion of a successful bowhead abundance survey even when all the best efforts are made. Since 1988, three successful censuses have been made (1988, 1993, 2001) in six attempts.

There was substantial discussion of what form any decrease in catches might take. After discussing a number of approaches, the Workshop **agreed** to the following principles to be applied to any 'grace period':

- (1) the grace period should not exceed five years (after which time, catches will be reduced to zero);
- (2) over the 5-year period, the block limit shall be reduced by 50% (analogous to a linear reduction);
- (3) carryover from the last block is permissible (the same conditions that can render a survey unusable can also preclude the hunt);
- (4) the distribution of strikes over the time period is the responsibility of the hunter (they may for example decide to place no restrictions at the beginning of the period – but in the absence of an estimate in that period the catch will be reduced to zero in less than the five years);
- (5) when a survey is successfully conducted, the *SLA* is applied and a quota generated — the quota is then applied retroactively to the current block and the 'used' strikes subtracted from the resultant block limit.

Concern had been expressed about the possibility that should sequential annual surveys be conducted, only the 'best' survey might be submitted. The 'strategic survey' trials examine this situation. It was also noted that survey plans will be submitted in advance to the Committee and that regardless of how many surveys are conducted, all resultant estimates are included in the survey database and used by the *SLA*.

The Workshop noted the need to consider how the application of the *SLA* in 5-year blocks, variable survey times and application of a 'grace period' might occur in practice. It briefly considered this subject and Donovan **agreed** to develop a paper for consideration at the next meeting.

4.1.3 Guidelines for surveys

The Workshop reviewed and reconfirmed the principles for surveys developed at last year's meeting agreed by the Commission regarding: survey/census methodology and design; Committee oversight; and data analysis. The Workshop **agreed** that it was not necessary to develop these into a formal document for inclusion in the overall AWS at the present time. It noted that if the *SLA* was to be adopted at the next meeting, some consideration would be needed of the fact that some of the criteria (e.g. submission of data by a particular time) may need to be relaxed.

4.1.3.1 SURVEY/CENSUS METHODOLOGY AND DESIGN

The SWG had **agreed** that plans for undertaking a survey/census should be submitted to the Scientific Committee in advance of them being carried out, although prior approval by the Committee is not a requirement. This should normally be at the Annual Meeting before the survey/census is to be carried out. Sufficient detail should be provided to allow the Committee to review the field and estimation methodology. Considerably more detail would be expected if novel methods are planned.

4.1.3.2 COMMITTEE OVERSIGHT

The SWG had **agreed** that it was appropriate that should it desire, the Scientific Committee could nominate one of its members to observe the survey/census to ensure that proposed methods were adequately followed. This would be more important if novel methods were being used.

Table 4
Work plan.

Task	To be undertaken by:	Timetable
Modify gray whale trials, including the inertia model. Complete modifications of <i>SLAs</i> and submit to Secretariat. Prepare RMP version.	Allison Givens; Dereksdottir and Magnusson	
Run trials for G-G, D-M and GUP and prepare new 'book'. Develop discussion document on survey interval and 'grace period'.	Allison Donovan	Shimonoseki Shimonoseki

4.1.3.3 DATA ANALYSIS AND AVAILABILITY

The SWG had **agreed** that it was appropriate that all data to be used in the estimation of abundance were made available to the Scientific Committee suitably in advance of the Annual Meeting at which an estimate was to be presented. If new estimation methods are used, the Committee may require that computer programs (including documentation to allow such programs to be validated) shall be provided to the Secretariat for eventual validation by them.

4.1.4 Guidelines for data/sample collection

The SWG had **agreed** that data from each harvested animal should be collected and made available to the IWC. The following information should normally be provided for each whale: species; number of animals; sex; season; position of catch (to the nearest village); and length of catch (to 0.1m). It further requested that information/samples on reproductive status and samples for genetic studies be collected where possible. The Workshop noted the value of traditional knowledge in its discussions and agreed that any such information will be valuable when conducting *Implementation Reviews*.

5. PRESENTATION OF RESULTS TO THE COMMISSION

The SWG **agreed** that its presentation to the Commission should resemble that to the Scientific Committee.

