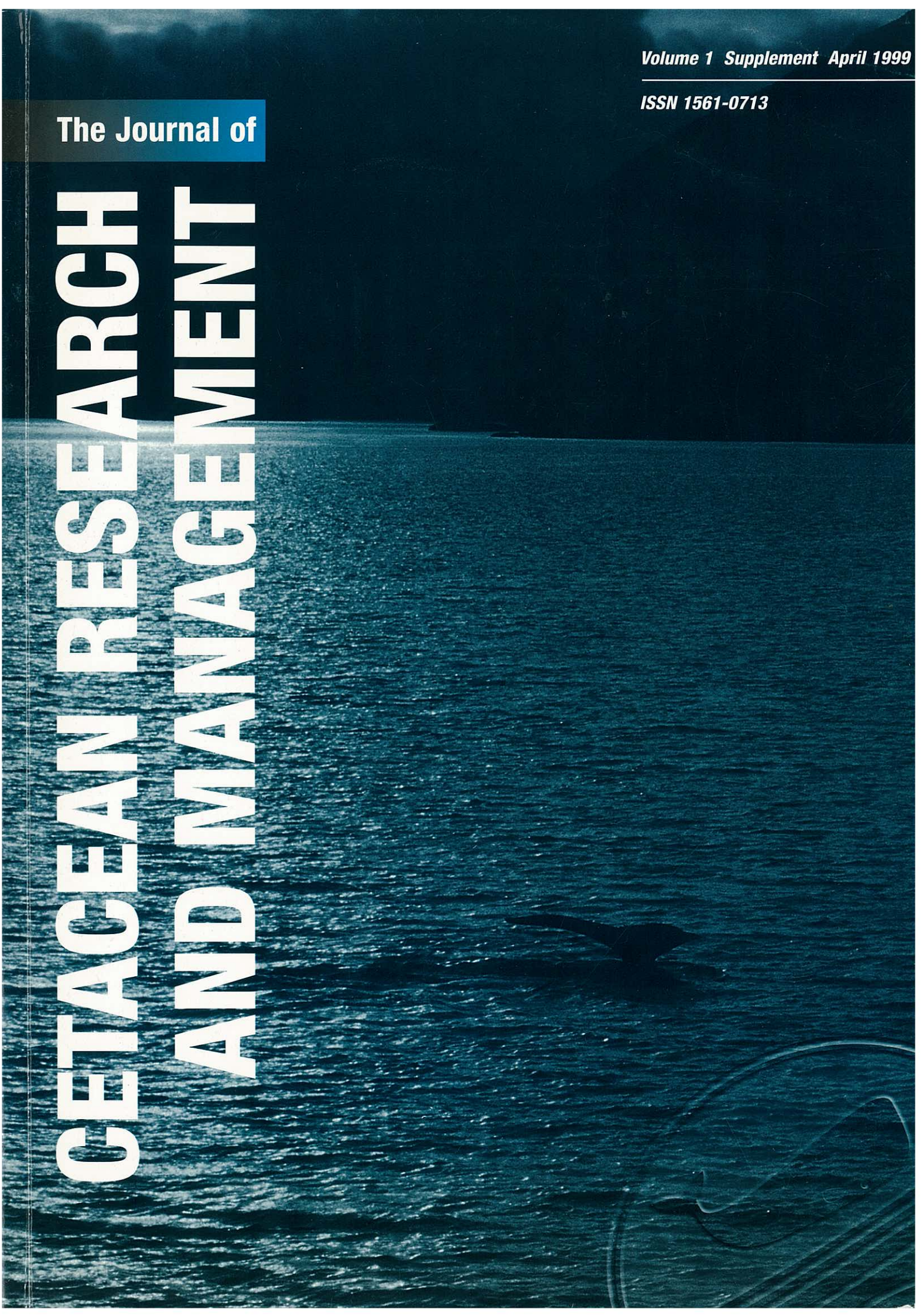
Volume 1 Supplement April 1999

ISSN 1561-0713

The Journal of

CETACEAN RESEARCH AND MANAGEMENT



Introduction

This supplement to the *Journal of Cetacean Research and Management* contains the report of the 1998 Annual Meeting of the Scientific Committee of the International Whaling Commission (IWC). The meeting was held in Muscat, Oman, from 27 April-9 May 1998 and was attended by over 115 participants (including some 30 invited participants); 22 member nations were represented. Several major topic areas were considered.

Discussion of the Revised Management Procedure for baleen whales (RMP) centred on: consideration of the software used; general issues regarding abundance estimation; the development of *Implementation Simulation Trials* for North Pacific minke whales and Bryde's whales; and further consideration of abundance estimates for the North Atlantic minke whales. General questions of data access and availability were addressed that are of relevance to many aspects of the Committee's work. The Committee also reviewed the final specification for the RMP and made a small number of clarifications to the wording.

The IWC has placed high priority on the development of a management procedure for aboriginal subsistence whaling (AWMP). Given the results so far, a likely potential scenario is that the Commission might establish an Aboriginal Whaling Scheme that comprises the scientific and logistical (e.g. inspection/observation) aspects of the management of all aboriginal fisheries. Within this, the scientific component might comprise some general aspects common to all fisheries (e.g. guidelines and requirements for surveys and for data c.f. the RMP) and an overall AWMP within which there will be common components and case-specific components.

Current aboriginal subsistence whaling operations were reviewed by the Committee, especially the Bering-Chukchi-Beaufort Seas Stock of bowhead whales. In addition, the need for the development of a cooperative research programme for the Greenlandic stocks of fin and minke whales subject to aboriginal subsistence whaling was identified.

The Committee also considered the results of a Workshop held on the status of right whales. Whilst certain populations in the Southern Hemisphere, although still depleted, are increasing, the same is not true for the Northern Hemisphere, where there is no evidence of increase. A series of management and research recommendations were made.

The IWC has a major research initiative in the Antarctic (SOWER - Southern Ocean Whale and Ecosystem Research Programme) with two main components, one concerning the abundance estimation of minke whales and other baleen whales south of 60ºS, and the second concerning the status of Southern Hemisphere blue whales. The initial component of this latter component involves the development of methods to identify pygmy blue whales from true blue whales at sea.

In recent years, the Committee has increased its interest in the relationship between cetaceans and their environment. Two major research initiatives are underway. One concerns the effects of pollutants on cetaceans, and will be called POLLUTION 2000+. The other concerns the influence of temporal and spatial variability in the physical and biological Antarctic environment on the distribution, abundance and migration of whales. The latter, called SOWER 2000, will be undertaken in cooperation with SO-GLOBEC and CCAMLR.

In its consideration of small cetaceans, the Committee concentrated on a review of species in the Indian Ocean and Red Sea, with special reference to the Middle East. It also gave further consideration to the criteria used for assessing the status of harbour porpoise populations.

The Committee continued to address scientific issues with respect to whalewatching operations. These included reviewing existing regulations, studies of the effects of different approach distances and platforms; quantitative methods used to assess the short-term reactions of cetaceans; and the basis for judgements of adverse effects.

Other matters considered by the Scientific Committee at the meeting included the review of scientific permits, progress on assessments of sperm whales, humpback whales and other species, and research needs and priorities for future years.

G.P. Donovan
Editor

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Report of the Scientific Committee

The meeting was held at the Al Bustan Palace Hotel, Muscat, Oman, from 27 April-9 May 1998 under the Chairmanship of J.L. Bannister. A list of participants is given as Annex A.

1. CHAIRMAN'S WELCOME AND OPENING REMARKS

Bannister welcomed the participants to the meeting. He referred to the sad news of the death of Dr Bill Dawbin, who had been prominent in whale research, particularly on humpback whales in the southwest Pacific, for many years. He was well known to many members of the Committee for his pioneering work on whale migrations and his continuing and wide-ranging interests in that and other fields including historical whaling records; he attended his first Committee meeting as representative for New Zealand in 1960. The meeting observed a period of silence in his memory.

The following items had been afforded high priority for this meeting:

(1) continued development of the Aboriginal Subsistence Whaling Management Procedure (AWMP);
(2) bowhead whale assessment;
(3) the Revised Management Procedure (RMP), especially in relation to North Pacific issues.

Bannister noted that while reviewing proposals for Invited Participants (following the new procedure agreed last year) it became clear that the available funding was only some 50% of the amount required to fund all the identified potential participants. As a result, some difficult decisions had had to be made, and, bearing in mind the agreed priorities, it was not possible to fund attendance of persons proposed especially for humpback assessments (Agenda Item 9.3) and mathematically-based techniques for whale recognition (Item 9.9.3). Further consideration of these concerns is included in Item 6.

2. ADOPTION OF AGENDA

The Draft Agenda had been restructured to reflect this year's Committee's priorities. The adopted Agenda is given as Annex B. Statements on two Agenda Items (Items 7 and 13) are given as Annex U.

3. ARRANGEMENTS FOR THE MEETING

3.1 Appointment of rapporteurs

Donovan was appointed rapporteur, with various members of the Committee assisting as appropriate. Chairs of sub-committees appointed rapporteurs for their meetings.

3.2 Meeting procedures and time schedule

The Committee agreed to a work schedule proposed by the Chairman.

3.3 Establishment of sub-committees

A number of sub-committees were established in addition to the two Standing Working Groups and the Standing Sub-committee. Their reports are given as:

Annex D – sub-committee on the revised management procedure

Annex E – sub-committee on other great whales

Annex F – standing working group on the development of the AWMP

Annex G – sub-committee on aboriginal subsistence whaling

Annex H – standing working group on environmental concerns

Annex I – standing sub-committee on small cetaceans

Annex J – sub-committee on whalewatching.

A number of *ad-hoc* groups were established and their reports are given as Annexes or incorporated under the relevant Agenda Items.

3.4 Computing arrangements

Allison outlined the computing facilities available which included printing facilities for delegate use.

4. REVIEW OF AVAILABLE DATA, DOCUMENTS AND REPORTS

4.1 Documents submitted

The list of documents submitted is given as Annex C. Document categories had been revised to reflect the Committee's Agenda more appropriately.

4.2 National progress reports on research

Last year, the Committee agreed new guidelines for national progress reports (IWC, 1998h). The Committee welcomed the provision of the reports in the new format. It reaffirmed its view of the importance of such reports and **recommends** that the Commission urges member nations to submit them following the revised guidelines (and see Item 4.3.4).

4.3 Data collection, storage and manipulation

This item was discussed in relation to the items listed last year (IWC, 1998b, table 5) and the priorities set.

4.3.1 Catches and other statistical material

Table 1 lists data received by the Secretariat since the 1997 meeting.

4.3.2 Progress of data coding projects

Allison reported that coding work had concentrated on data from the International Marking Scheme in the Southern Hemisphere prior to 1940. Those from 1940 and onwards are already in the database. In addition, data from the 1996/97 SOWER sightings cruise had been validated but there had not been time for an analysis to be carried out.

Allison raised the question of Soviet catch data in the IWC database. She was concerned that at present it contains the original (i.e. falsified) Soviet Southern Hemisphere catches, particularly for the 1960s. She sought guidance on the status of the corrected data so far available. A small subgroup (Allison, Bannister (convenor), Brownell, Gambell, Reilly) was established to consider the question. The Committee adopted its conclusions as follows.

Responses to requests for data from the IWC database should not include the falsified catches, and should be accompanied by the information that, in the present incomplete state of the corrected data, they are not available from the IWC. Because revised data are still being collected and analysed by the relevant scientists, a fully revised database is not yet available but is in the process of development. Persons wishing to access the available corrected data should be directed to the relevant scientists[1]. In the meantime, the Scientific Committee will continue to have access to, and use, the available corrected data under the existing conditions, i.e. either as currently published, e.g. in Zemsky *et al.* (1995b), or by reference to the relevant scientists.

Yagi questioned the accuracy of the data presented, asking whether the primary data had been peer-reviewed or made available to other scientists. Mikhalev responded that the information on past USSR catches had been collated by those who had sailed with the Soviet fleets and witnessed the whaling. The Committee agreed that Mikhalev's paper, SC/50/O18 which includes such information as a continuation of earlier compilations, should be considered for publication following the normal review process.

[1] i.e. as in Zemsky *et al.* (1995b).

4.3.3 Progress on program verification projects and other computing tasks

Allison reported on progress with the computing work identified last year (IWC, 1998b, item 18, table 5):

(i) the Common Control Program to implement single stock aboriginal subsistence whaling trials had been amended;
(ii) a program to implement multi-stock aboriginal subsistence whaling trials had been written by Punt;
(iii) Allison had attended an *S-plus* course;
(iv) the existing *CLA* program had been converted to double precision and used in retuning trials (however, the program was too slow for the required tuning precision to be achieved in the time available);
(v) the program for conditioning and running the North Pacific minke whale trials specified in IWC (1997b, pp.246-9) had been developed (however, it had not been possible to finalise this program or conduct trials because some of the specifications were incomplete).

Progress made on the sightings database contract is reported and discussed under Item 7.3.2.

4.3.4 Whale marking, including artificial and natural marks, and biopsy sampling

Information from the progress reports on natural and artificial marks and biopsy sampling is summarised in Annex K.

New information on Soviet recoveries by the *Slava* was presented in SC/50/O18.

5. COOPERATION WITH OTHER ORGANISATIONS

5.1 CMS

Perrin agreed to serve as IWC observer at the next meeting of the CMS Scientific Council in the Netherlands in June.

5.1.1 ASCOBANS

SC/50/SM12 was a progress report on the work of the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS). It welcomed collaboration between the IWC and ASCOBANS and was considered in more detail in Annex I.

The report of the IWC observer at the 2nd Meeting of Parties to ASCOBANS held in Bonn in November 1997 is given as IWC/50/10E. In recognition of the contribution that the IWC Scientific Committee has made to scientific

Table 1

Data and Programs received by the IWC Secretariat since the 1997 meeting.

Date	From	IWC ref.	Comments
Catch data			
3 Feb. 1998	K.H. Kock	E19	Revised *Olympic Challenger* catch data.
30 Mar. 1998	Norway: N. Øien	E20	Individual catch records from the Norwegian 1997 commercial catch.
27 Apr. 1998	Japan		Individual catch records from the Japanese 1997/98 Antarctic Special Permit catch.
27 Apr. 1998	P. Best		Some individual catch records from Namibia 1923-1929 (Walvis Bay).
Sightings data			
16 Dec. 1997	Japan: T. Miyashita	E18	North Pacific sightings data 1995-96. (Access restricted).
23 Mar. 1998	P. Ensor	D164	1997/98 SOWER cruise data (sightings, effort, weather, ice-edge and cruise tracks).
14 Apr. 1998	Iceland: G.A. Vikingsson	E21	Permission for Icelandic shipboard sightings data to be used by Scientific Committee members up to and during the 1998 meeting. 1995 Icelandic NAMMCO data forwarded to IWC by D. Borchers.
Programs			
11 Nov. 1997	Norway: M. Aldrin	E17	Norwegian management program (as reported in SC/49/Mg1).

discussions in ASCOBANS on areas of mutual interest, the Meeting of Parties adopted a resolution that *inter alia* agreed that the IWC should be automatically accorded observer status at both the Meeting of Parties and the meetings of the ASCOBANS Advisory Committee. In conclusion, the observer reported that ASCOBANS recognised the value of cooperation with the IWC on matters of mutual scientific interest and was appreciative of the work of the IWC. Scientific aspects of the observer's report are considered in Annexes H, I and L.

In Annex L, the IWC observer to ASCOBANS and the ASCOBANS observer to the IWC noted that there are two major areas of mutual scientific interest between the IWC and ASCOBANS: the status of the North Atlantic harbour porpoise, and the research programme to examine cause-effect relationships between pollutants and cetacean health. Current cooperation is detailed in Annex L. The Committee particularly welcomed the adoption of a resolution by ASCOBANS endorsing the research programme on pollutants.

The Committee noted that at its 5th meeting in Hel, Poland, held immediately prior to the IWC Scientific Committee meeting, the ASCOBANS Advisory Committee formally requested cooperation with the IWC Scientific Committee.

The Committee thanked Donovan for attending the meeting on its behalf. The Chairman will consult with the Secretariat on an observer for the next Advisory Committee meeting once the dates for that meeting are known.

The Committee welcomed the request for cooperation on a scientific level. It recognised that one way to encourage cooperation was the holding of joint workshops or working groups on matters of mutual scientific interest (Annex L).

In this context, it welcomed the participation of ASCOBANS in the Workshop to develop further the IWC pollution research programme to be held in Barcelona in November 1998 (Annex H). The Committee also **agrees** that it will be valuable to further the scientific work on the status of harbour porpoises in the North Atlantic by holding the joint working group meeting suggested in Annex I and **recommends** that this take place. It emphasised that this meeting will be discussing scientific and not direct management issues. No funding is requested.

Okamoto noted that the ASCOBANS conservation objectives were not necessarily shared by non-ASCOBANS members. He also noted that in some areas, harbour porpoises are subject to directed takes under completely different conservation philosophies, as noted in the 1995 report of the sub-committee on small cetaceans (IWC, 1995c).

5.1.2 ACCOBAMS

The ACCOBAMS agreement has not yet come into force. However, cooperation between the Secretariats continues.

5.2 ICES

The report of the IWC observer at the 1997 ICES Annual Science Conference, Baltimore, USA (85th Statutory Meeting of ICES) is given as IWC/50/10A.

As a result of restructuring, the 1997 meeting was the last meeting of the Marine Mammals Committee. Two new Working Groups have been established that ensure an active presence of marine mammal scientists within ICES. These are:

(1) Working Group on Marine Mammal Population Dynamics and Trophic Interactions (WGMMPD);

(2) Working Group on Marine Mammal Habitats (WGMMH).

It was noted that Donovan had been invited to serve on the latter Working Group but had been unable to attend the first meeting which clashed with the IWC Right Whale Workshop. However, he reported that WGMMH had endorsed the IWC pollution research programme. This is discussed further in Annex H.

The Committee thanked Haug for attending the meeting on its behalf and agreed that he should represent it at the next meeting.

Butterworth drew attention to an ICES Symposium entitled 'Confronting Uncertainty in the Evaluation and Implementation of Fisheries-Management Systems' being held from 16-19 November 1998 in Cape Town, which had its origins in the 'Management Procedures' developed in the IWC Scientific Committee.

5.3 IATTC

The report of the IWC observer at the 58th meeting of the Inter-American Tropical Tuna Commission (IATTC) is given as IWC/50/10B.

With respect to scientific matters, IATTC focused primarily on reviewing the tuna-dolphin research programme and progress under the International Dolphin Conservation Program (IDCP). Dolphin mortality fell again in 1996 to 2,547 animals, substantially below levels believed to be sustainable.