The SWG considered how best to compare the performance of the preferred *SLA* to performance that might be achieved using the current management regime, and to that achieved with management conducted according to an implementation of the RMP. For the former comparison, the SWG **agreed** that it would be counterproductive and probably infeasible to make an accurate comparison via simulation. Instead, the SWG **agreed** to develop a qualitative list of reasons why the AWMP represents a better approach to management than the existing approach. Donovan **agreed** to provide a draft for discussion at the next meeting of the SWG.

For comparison with the RMP, the SWG **agreed** to implement the RMP on trials BE01, BE09 and BE10. These results will be summarised by the SWG for presentation to the Commission.

6. WORKPLAN AND PRIORITY TASKS

The Workshop agreed to the following work plan given in Table 4.

7. TYPE THREE FISHERIES

Punt and Breiwick (2002) provides the specifications for a generic framework within which operating models for Type 3 fisheries can be developed. This framework is founded on

an individual-based model that includes temporally correlated environmental variation in births and survival as well as the possibility of occasional catastrophic reductions in survival. Methods are developed to specify the value of the parameter that determines the productivity of the resource from that for *MSYR*, to enable simulation trials based on this framework to be parameterised in terms of *MSYR*. Three potential candidate *Strike Limit Algorithms* are evaluated using 14 'generic' simulation trials that capture a range of factors pertinent to Type 3 fishery situations.

SC/J02/AWMP3 examined the question of whether it is necessary to use an individual-based operating model for Type 3 fisheries or whether a framework based on an operating model that is age- and stage-structured but also considers demographic uncertainty, environmental variability in births and survival and catastrophes would be adequate. The stages considered in SC/J02/AWMP3 were males, immature females, mature females that can give birth this year and mature females that gave birth last year. This stochastic age- and stage-structured model leads to qualitatively, and also largely quantitatively, identical results to the individual-based model described in Punt and Breiwick (2002). SC/J02/AWMP3 argued that an age- and stage-structured model would be appropriate as the basis for operating models for Type 3 fisheries.

In discussion, it was noted that the approach of SC/J02/AWMP3 was based on the assumption of homogeneity in the values for biological parameters such as fecundity and survival among animals of the same age and stage while the individual-based model of Punt and Breiwick (2002) could allow for heterogeneity in these parameters. The Workshop suggested that further work related to developing operating models for Type 3 fisheries might be to apply the approaches of Punt and Breiwick (2002) and SC/J02/AWMP3 to the data for North Atlantic right whales to assess whether they are capable of replicating the dynamics of this well-studied population. It was also suggested that the approach in SC/J02/AWMP3 could be compared with an extension of the SE model that underlies the trials for the Bering-Chukchi-Beaufort Seas stock of bowhead whales to assess whether the complications of integer-based dynamics inherent in SC/J02/AWMP3 are necessary.

8. ADOPTION OF REPORT

The draft report was adopted at the end of the meeting. The final sections were completed intersessionally. The Workshop thanked the Chair for his excellent chairmanship. The Chair thanked the participants for: not mentioning North Pacific common minke whales; for their hard work and cooperative spirit; and most of all for the proposed GUP solution which seemed to him both elegant and fair, and in

the best interests of both the Commission and the hunters. Finally, he thanked NMML for its usual hospitality, kindness and efficiency in hosting the meeting.