The Committee thanked Tillman for attending the meeting on its behalf. It noted the value of continued cooperation and agreed that Tillman should attend the next meeting as IWC observer.

5.4 CCAMLR

The report of the IWC observer to the 16th meeting of the Scientific Committee of CCAMLR is given as IWC/50/10C.

In particular, the CCAMLR Scientific Committee adopted the following terms of reference for a small liaison group to be formed with the IWC Scientific Committee and WG-EMM to further collaboration between the IWC and CCAMLR:

(i) to facilitate communication between CCAMLR and the IWC on all scientific matters of mutual interest;

(ii) to advise the CCAMLR Scientific Committee on the matters relevant to potential collaborative work, e.g. exchange of information, analysis of historical datasets, survey methods, studies of interactions between whales, prey and the environment, and estimation of prey consumption by whales.

The Committee reiterated the great importance it attached to cooperation with CCAMLR. It endorsed the formation of the liaison group. Detailed consideration of this and other CCAMLR-related matters is given under Item 12.2.1.1 and in Annex H.

The meeting thanked Ichii for attending the meeting on its behalf and agreed that he should represent it at the next meeting.

5.5 NAMMCO

The report of the IWC observer at the NAMMCO Scientific Committee meeting is given as IWC/50/10F.

In 1997, the NAMMCO Council had requested its Scientific Committee to undertake an assessment of the status of the Central North Atlantic minke whale stock and to evaluate the long-term effects of past and present removal levels on the stock. The question was dealt with by its

Working Group on Management Procedures, which operated by correspondence and decided to contact relevant experts to summarise results on stock structure and population trajectories. Since stock structure information is not conclusive, population trajectories were run for (1) the Central stock area and (2) the coastal waters of Iceland; both were considered as discrete stocks. In both cases they were found to be close to their pre-exploitation levels; most of the previous harvesting regimes would be sustainable under the model parameters considered most appropriate.

To deal with a request for population status of narwhals and white whales, a Working Group on the population status of narwhals and belugas in the North Atlantic was established with the expectation of meeting in 1999.

At the NAMMCO Scientific Committee a proposal for an international workshop/symposium on harbour porpoises in the North Atlantic was discussed. It was decided to hold a symposium in the latter half of 1999 (preliminary dates 10-14 September); invitations were extended to ICES, ASCOBANS and the IWC to ensure a broad participation. They were sent on 16 April 1998.

In discussion, the (IWC Scientific) Committee noted considerable overlap in the scientific topics being addressed by the two Scientific Committees. For example, aspects of all three topics referred to in the observer's report either had been (central North Atlantic minke whales, harbour porpoises) or would soon be (white whales and narwhals in 1999) discussed in this Committee.

After considerable discussion the Committee agreed that it was desirable to avoid duplication of effort by the two Committees. It was noted that, at present, the Secretariats exchange scientific documents and it was agreed that this should continue. In 1993 (IWC, 1994a), the Committee had agreed that scientific cooperation with the NAMMCO Scientific Committee should be encouraged, where appropriate.

The Committee **requests** that the Commission provide it with advice on whether it should take a more active role in establishing cooperation with the NAMMCO Scientific Committee.

The Committee thanked Øien for attending the meeting on its behalf and agreed that he should continue to represent it at NAMMCO Scientific Committee meetings.

5.6 UNEP

There have been no meetings of the Planning and Co-ordinating Committee of the Marine Mammal Action Plan since that held in Bonn in June 1997 (IWC, 1998b, item 5.8).

5.7 Southern Ocean GLOBEC

The report of the IWC observer at the Southern Ocean GLOBEC Planning Group is given as IWC/50/10G. This issue is directly related to the SOWER 2000 research programme and is discussed in detail in Annex H and Item 12.2.2.1. The Committee reiterated the importance of cooperation with SO-GLOBEC and in particular its planning meetings. It thanked Hammond and Reilly for acting on its behalf and agreed that they should continue to do so.

5.8 FAO/COFI

The Committee agreed that a Japanese scientist would act as its observer at the next session of the Committee on Fisheries of the Food and Agriculture Organisation of the United Nations.

6. COMMITTEE OBJECTIVES AND PRIORITIES

6.1 Amendments to the Rules of Procedure

Last year, the Committee had developed revised Rules of Procedure (IWC, 1998i) and agreed that they should be given final consideration at the 50th meeting. These had been submitted to the Commission last year and in fact formed part of a Commission document (IWC/50/15) that had been pre-circulated to the Commission.

The Committee reviewed the draft Rules, and in particular the experience gained in trying to use the rules developed last year concerning invited participants. It **agrees** to a suggested modification to these to take into account problems encountered. The Committee **agrees** to the following revised rules concerning invited participants:

(a) Convenors will submit suggestions for Invited Participants (including the period of time they would like them to attend) to the Chairman and the Secretariat **not less than four months** before the meeting in question. The Convenors will base their suggestions on the priorities and initial agenda identified by the Committee and Commission at the previous meeting. The Chairman may also consider offers from suitably qualified scientists to contribute to priority items on the Committee's agenda, if they submit such an offer to the Secretariat **not less than four months** before the meeting in question, providing information on the contribution they believe that they can make. **Within two weeks of this,** the Chairman, in consultation with the Convenors and Secretariat, will develop a list of invitees.

(b) The Secretary will then **promptly** issue a letter of provisional invitation to those potential IPs suggested by the Chairman and Convenors. That letter will state that there may be financial support available. Invitees who wish to be considered for travel and subsistence will be asked to submit an estimated airfare (incl. travel to and from the airport) to the Secretariat, **within 2 weeks.** Under certain circumstances (e.g. the absence of a potential participant from their institute), the Secretariat will determine the likely airfare.

(c) At least three months before the meeting, the Secretariat will supply the Chairman with a list of participants and the estimated expenditure for each, based on (1) the estimated airfare, (2) the period of time the Chairman has indicated the IP should be present and (3) a daily subsistence rate based on the actual cost of the hotel deemed most suitable by the Secretary and Chairman*, plus an appropriate daily allowance. [*Footnote: Invited participants who choose to stay at a cheaper hotel will receive the actual rate for their hotel plus the same daily allowance.]

(d) The Chairman will review the estimated total cost for all suggested participants against the money available in the Commission's budget. Should there be insufficient funds, the Chairman, in consultation with the Secretariat and Convenors where necessary, will decide on the basis of the identified priorities, which participants should be offered financial support and the period of the meeting for which that support will be provided. Scientists not supported for the full period, may, with the agreement of the Chairman, attend the remainder of the meeting at their own expense.

(e) **At least two months before the meeting,** the Secretary will send out formal invitations to all the selected scientists, in accordance with the Commission's Guidelines (IWC, 1997a), indicating where appropriate that financial support will be given and the nature of that support.

(f) In exceptional circumstances, the Chairman, in consultation with the Convenors and Secretariat, may waive the above time restrictions.

The letter of invitation will include the following ideas:

Under the Committee's Rules of Procedure, Invited Participants may present and discuss papers, and participate in meetings (including those of subgroups). They are entitled to receive all Committee documents and papers. They may participate fully in discussions pertaining to their area of expertise. However, discussions of Scientific Committee procedures and policies are in principle limited to Committee members nominated by member governments. Such issues will be identified by the Chairman of the Committee during discussions. Invited Participants are also urged to use their discretion as regards their involvement in the formulation of potentially controversial recommendations to the Commission; the Chairman may at his discretion rule them out of order.

In addition, it **agrees** to add a new rule, based on the decision taken in 1980 (IWC, 1981, p.51) with respect to the admission of local scientists:

> A.7 A small number of interested local scientists may be permitted to observe at meetings of the Scientific Committee on application to, and at the discretion of, the Chairman. Such scientists should be connected with the local Universities, other scientific institutions or organisations, and should provide the Chairman with a note of their scientific qualifications and relevant experience at the time of their application.

The Committee also considered its rules for data availability in the light of its discussions under Item 7.

The Committee **recommends** that the Commission be asked to adopt the amended Rules of Procedure given in Annex M and included in IWC/50/15Rev.

6.2 Longer term priorities and directions

At the beginning of the meeting, the Chairman stressed the importance of considering the longer-term priorities and future workload of the Committee. Sub-committees were asked to consider what items they believed should be given priority by the Committee on subjects relevant to their agendas. It was stressed that this should reflect priorities by topic and not necessarily in the context of the present sub-committee structure. These discussions are reflected in the relevant Annexes.

After reviewing the sub-committee reports and a discussion paper prepared for this subject (SC/50/O9), and the revised Rules of Procedure, the Committee considered its longer term priorities taking into account both long- and short-term priorities of the Committee and Commission, and progress made this year.

The Committee developed a list of seven topic areas that it believed were of priority in terms of the advice required by the Commission. These are shown in Fig. 1, together with the perceived links between them. The Committee also arranged the topics in current order of priority. It noted that a major function of the Committee is to review Special Permits in the light of guidelines developed by the Commission. It noted that aspects of this review are covered under several of the priority topics, including the Revised Management Procedure and Environmental Concerns, as reflected in the discussions this year. It also noted that this would also probably be true in the case of any future discussions of Sanctuaries. However it **draws attention** to its request for Commission advice on scientific objectives for the Southern Ocean Sanctuary (see Item 16).

6.3 1998/99 work plan and initial agenda for the 1999 meeting

With the agreement of the Committee, after the close of the meeting the Convenors drew up the following as the basis of an initial agenda for the 1999 meeting. They took into account the priorities recognised under Item 6.2 above, and, within them, the highest priority items agreed by the sub-committees. The Committee noted that the priorities may be revised in the light of Commission discussions. Following the Commission meeting, the revised initial agenda will be circulated to members for information and will form the basis of the draft agenda to be circulated 60 days before the next meeting. As agreed in the Committee's revised Rules of Procedure, it will also provide a framework for determining invited participants to the 1999 meeting.

RMP

1. Completion of *CLA* program revision and tuning.
2. Abundance estimation - general and specific matters relevant to the RMP.
3. North Pacific minke whale trials – review simulation results and new survey data.
4. North Pacific Bryde's whales – develop trials.

AWMP

1. Continue development process including review of trial results.

Aboriginal Subsistence Whaling

1. Annual review of catch limits as instructed in the Schedule.
2. Development of Greenlandic research programme (especially stock structure and abundance) for fin and minke whales.

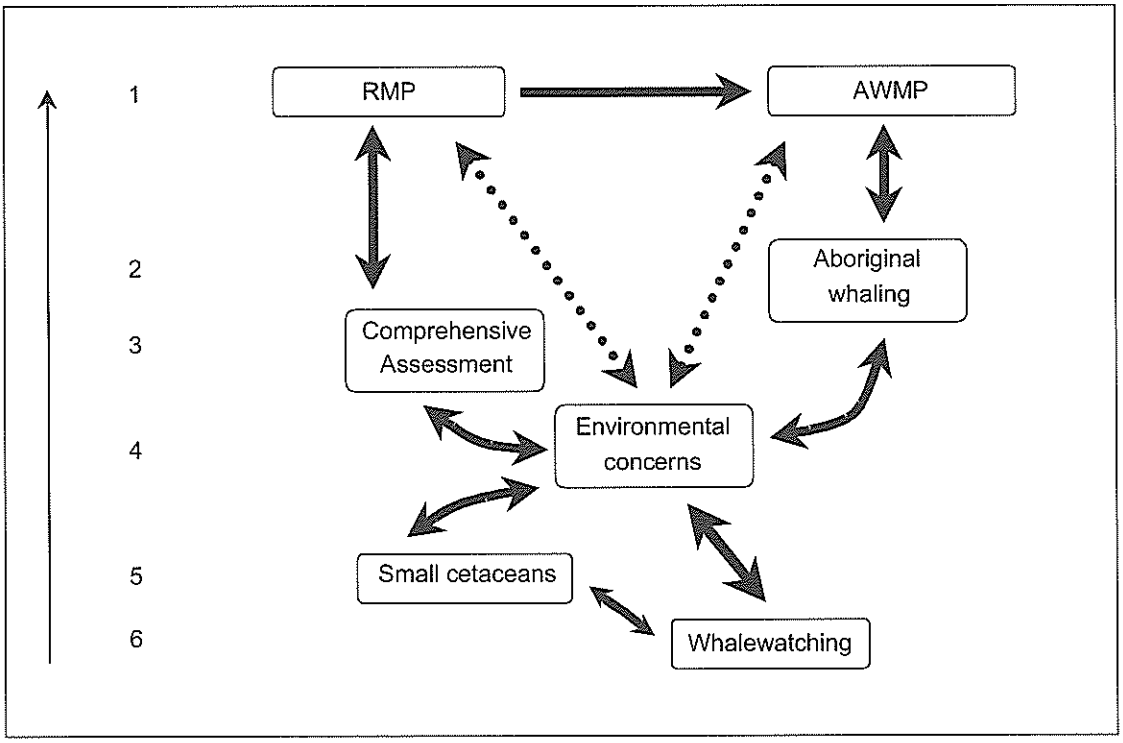


Fig. 1. Seven priority topic areas and their perceived links.

3. Review status of bowhead whale stocks other than the Bering-Chukchi-Beaufort Seas stock.

Comprehensive Assessment of Whale Stocks
1. Southern Hemisphere minke whales – review of JARPA (especially VPA question and abundance).
2. Southern Hemisphere blue whales – differentiation of sub-species; abundance estimation.
3. Western North Atlantic right whales – recent population trends (results of intersessional work and/or workshop).
4. Southern Hemisphere humpbacks – review intersessional work on preliminary assessment.

Environmental Concerns
1. Continue consideration of (a) pollution programme (b) Antarctic SOWER 2000 programme.
2. Arctic matters.

Small Cetaceans
1. White whales and narwhals.
2. By-catch mitigating methods (especially acoustic).

Whalewatching
1. Continue work on five previously identified long term topics.
2. Review progress made by intersessional group.

7. COMPREHENSIVE ASSESSMENT – REVISED MANAGEMENT PROCEDURE (CA/RMP) – GENERAL ISSUES

7.1 *CLA* program and tuning–report of the intersessional Working Group

7.1.1 Tuning

Last year the Committee requested the Secretariat to convert the MANAGE computer program, which calculates catch limits for the RMP, to use double precision arithmetic. The Committee also asked the Secretariat to use this modified program to determine a revised value for the tuning parameter that assures that the median final depletion for the D1 trial is 0.72K (accurately to 10^{-6}K) (IWC, 1998b). Allison reported that the program had been successfully converted, but that it was too slow to allow her to achieve the level of precision specified by the Committee in the time available. The MANAGE program had been originally designed for quickly determining approximate catch limits in simulation trials and had then been adapted for implementation purposes. The numerical integration methods used cannot achieve the required precision because precision does not improve rapidly enough with decreasing integration step size.

The precision specified by the Committee is necessary, in the case of a population as large as one million animals, to guarantee the requirement in the RMP that calculated catch limits are accurate to one whale. It is recognised that this level of precision exceeds the precision of the biological input data. Rather, it ensures that exactly the same catch limit will be obtained regardless of the numerical integration methods used in any computer program that correctly implements the *Catch Limit Algorithm*.

A procedure for determining the tuning parameter was developed that the Committee believed was sufficient to ensure a unique value for the tuning parameter. The steps in this procedure are given in Annex D, Item 3.1.

The Committee **recommends** that these steps be followed to determine a revised value for the tuning parameter. The Committee noted that the first step in this procedure required revision of the *CLA* program.

7.1.2 Revision of program

At last year's meeting (IWC, 1998b, item 7.2.2), the Committee recommended that the Secretariat investigate methods to calculate catch limits under the *CLA* more efficiently. It noted that it would be desirable if the same computer program could be used for calculating catch limits and for simulation studies. The Committee also recommended that this work be completed before the 1998 meeting and that the Secretariat should consider contracting out this task. An intersessional Working Group had been set up to facilitate this (members: Allison, Butterworth, Cooke, Givens, Hammond (Chair), Punt, Smith, Wallløe).

During the intersessional period, the Working Group finalised a specification for computer program structure, documentation, and performance, including specification of a set of test conditions. This is given as Annex D, Appendix 2, and formed the basis of an invitation to bid for a contract to revise the program that implements the *CLA*. The invitation to bid was distributed to the members of the Working Group. One bid was received that substantially exceeded the amount allocated by the Secretariat. Recognising this and after some discussion, the Committee believed that these requirements could be met using a program previously presented by the Norwegian Computing Center (Fenstad *et al.*, 1993). Noting that this program was shown during the last meeting to give the same answer as MANAGE when converted to double precision in at least one case, the Committee **agrees** that, suitably documented, it should meet the above needs.

The Committee **recommends** that the authors of the program be approached about completing the work required to meet the most important requirements of Annex D, Appendix 2, with the expectation that by using that previous coding, and allocating some tasks to the Secretariat, the costs might be more in line with the amount allocated last year (£3,000). Walløe reported that informal discussions with staff of the NCC had indicated that the work required from the NCC could be completed for approximately the amount allocated last year.

Annex D, Item 3.2 describes the most important requirements for the NCC to complete and the remaining aspects that should be addressed by the Secretariat.

7.2 Additional variance

Some years ago the Committee specified that, to improve its basis for drawing inferences from trends from surveys, IDCR sightings data should be extracted on several spatial scales over the time series of the surveys. The task has yet to be completed. The Committee **agrees** that it is still important to complete the work. The required data extraction may require up to two weeks using the DESS computer system. The Committee **recommends** that the task receive high priority during the intersessional period. It noted that the task was included in the list of those to be undertaken in the work of the proposed part-time position at the University of St Andrews (see Item 7.3.2).

7.3 Abundance

7.3.1 Report of intersessional Working Group on statistical estimators

At last year's meeting an intersessional Working Group was re-established to test the performance of abundance estimation procedures over an appropriate range of sighting survey factors. It initiated a simulation experiment at the meeting in which two abundance estimation methods were applied to 25 replicates of 32 sets of data that simulated shipboard line transect two-platform surveys where there

were different types of sighting heterogeneities and $g(0) < 1$. The results were reported to the meeting (Palka and Polacheck, 1997). During the intersessional period, two additional estimation methods (perpendicular distance implementation of the hazard probability model by Skaug and a radial distance implementation of the hazard probability model by Cooke) were applied to the simulation datasets. These results were presented to the Committee this year (Annex D, items 5.3 and 8.3.1.2). In addition, during the intersessional period more sets of simulated datasets with different conditions were created and more replicates of all the datasets were, and continue to be, created so that there will eventually be 100 replicates of each set of data.

The intersessional Working Group also began discussions about topics to be addressed in the near future. It recognised that the remit was broad and so should focus on topics that are the most relevant to abundance estimates that are currently or will in the near future be submitted to the Committee. Priority topics identified are listed in Annex D, Item 5.1.