REFERENCES

- Butterworth, D.S., Korrübel, J.L. and Punt, A.E. 2002. What is needed to make a simple density-dependent response population model consistent with data for the eastern North Pacific gray whales? *J. Cetacean Res. Manage.* 4(1):63-76.
- Grebmeier, J.M. and Harrison, N.M. 1992. Seabird feeding on benthic amphipods facilitated by gray whale activity in the northern Bering Sea. *Mar. Ecol. Prog. Ser.* 80(2-3):125-33.
- Highsmith, R.C. and Coyle, K.O. 1990. High productivity of northern Bering Sea benthic amphipods. *Nature, Lond.* 6269:862-4.
- Highsmith, R.C. and Coyle, K.O. 1992. Productivity of Arctic amphipods relative to gray whale energy requirements. *Mar. Ecol. Prog. Ser.* 83(2-3):141-50.
- International Whaling Commission. 1998. Chairman's Report of the Forty-Ninth Annual Meeting. *Rep. int. Whal. Commn* 48:17-52.
- International Whaling Commission. 2001. Report of the Scientific Committee, Annex E. Report of the Standing Working Group (SWG) on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP). Appendix 3B. Fishery type 2: Implementation for Bering-Chukchi-Beaufort bowhead whales. *J. Cetacean Res. Manage. (Suppl.)* 3:142-52.
- International Whaling Commission. 2002a. Report of the Scientific Committee, Annex E. Report of the Standing Working Group (SWG) on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP). *J. Cetacean Res. Manage. (Suppl.)* 4:148-77.
- International Whaling Commission. 2002b. Report of the Third Workshop on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP). *J. Cetacean Res. Manage. (Suppl.)* 4:415-53.
- Punt, A.E. 1999. Report of the Scientific Committee, Annex R. A full description of the standard BALEEN II model and some variants thereof. *J. Cetacean Res. Manage. (Suppl.)* 1:267-76.
- Punt, A.E. and Breiwick, J.M. 2002. A framework for evaluating *Strike Limit Algorithms* for population reduced to small numbers. *J. Cetacean Res. Manage.* 4(2):165-77.
- Witting, L. 2001. On inertial dynamics in whale populations. The case of the eastern North Pacific gray whale. Paper SC/53/AWMP6 presented to the IWC Scientific Committee, July 2001, London (unpublished). [Paper available from the Office of this Journal].

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
 - 1.4 Review of documents
2. Gray whale trials structure
 - 2.1 Review of trial specifications
 - 2.1.1 Model related issues
 - 2.1.1.1 New trials
 - 2.1.2 CVs
 - 2.1.3 Other
3. Bowhead whales and the selection of an *SLA*
 - 3.1 Review of trial structure
 - 3.2 Intersessional progress
 - 3.2.1 Selection of preferred *SLA*(s)
 - 3.2.2 Review of Appendix 4 of Annex E
 - 3.3 Presentation of results for the SWG
 - 3.4 Presentation of results to the Scientific Committee
- 3.5 Tuning
4. Aboriginal whaling management scheme
 - 4.1 Rules
 - 4.1.1 Carry-over
 - 4.1.2 Survey interval and related issues
 - 4.1.3 Guidelines for surveys
 - 4.1.3.1 Survey/census methodology and design
 - 4.1.3.2 Committee oversight
 - 4.1.3.3 Data analysis and availability
 - 4.1.4 Guidelines for data/sample collection
5. Presentation of results to the Commission
6. Work plan and priority tasks
7. Type three fisheries
8. Adoption of report

Annex B

List of Documents

SC/J02/AWMP

1. DEREKSDÓTTIR, E.H. and MAGNÚSSON, K.G. Further developments of a *Strike Limit Algorithm* for the BCB Seas stock of bowhead whales based on Adaptive Kalman Filtering.
 2. GIVENS, G. Pilot studies and discussion of potential revisions to a *Strike Limit Algorithm* for managing aboriginal hunting of bowhead whales.
 3. PUNT, A.E. On the basis for evaluating *Strike Limit Algorithms* for Type 3 fisheries.
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Annex C

Fishery Type 2: Implementation for Eastern Gray Whales

[See Appendix 3ii of Scientific Committee Report, Annex E, this volume, pp.183-190]

Annex D

Instructions for *SLA* Developers Regarding Intersessional *SLA* Alterations

Geof Givens

Three different issues were raised with respect to discontinuities in procedures. First, both procedures could produce strike limits that were discontinuous with respect to abundance at a given time. In the case of the D-M procedure, this would arise if, for example, the distributions of quotas corresponding to the $MSYR = 1\%$ filters and the $MSYR = 2\%$ filters were mostly disjoint. Then, when the 70th percentile of the catch control law output shifted from belonging in one distribution to the other due to a negligible change in the abundance estimate, the strike limit would jump discontinuously. In the case of the G-G procedure, the discontinuities were explicit: if an estimator depending on abundance was less than, for example, 6,700 whales, the strike limit is reduced by 30%.

For the G-G procedure, it was agreed that Givens should examine the quantity that triggers the intermediate protection level effects to determine how much variation in it is induced by a ± 2 standard error variation in the current abundance estimate. Then, he should interpolate the desired protection level (e.g. reduction from 100% to 70% of the nominal strike limit) over this range of the estimator. This approach was only a SWG suggestion to indicate the degree of smoothness desired; if Givens developed a better approach the SWG would welcome it. For the D-M procedure, the SWG believed it could be beneficial (but not required) to increase the fineness of the mesh in the grid of parameter values used, as this might increase smoothness.