The Committee re-established the intersessional Working Group under Palka to continue its work of testing the performance of abundance estimation procedures over an appropriate range of sighting survey factors.

7.3.2 IWC-DESS (Database Estimation Software System)

Borchers reported that the work contracted to the University of St Andrews, described in last year's report (IWC, 1998g, annex O, appendix 1), had been completed and the relevant data files transferred to the Secretariat. Some problems were encountered during the transfer; Borchers reported that these were being addressed and would soon be resolved.

The Committee established a Working Group under Donovan to consider the future maintenance, support and development of IWC-DESS. Its report is given as Annex D, Appendix 3.

The report proposes that the best way for the Secretariat to ensure the appropriate maintenance, support and development of DESS is to fund a part-time post at the University of St Andrews. This would have a number of advantages concerning the working environment, flexibility and continuity. The cost to the Secretariat is estimated at approximately £19,000 plus VAT per annum. Routine requests for data from accredited members of the Committee and international organisations would still be handled by the Secretariat. The intention is that items 1-7 under existing relevant tasks in Annex D, Appendix 3 would be completed as soon as possible and that items 1-3 under possible tasks in the near future in Annex D, Appendix 3 would be considered in due course.

The Committee **recommends** that the proposal described in Annex D, Appendix 3 be adopted as a matter of priority.

7.3.3 New information

A number of papers dealing with new developments in abundance estimation methods were presented to the Committee. Details of these papers and discussions of them are given in Annex D, Item 5.3.

7.4 RMP – Documentation for future possible Schedule amendment

This item was included this year, so that in the event that the Commission adopts the RMS, the Committee is in a position to recommend an agreed form of words to be inserted as the formal description of the RMP in a Schedule amendment.

At last year's meeting, an intersessional Working Group was established under Donovan to finalise documentation of the RMP for incorporation into the Schedule. Donovan presented the report of the Working Group, highlighting changes that the Committee had agreed since the RMP specification was last published in full (Table 2).

The Working Group identified some additional minor editorial changes and one more substantial change (and accompanying Annotation) with respect to the definition of *Year*. The change was suggested in the light of the Committee's work on North Pacific minke whales.

The Committee **agrees** to adopt the following amendments (shown in square brackets):

> Years[6] are consecutive periods of 12 months used for the compilation of time series of catches and abundance data for application of the Catch Limit Algorithm. [Neither this definition, nor any statement following, should be construed as precluding the possibility of a regulation that a catch limit calculated in such an application may be taken only during a certain part of the *Year*.]
>
> [[6^]The provision is to make allowance for the fact that mixing between different stocks in a *Small Area* may change during a Year, so the catches from that *Small Area* may be restricted at certain times in the interests of reducing their impact on one of these stocks (IWC, 1997d, pp.203-26).]

The Committee also **agrees** to slightly amend Annotation 16 to clarify issues related to 'indirect' catches. The revised wording (shown in square brackets) is:

> (16) The population model used in the *Catch Limit Algorithm* (see Section 4) effectively assumes that all whales that die from causes other than those resulting from natural mortality are included in the catch history. Thus, known [or estimated] 'indirect' catches, e.g. whales killed through entanglement in fishing gear [(including those that subsequently strand)], should also be included in the catch history, in addition to whales caught or struck and lost in direct whaling operations. On the other hand, stranding is assumed to be part of the process of natural mortality, and numbers of whales stranded [due to natural causes] should not be included in the catch history.

The Committee **recommends** that these amendments be adopted by the Commission. The revised full specification is given as Annex N (Note: the value for the lower percentile of the marginal posterior distribution of L_T, cannot be included until the work outlined under Item 7.1 is completed).

Table 2

History of RMP specifications and amendments.

Item	Year	Reference
First agreed version.	1992	*Rep. int. Whal. Commn* 43: 146ff
Final published full version (incl. amendments concerning: overall consistency and clarity process error; *Catch Limit Calculation*; Implementation; Implementation Review; phase-out rule).	1993	*Rep. int. Whal. Commn* 44: 44-8, 145ff
Minor amendments to Annotations: 9 (*Implementation Simulation Trials*); 12 (reference change); 23 (style change).	1994	*Rep. int. Whal. Commn* 45: 64-68, 214
Carry-over of catches.	1997	*Rep. int. Whal. Commn* 48: 64

The Working Group also suggested that Annotation 17 may need some discussion in the future. This would be to examine cases where a series of abundance estimates containing both absolute and relative estimates based on sightings (c.f. bowhead whales) is available. Any eventual changes would consequently need to be reflected in the last sentence of Annotation 21.

Finally, in the Committee, there was some discussion over the question of the timing of surveys (every six years) and of *Implementation Reviews* (at least every five years). It was noted that there is no requirement for these to be synchronous and that in fact the phase-out rule does not come into effect until eight years have elapsed since a new abundance estimate has been agreed. The Committee **agrees** to keep this under review, along with the question related to Annotation 17.

7.5 Stock identity

It was suggested that it may be useful for the Committee to reconsider its definitions of the term stock. The importance of the stock definition, or population subdivision, for the purposes of management and conservation of whale resources by the IWC is obvious. For exploited species, an understanding of stock boundaries is critical for estimating abundance, setting catch limits and interpreting life-history parameters. For protected species, stock boundaries are important for assessing population trends, establishing territorial jurisdiction and identifying critical habitats (Baker *et al.*, 1994).

Under the New Management Procedure (NMP), the IWC managed the different whale species using specific 'management units' (see Donovan, 1991). An example of these 'management units' is the six management Areas in the Southern Hemisphere used by the IWC to manage the baleen whales species (except Bryde's whale). Under this scheme, the 'management stock' was defined as the group of whales occurring within a specific geographical boundary which is actively or potentially exploited by IWC member countries. These are the individual stocks whose status is assessed by the Committee (Hoelzel and Dover, 1989).

To date, most studies on stock identity of large whale species have attempted to test hypotheses that IWC management units (management stocks) correspond to biologically defined entities (biological stocks). For that purpose, different techniques such as genetics, morphology, 'Discovery' marks, ecological markers, sighting pattern and catch distribution have been used. In recent Committee discussions on the stock identity issue, however, difficulty in interpreting genetic data has been evident.

There has been substantial development in techniques useful for determining stock structure in recent years, especially genetics-based methods. The Committee **agrees** that, given this development, it would be useful to undertake a review with the goal of establishing more useful definitions of the term stock.

An *ad hoc* Working Group was established under DeMaster to develop terms of reference for such a review, and to outline the tasks that it may be useful to address overall in such a review, including identifying specific steps that can be taken intersessionally in preparation for a more comprehensive discussion during the next meeting. The report of the Working Group is given as Annex D, Appendix 4.

The Committee **agrees** that the Steering Group on Stock Definition identified in Annex V should work intersessionally to progress the work and present an update to the next meeting of the Committee. An intersessional workshop was proposed and may be necessary after the next meeting.

In response to last year's Committee recommendation, SC/50/RMP6 presented a list of tissue samples of southern minke whales preserved at the National Research Institute of Far Seas Fisheries, which were collected under past commercial whaling. The Committee welcomed submission of the list but no time was available to review it.

8. CA/RMP – PREPARATIONS FOR IMPLEMENTATION

8.1 Questions relating to implementation trials

Implementation Simulation Trials involve:

> 'identifying the range of plausible hypotheses relevant to recommending an *Implementation* or *Implementation Review* for the RMP and formulating simulation models which conform with these hypotheses' (IWC, 1995d, p.214).

Annex D, Appendix 5 provides a structured approach to the development of *Implementation Simulation Trials* in cases in which there is uncertainty about stock structure. The need for addressing each of the issues in Annex D, Appendix 5 sequentially was emphasised because, for example, assumptions regarding choices of sub-Areas depend on hypotheses about the number of stocks and how they migrate. The Committee thanked Butterworth for completing this task which it had requested at last year's meeting.

8.2 North Pacific minke whales

At its 1996 meeting, the Committee developed a set of *Implementation Simulation Trials* for North Pacific minke whales and recommended that the Secretariat develop a computer program to implement these trials and then conduct them (IWC, 1994a, p.70). The trials involve 13 sub-Areas in the North Pacific and consider two hypotheses regarding the number of breeding stocks of minke whales in the North Pacific: (1) that there are three stocks, the J stock ('home' area - Sea of Japan and perhaps also the Yellow Sea and East China Sea), the O stock ('home' area - the Okhotsk Sea, the east coast of Japan) and the W stock (West Pacific); (2) that there are only the two stocks, J and O.

During its 1997 meeting, the Committee had reviewed recent information on stock identity and catches and made some revisions to the trials.

8.2.1 Progress during intersessional period

Allison reported that she had developed most of the program to implement the trials. However, she had been unable to complete this task and conduct the trials because some of the specifications were incomplete. At this year's meeting, the sub-committee on the Revised Management Procedure established a Working Group under Allison to finalise the specifications for the trials, taking into account discussions during the meeting.

8.2.2 Uncertainty over catches

IWC (1994b, p.150) states that 'known 'indirect' catches, e.g. whales killed through entanglement in fishing gear, should also be included in the catch history' in the RMP. This issue is discussed further under Item 7.4. The

Committee noted that *Implementation Simulation Trials* should include estimates of all non-natural removals. Some of the currently specified trials are used to examine the implications of alternative assumptions about catches. At last year's meeting, the Committee had agreed to modify the trials to include incidental catches of minke whales by Korea and Japan (IWC, 1998b).

In response to a request at last year's meeting, Kim presented new information about incidental catches of minke whales off Korea (Annex D, Appendix 7). In response to a question, he indicated that the increase in incidental catches during 1996 was related to unusual environmental conditions that also led to substantially increased fish catches. Information about fishing effort and catches for the years before 1996 is not available due to the lack of a systematic recording system. Kim suggested that examination of further information including prices in the market could be used to provide estimates of earlier catches. He indicated that incidental catches off Korea had increased following the cessation of whaling in 1986 and suggested that this may be because of an increase in the abundance of minke whales in the inshore waters off Korea.

At last year's meeting, it was agreed to include variants of the four base-case trials in which an incidental catch of 150 whales per annum is taken from sub-Area 6 (IWC, 1998b, item 8.1.2.2). This means that the incidental catch does not respond to changes in abundance. The Committee **agrees** to retain these trials but also to include incidental catches off Korea (sub-Area 6) in all the other trials. Details are given in Annex D, Item 8.2.2.

At last year's meeting, a Working Group was established to consider all the information on incidental catches in Japanese fisheries (estimated and observed) and to specify a time series of total incidental catches. Brownell reported that no agreement had been reached. He also noted that the incidental catches reported in the Japanese Progress Reports are notably lower than the estimates in Tobayama *et al.* (1992). While it is likely that the reported incidental catches are under-estimates, it is unclear whether the extrapolations made by Tobayama *et al.* (1992) are appropriate. Intersessionally, Brownell and Yagi had discussed the issues of what correction factors to apply to the reported estimates of incidental catch and how to collect better data in the future. Yagi reported that a project had been initiated to examine the first of these issues but it had not yet been completed. It was agreed that completion of this work was necessary before the Commission could actually apply the RMP to this stock. In the meantime, it was also agreed that plausible scenarios on incidental catch should be used for the purpose of *Implementation Simulation Trials*.

The Committee agreed that two scenarios should be considered in trials: (a) the incidental catches are taken to be those in the Japanese Progress Reports; and (b) the incidental catches should be based on the values reported in Tobayama *et al.* (1992). These trials include cases where the true removals are the larger incidental catches as defined under (b) but the RMP assumes that the smaller catches as defined under (a) are taken. Specifications incorporating these bycatches are given in Annex D, Appendix 6, Section D.

Although it was generally agreed by the Commission last year that, as far as possible, the *CLA* should be used 'to determine the allowable removals and then take account of all known human-induced mortalities', other views were also expressed. The Committee therefore **agrees** that trials should be conducted in which (a) the incidental catches are taken over and above commercial catches as set by the RMP and (b) in which the removals from each sub-Area are the maxima of the incidental catches and the catches set by the RMP. This last case corresponds to the assumption that the RMP catch limits cover all non-natural removals.

8.2.3 Sightings survey planning - report of intersessional Working Group

Last year, an intersessional North Pacific Sighting Survey Steering Group (NPSSSG) was established and assigned five tasks (Annex D, Appendix 8). The Steering Group was able to address several of these, and additional material was presented to the Committee relative to the remaining tasks.

SC/50/RMP4 described the revised version of the sighting survey plan which took into account recommendations made by the NPSSSG. It outlined the key features proposed for the conduct of the survey; the expected number of sightings if the survey were conducted in the area proposed would be 80.

In discussion, it was clarified that although this is a feasibility study, it was intended that, if the survey is successful, estimates of abundance using the data were intended to be used both in *Implementation Simulation Trials* and, potentially, in actual implementation of the RMP. It was suggested that because the applicability of the proposed methodology was not known, and because of concerns that some had raised about possible biases due to whale responsive movement (Annex D, Item 5.3), it would be useful to include in the design the possibility of using an alternate estimation method. One possibility would be to use standard line transect analysis methods assuming $g(0) = 1$. The possibility of using the method employed during the SCANS survey, due to Buckland and Turnock (1992) was discussed. It was noted, however, that the latter two methods require different searching patterns and that the observers would be required to adopt different search patterns, so that simultaneous application of both methods is not practical.

The Committee noted that the proposed determination of dive times using visual observations was not recommended as it is difficult to be confident about tracking individual animals as some surfacings may be missed. The Committee **recommends** the use of other approaches such as monitoring diving using VHF telemetry. While it was noted that such observations would most desirably be made during the survey, as proposed for the visual observations, it would be acceptable if they were made at appropriate different times and even locations as was the case for abundance estimates in the northeast Atlantic (Schweder *et al.*, 1997). It was also suggested that if visual observations are attempted, they might be compared with observations using VHF or other more direct methods to determine the degree of bias in the visual observations.

The use of binoculars for searching and distance estimation was discussed. The Committee **recommends** that the experiments and testing of estimation of angles and distances should be conducted using the same methods as in the actual survey. The possibility of using binoculars for searching if the Buckland and Turnock method were adopted was noted.

Miyashita thanked the NPSSSG for its helpful assistance, and requested that it continue to function as the preparations are made for this survey and that for Bryde's whales (see Item 8.4.2). The Committee agreed and re-established the Steering Group under Smith (for members see Annex V).

The Committee considered the requirements for participation of a member of the Scientific Committee in this survey. It **agrees** that Scientific Committee representation on the planned survey should take the form of participation of a

scientist with active experience of surveys of the type proposed (hazard probability approach) and other methods that may be incorporated (such as the Buckland and Turnock method). The Committee noted that Miyashita (who has participated in Norwegian surveys using the hazard probability approach) would participate in the survey and agreed that he was an appropriate scientist to represent the Committee.

The Committee reiterated from last year its **strong recommendation** that the survey includes waters within the Russian EEZ in order to provide the necessary coverage. It **recommends** that the Commission requests the relevant authorities of the Russian Federation to grant permission for the vessels to operate in their EEZ. The Committee **agrees** that, if permission is not granted, additional trials should be specified to represent a worst case scenario that no surveys would be conducted in, and no future catches would be taken from, the Russian EEZ in this sub-Area. More generally, the Committee **agrees** that this recommendation should apply to all relevant countries in similar situations for all such surveys in the future.

8.2.4 Revision of trials specification

The Committee considered the new information regarding stock structure for North Pacific minke whales in the context of whether it implied that changes had to be made to the specifications of the *Implementation Simulation Trials*. Details of the papers presented (SC/50/RMP7, 8, 12, 15 and SC/50/O8) are given in Annex D, Item 8.2.4.

Yagi recalled that, when papers similar to SC/50/RMP15 and SC/50/O8 were presented by Baker last year to the Committee, 'some members noted that these reports did not provide information that could be used to evaluate stock structure as the geographic location of the samples referred to was unknown' (IWC, 1998b). This year's documents, SC/50/RMP15 and SC/50/O8, had exactly the same problem and he believed that they did not contain new information relevant to specifying *Implementation Simulation Trials*.

In discussion in the sub-committee (Annex D, Item 8.2.4), Baker, Brownell and Wade stated that they believed that the analysis of mtDNA control region sequences in SC/50/RMP7 provided valuable new information on the question of stock differences or mixing between the J and O stocks. In particular, it allowed the comparative identification of previously defined RFLP haplotypes 2/5 using the direct sequencing methods of Baker *et al.* (1996) as applied specifically to the Japanese and Korean markets (SC/50/RMP15). The 2/5 types account for 76.7% of the samples representing the J stock (i.e., sub-Area 6) and only about 4% of the O stock (i.e., sub-Areas 7, 8 and 9), except in sub-Area 11 where seasonal mixing results in about 13.7% of types 2/5 (table 4 of SC/50/RMP7). However, the large majority of whaling since 1994 has been in sub-Areas 8 and 9. Only 30 whales were killed in sub-Area 11 (Pastene *et al.*, 1998) of the total of nearly 300 from 1994-97. For these reasons, the frequency of type 2/5 products, representing J stock whales, should be low in Japan, perhaps 6%.

Baker noted further that information in SC/50/RMP7 showed that a 'G' in position 298 of the control region identified all 21 of the type 5 sequences and one of the two type 2 sequences (table 8, SC/50/RMP7). Only one of the other 124 sequences from sub-Area 7 and 9 was characterised by this 'G', suggesting a potential misclassification error of about 0.8% for non-type 2/5 sequences. Based on this information, a review of figs 1 and 2 of SC/50/RMP15 showed that 7 (28%) of the 25 Japanese North Pacific minke whale products purchased from 1993-97 were type 2/5. Baker noted that unpublished data also showed that 6 (40%) of the 15 North Pacific minke whale products purchased in late 1997 and early 1998 were type 2/5. Overall, type 2/5 products accounted for 32.5% of the 40 North Pacific minke whale products purchased in Japan from 1993-98. Baker believed that this is difficult to reconcile with the expectation of a small percentage of J stock whales in the Japanese markets and supports the need to address uncertainty about stock structure or mixing rates in the *Implementation Simulation Trials*.

Yagi stated that there was no reason to assume that the difference between 32.5% and 6% of the frequency of type 2/5 samples reflects uncertainty about stock structure or mixing rate. Rather the difference could be explained by the different nature of the two datasets: Baker's value of 32.5% was calculated using samples of unknown origin while the value of 6%, which was estimated using data from SC/50/RMP7, came from samples of known origin. Thus, he saw no reason to reconcile this difference.