The developers of both procedures were instructed not to change the aspect of either procedure that sets the strike limit to zero when the *SLA* estimates that the stock has fallen below 2,000 whales.

The second issue was that some protection levels in the G-G procedure were introduced only at fixed times (e.g. after 35 years) during the 100-year period. The SWG agreed that it was not necessary for protection levels to be invoked from year zero; however it believed that their invocation might be phased in gradually rather than instantaneously. It asked Givens to investigate this idea.

The third discontinuity issue was that the relationship between the strike limit and one of the predictors in the G-G procedure had a different slope after year 35. Again it invited Givens to investigate whether the *SLA* could be altered to phase in the change in slope more gradually.

The G-G procedure also included a 'snap-to-need' feature that made small, discontinuous increases in need satisfaction

in cases where this was sure to have negligible management consequences. The SWG agreed that this feature was not a cause for concern, and could be a useful component of a good *SLA*. Butterworth cautioned that such features could lead to practical implementation problems, as with the discontinuities discussed above. The SWG believed that the D-M procedure might be improved if this feature were added to it.

The SWG agreed that the D-M procedure could be retuned by changing the values of the parameters of the catch control law (eg. changing permissible catch from 80% to 90% of replacement yield for moderately depleted stocks). However, the SWG also agreed that the functional form of this catch control law should not be altered.

The SWG agreed that each developer should provide a low, central, and high tuning of their procedure to the next meeting. There was not time to specify sufficiently what range these tunings should cover; however the group believed that examination of the 5th percentile of D_{10} , for zero catch or ideal catch, in one or more trials where $MSYR_{1+} = 0.01$ might be helpful in this regard. The group agreed to continue discussions intersessionally with the aim of providing some general guidance while avoiding the pitfalls of overspecification it encountered with its previous attempts to define a tuning.

One potential improvement that might be made to the G-G *SLA* would be if it incorporated the D-M *SLA* in its H-optimisation step. The developer had noted that the G-G procedure had been built using only predictors from the A-P and J-B procedures, which had inferior performance to the D-M procedure, yet it had built from these a procedure with performance similar to that of the D-M *SLA*. It was unclear to what extent performance could be improved further through incorporation of the D-M *SLA* predictors. The SWG agreed that it would be interesting to investigate this question, but also had some concerns about maintaining recognizable evolution of the G-G procedure. It decided that this investigation had a very low priority.

Concerned about maintaining comparability to this year's *SLA* candidates, the SWG agreed that unless the G-G *SLA* was expanded to incorporate predictors from the D-M *SLA*, the developers of the D-M procedure should not add any new filters to their procedure (including bias filters). The SWG asked Givens to notify the D-M developers if he decided to incorporate D-M predictors in G-G; and it instructed the

D-M developers not to make substantial changes to their procedure unless so notified. An exception to this is that the SWG believed it would be appropriate for the developers to alter their existing grid of filters to have a finer mesh, if they believed this to be necessary. The SWG also agreed that the D-M *SLA* should not be altered to rely on fewer values of *MSYR* than at present.

In general, the SWG held the view that the remaining development period was intended for modest changes to procedures in direct response to SWG concerns. It intended that developers should not engage in further, open-ended efforts to improve the performance of their procedures. The SWG wanted the *SLAs* at the next meeting to remain as similar as possible to those it had examined at this meeting. It was also noted that if substantially improved *SLAs* were eventually developed, they could be considered after adoption of an *AWMP* via the mechanism of an

Implementation Review. For the D-M procedure, the SWG had identified very few design features it wished to see improved. Because the SWG had identified more design features to improve for the G-G procedure, and since these changes were more likely to impact performance, the SWG agreed that Givens would need some latitude to change the G-G *SLA* design to meet the SWG's design priorities while maintaining its high level of performance.

Finally, the SWG emphasised that there was an important distinction to be drawn between the 'design' features and the 'performance' features. The SWG was very pleased with the performance of both procedures and did not intend for this discussion to negate its belief that either procedure would provide performance that adequately meets the IWC's aboriginal whaling management goals. The intent is facilitate the development of procedures that have equally suitable design features.