The Committee noted that the location of the samples in SC/50/RMP15 and SC/50/O8 was unknown. Some members believed that because of this SC/50/RMP15 and SC/50/O8 did not provide information that could be used to evaluate stock structure. Hatanaka noted that some of the animals could have been taken incidentally from the Sea of Japan, and that substantial quantities of frozen meat remained. Other members believed that the information in these papers was useful and might necessitate changes to the assumptions regarding stock structure and the values in the mixing matrices.

The Committee noted that the number of samples from sub-Area 6 that had been genetically analysed in SC/50/RMP7 and previous papers was small (30) and had been collected from a limited area over a very short period (September–October 1982). It agreed that additional samples from animals stranded in Japan and from the incidental catches off Korea would further its understanding of stock structure in the Sea of Japan. Kim stated that he would contribute morphological and genetic samples from bycatches to improve understanding of stock structure in the region.

The Committee agreed that an additional set of trials based on the four base-case trials would be developed that include the fraction of the type 2/5 haplotypes in the Japanese market in the conditioning (Section F (g) of Annex D, Appendix 6) assuming that the product available in the market each year is selected randomly from catches during that year. It was recognised that this last assumption was extreme because of the unknown locality of the samples. The values for the coefficients in the mixing matrices (e.g. the fraction of J stock animals in sub-Area 7) would be chosen to mimic this fraction as well as to be consistent with the other information used for conditioning. It was agreed that this overall issue would be considered further when additional genetic samples from the incidental catches off Korea and from strandings and incidental catches in Japan are analysed.

Allison presented the revised specification for North Pacific minke whale *Implementation Simulation Trials* (Annex D, Appendix 6). She drew attention to those aspects that had changed since the specification had last been published (IWC, 1997d, pp.216-225). Details of these are given in Annex D, Item 8.2.4.

Several members expressed reservations about the plausibility of Option J(ii) in the trials concerning incidental catch in Japan as an independent review of this issue is ongoing. Nevertheless they accepted that this option should

be included in the *Implementation Simulation Trials* at this time. Brownell expressed reservations about the plausibility of option J(i).

In respect of the status of the trials specified in Annex D, Appendix 6, Butterworth drew attention to the Report of the Working Group on North Pacific Minke Whales held in 1996 (IWC, 1997d) which stated:

> The basis used to select the trials was by and large that used in the past, *viz.* concentrating on cases with MSYR(mature) = 1% and factors likely to render the trials more difficult with regard to meeting risk criteria. The Group agreed that the relative plausibility of the different trials needed to be taken into account, but that this could not be done in the absence of considerations of the risk associated with the results for each. There was insufficient time for a full discussion of this issue, and it was agreed that it should be debated further in conjunction with a review of the results of the trials.

Butterworth and Punt believed that the intent of the statement by the Working Group in 1996 related purely to considerations of efficiency. If initial trials showed that certain hypotheses correspond either to small risk, or little difference in risk compared to other hypotheses, this obviated the need to spend considerable time discussing their relative plausibilities as this then became irrelevant.

Hammond and Smith believed that determining relative plausibility should not take into account the risk associated with trial results. They believe that pursuing Butterworth and Punt's interpretation of the 1996 Working Group's statement could confound the RMP implementation process by allowing one's perceptions of plausibility of a hypothesis to be influenced by the level of risk associated with it. This could decrease the ability of an *Implementation* of the RMP to meet conservation objectives. Furthermore, this approach is iterative, and thus potentially lengthy.

Butterworth and Punt agreed that the relative plausibility accorded to a trial should be based on biological considerations and be independent of the risk associated with the corresponding results. They also recalled the key role of new data as a basis for revising hypotheses during the process of conducting *Implementation Simulation Trials*. Nevertheless, they considered, on the basis of their experiences with such trials for management procedures for many different fisheries, that using trial results to concentrate subsequent computations around the scenarios to which risk was most sensitive was the only practical way forward.

The Committee **agrees**, as a matter of expediency, to use the results of trials for North Pacific minke whales to limit the extent of future trials in this manner. The Committee noted that it has not finalised discussion on the relative plausibility of the hypotheses underlying the trials. It also **agrees** that further discussion would be needed of how results of trials were best evaluated for scenarios with differing relative plausibilities (e.g. see IWC, 1996b, pp.109-10) and for those for which there were differences of opinion about plausibility, when the results became available.

The Committee **agrees** to adopt the revised specification for North Pacific minke whale *Implementation Simulation Trials* as given in Annex D, Appendix 6 and **recommends** as a high priority that the Secretariat conduct the trials during the intersessional period and report the results to next year's meeting.

Two years ago the Committee had established a Steering Group to consider and resolve any inconsistencies that remained when the trials were conditioned and run and to make decisions about the choices specified in Annex D, Appendix 6. It re-established this Steering Group with membership of Allison, Butterworth (Chairman), Hatanaka, Kawahara, Punt, Smith and Taylor, with the following terms of reference:

(i) review results of the specified initial trials intersessionally by correspondence;
(ii) advise the Secretariat of those trials that need not be carried out if the initial results are not sensitive to the differences among the associated hypotheses being tested;
(iii) effect minor amendments to the specifications in Annex D, Appendix 6, as may be necessary to match the conditioning requirements therein.

8.3 North Atlantic minke whales

8.3.1 Northeastern stock

8.3.1.1 PROGRESS DURING INTERSESSIONAL PERIOD

Two years ago it was agreed that additional analyses should be undertaken with respect to the estimates of abundance for northeast Atlantic minke whales from the NASS 1989/90 and NILS-95 surveys. The identified analyses were (IWC, 1997b, p.76):

(1) additional simulation tests to more fully explore the statistical properties of the Norwegian Computing Center (NCC) estimator and to further confirm that software was adequately verified;
(2) to reconcile any differences between comparable estimates obtained from the NCC and Cooke implementations by identifying the main causes of any such differences;
(3) to further assess the implications, in terms of possible bias in the NCC estimates, of the lack of model fit to the Bernoulli data, with respect to the marginal distributions of radial distances.

An intersessional Steering Group was established to undertake the above analyses but although significant progress was made by that Group at last year's meeting, definitive answers were not reached. Consequently, the Steering Group was asked to continue work on these issues intersessionally and to 'define and pursue a course of analysis that in its judgement would allow definitive answers to these questions to be available at the next Annual Meeting'. The work of the Steering Group is described in Annex D, Item 8.3.1.1. It was unable to complete a review of the three analyses in the time available.

8.3.1.2 REVIEW OF NEW INFORMATION

Papers that provided new information to address the three analyses listed in Item 8.3.1.1 (SC/50/RMP1, 2, 3, 20, 21 and 22) were presented and discussed by the sub-committee on the Revised Management Procedure. Details are given in Annex D, Item 8.3.1.2.

The Committee **agrees** that the large amount of new information available at this meeting provided a sufficient basis for resolving the three outstanding issues (IWC, 1997b) with respect to the Schweder *et al.* (1997) abundance estimates for northeast Atlantic minke whales from the NASS 1989/90 and NILS-95 surveys. The Committee agreed that it was the estimates that needed to be validated and not the estimator. The Committee also agreed with the approach taken by the Intersessional Steering Group to compare the estimates from the NCC implementation with estimates produced by the implementation, and the methods

in SC/50/RMP1 and SC/50/RMP22, as a sufficient basis for validating the NCC estimates with respect to the above three issues. The Committee noted that the comparable estimates from these alternative approaches were either quite similar or, when the discrepancies were greater, the NCC estimate was always the smaller estimate. In these latter cases, potential reasons had been identified that could be introducing positive biases in the alternative implementations. The Committee noted that in terms of implementation within the RMP the primary concern is to avoid positively biased estimates. In this context, the comparative results provide no indication of a positive bias in the NCC estimates.

The new information available this year contained results which dealt directly with each of the three outstanding issues. With respect to the first issue, the additional simulation results in SC/50/RMP20 provided additional information on the statistical properties of the general hazard probability approach and indicated general agreement between the *estimated strip half width* using this approach and the 'true' value within the simulated datasets. The question of software verification had been resolved at last year's meeting. With respect to the second issue, the results in SC/50/RMP22 provided comparable estimates from the NCC and Cooke implementations which provided no indication of any positive bias in the NCC estimates. With respect to the third issue, reconsideration of the statistical test performed at last year's meeting suggested that the test, as performed, was inappropriate. The test in SC/50/RMP3 appeared not to indicate significant lack of fit to the Bernoulli data in the NCC implementation, although the power of the test is limited. SC/50/RMP22 also found no lack of fit in its implementation and SC/50/RMP19 indicates that the apparent lack of fit in the NCC implementation could be the result of not having taken into account the rounding error. Taking all of these factors into consideration, the Committee agreed that the model fit appeared to be acceptable.

Overall, the Committee **agrees** that the comparative results from the different implementations combined with the other additional new information means that the task of undertaking additional analyses with respect to the NCC estimates of abundance for northeast Atlantic minke whales from the NASS-89/90 and NILS-95 survey as defined at the 48th Annual Meeting has now been completed. The Committee further **agrees** that the results from these analyses do not indicate any problem with the estimates in terms of the issues that had been raised at the 48th Annual Meeting and supported the Committee's previous conclusion that the abundance estimates in Schweder *et al.* (1997) are adequate for use in the RMP.

The Committee expressed appreciation to Polacheck for chairing discussions on this subject over the last several years and steering the work to its conclusion.

8.3.2 Central Stock

8.3.2.1 RECONSIDERATION OF EARLIER ESTIMATES

CIC Small Area. Last year, the Committee had noted an apparent discrepancy between the previously accepted abundance estimate for the NASS-87 Icelandic aerial survey block (Hiby *et al.*, 1989), and a recent reanalysis of these data (Borchers *et al.*, 1997).

SC/50/RMP14 reported an investigation into the source of this discrepancy. The effective search area estimated by Borchers *et al.* (1997) was about half that estimated by Hiby *et al.* (1989). The major discrepancy resulted from the use of a peaked detection function, without correction for error in distances estimation, by Borchers *et al.* (1997) versus a detection function with a wider shoulder, in combination with correction for error in distance estimation, used by Hiby *et al.* (1989). Further details are given in Annex D, Item 8.3.2.1.

In discussion, it was noted that these data alone are insufficient to distinguish between detection functions which are peaked or flat near the origin and there was some inconclusive discussion as to whether a peaked or flat detection function might be expected *a priori.*

In conclusion, the Committee **agrees** that the previously accepted estimate should remain so (pending resolution of the matters raised above). The Committee noted that the data from this survey had been provided for use during the current meeting. However, no arrangements were in place for continuing access. The Committee **agrees** that if the estimate is to be used in the implementation of the RMP then the data would need to be available on a continuing basis in accordance with the Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme (IWC, 1997e, pp.227-28). This was considered critical in order that issues such as those raised in the discussion could be examined further when necessary. The question of data availability was considered further under Item 8.3.2.2.

CM Small Area. The Committee had previously calculated an abundance estimate from the NASS-87 data for this area from an *ad hoc* proration of the estimates from Norwegian and Icelandic surveys, based on the number of sightings in the area (IWC, 1993a, p.66).

SC/50/RMP17 presented a reanalysis of the NASS-87 data for this area.

In discussion, three concerns were raised about the analysis. First, no smearing of the line transect data had been carried out. Second, data were pooled across Icelandic and Norwegian vessels. Third, survey block B2 contributed over 50% to the total abundance estimate, yet survey coverage in this block was very low. Further details are given in Annex D, Item 8.3.2.1.

The authors of SC/50/RMP17 indicated that they would undertake to reanalyse the data to address the concerns raised. The Committee noted that the data from this survey were also available only during the current Annual Meeting. The Committee emphasised that if the abundance estimates from these data are to be used as input to RMP implementation, the data will need to be available on a continuing basis (see Item 8.3.2.2).

SC/50/RMP10 analysed minke whale sightings data collected in the NVS stratum of the CM *Small Area* from Icelandic vessels in the NASS-95 survey. An estimate of 5,869 minke whales (CV = 0.427) was obtained using standard line transect methodology assuming $g(0) = 1$. The estimate for the NVS stratum was added to estimates for the NVN and JMC strata of the CM *Small Area* obtained from the NILS-95 survey using different methodology (Schweder *et al.*, 1997) to yield a total abundance estimate of 12,043 minke whales (CV = 0.277) for the whole CM area in 1995.

The Committee had a number of questions concerning the conduct of the survey and the field protocols followed, such as whether there had been experiments to test distance estimation and how duplicate sightings had been identified. Details are given in Annex D, Item 8.3.2.1.

Because this survey had been conducted recently, the Committee considered the extent to which it had met the Requirements and Guidelines for Conducting Surveys under

the RMP. To facilitate this a checklist was developed summarising the extent to which these were met. The checklist is given in Annex D, Appendix 9 and possible implications for future use of estimates from these data in implementing the RMP are discussed under Item 8.3.2.2.

8.3.2.2 DATA AVAILABILITY

Last year the Committee posed four general questions (IWC, 1998b, item 8.2.2) arising out of specific discussion about the availability of sightings survey data for estimates that it might review for suitability under the RMP. These questions arose out of the specific issue of the suitability of abundance estimates from the CM area that were based in part on data collected by a non-member state and for which the Committee did not have access to the primary data.

In general discussion of data availability issues the Committee recalled that these questions had arisen out of the Requirements and Guidelines for surveys under the RMP (IWC, 1996d, p.211) and that these requirements and guidelines pertain strictly to data for estimates to be used in an implementation of the RMP. The Committee **agrees** that availability means that the data need to be lodged with the Secretariat on a continuing basis and that they are freely available to all accredited members of the Committee without restriction. Data availability in this context does not extend to public access nor does it allow for further redistribution of the data by members of the Scientific Committee.

The Committee noted the desirability of having access to data from abundance surveys that were conducted by non-members states on stocks of interest to the Commission. The Committee **recommends** that the Commission request non-member states to cooperate in the work of the Committee by providing information on abundance surveys that they conduct on stocks of interest to the Commission and to make the data from such surveys available.

Requirements for data used by the Committee to address other issues do not fall under these same requirements. The Committee recognised that results from various other analyses (such as genetic analyses to inform decisions on stock structure and assessments of stocks subject to aboriginal subsistence whaling) were used to provide management advice to the Commission for which the data were not available to the Scientific Committee. Some members considered that the question of data availability for these other analyses needed to be addressed. The Committee noted that this issue is being addressed in the development of the Aboriginal Whaling Management Procedure.

Discussion then focused on the following four questions posed last year.

(1) REQUIREMENTS FOR CONTINUING AVAILABILITY OF DATA FROM ABUNDANCE SURVEYS

The Committee noted the critical importance of having continuous access to data from abundance surveys. Such access is essential in order to be able to verify estimates when questions arise and to update previous analyses in response to methodological improvements and developments. In addition, a key component of the RMP is the requirement to periodically review the definition of *Small Areas* used in any particular implementation and to redefine these areas in light of additional information. Unless the data used to estimate abundance are available, it would not be possible to re-calculate appropriate abundance estimates that corresponded to redefined *Small Areas*.

The Committee **recommends** that, as a minimum requirement, data from abundance surveys be available on a continuing basis if abundance estimates from such surveys are to be used in an implementation of the RMP.

The Committee further **recommends** that it should not review such estimates under the terms of the RMP unless there are assurances of such access.

(2) ACCESS TO DATA SUPPLIED BY A COUNTRY SUBSEQUENTLY LEAVING THE COMMISSION

The Committee noted the discussion above about the necessity to ensure continuous availability of data for abundance estimates when such estimates are for use in the RMP. If data access were lost in the event that a member state subsequently left the Commission then the continued implementation of the RMP could be compromised. As such, the Committee **recommends** that the Commission develop appropriate provisions that ensure that any data supplied by a member country for use under the RMP remain available to the Scientific Committee in the event that a member country withdraws from the Commission.

(3) POSSIBILITY OF ALLOWING 'SLIGHTLY MORE LIMITED RESTRICTIONS' WHERE DATA OF GREAT INTEREST TO THE COMMITTEE ARE OWNED BY A NON-MEMBER NATION

Last year the Committee agreed 'that it would be useful to attempt to make an estimate for the entire CM area (for North Atlantic minke whales) for 1995.' At this year's meeting, abundance estimates for the CM area that incorporated data collected by Iceland were presented to the Committee. The data were available to the Committee during the meeting, but no arrangements had been made for continuing access. The Committee recognised that Iceland was not currently a member of the IWC and, as such, was under no obligation to supply data or meet other requirements and guidelines when conducting surveys.

The Committee recognised that in both the case of the use of an estimate under the RMP and the use of an estimate to address other issues of interest to the Committee, limitations on the use of such data for analyses beyond that required for the RMP or the issue for which they were supplied might be considered. Such restrictions might include ensuring that the rights of collectors for the first use of the data for their own purposes are safeguarded. Such restrictions might be included as a part of the conditions under which the data would be provided to the IWC. The Committee considered that such restrictions should not necessarily preclude the use of abundance estimates from such data as long as there was adequate access to the data for use in the RMP. The Committee stressed that within the RMP context such data would need to be available without restriction to accredited scientists. However, the publication of results of analyses not clearly and directly related to implementation issues, without the agreement of and/or collaboration with the data collectors, could be forbidden.

The Committee **recommends** that a set of guidelines be developed for the types of availability restrictions that it would consider acceptable if a non-member country, individual scientist, or international organisation were to provide data for use in the RMP. In developing such guidelines, consideration should be given both to the needs for ensuring continuing adequate implementation of the RMP and the limitations on data uses that would facilitate and encourage the provision of such data. Smith agreed to present a proposal for a set of guidelines to next year's meeting.

(4) COMMITTEE POLICY ON REVIEWING PUBLISHED ESTIMATES IF THE RAW DATA ARE NOT AVAILABLE

The Committee **recommends** that it should not review estimates for use in an application of the RMP based on data that it judges do not adequately meet its requirements and guidelines. However, the Committee also **recommends** that it should consider the specifics of any data set in terms of its requirements and guidelines. It should evaluate the degree to which the data are adequate for use in the RMP and should judge the relative importance in terms of the behaviour of the RMP in those areas where the requirements were not met and guidelines were not followed. In particular, some aspects of the guidelines dealing with prior notification and timing of data provision, etc., may be inappropriate or irrelevant depending upon the situation under which the survey was conducted by a non-member country.

In the case of the 1995 Icelandic data for the CM area, Annex D, Appendix 9 provides an evaluation of these data in terms of the RMP requirements and guidelines. It was noted that several members of the Committee had participated in the planning meeting in Tromsø for this survey. In addition, the methodology and procedures were similar to those used in the previous NASS-87 and 89 surveys. Moreover, results of analyses in SC/50/RMP10 suggested that if a standard line transect estimator was used with these data the resulting estimate would be negatively biased. With the exception of the issue of data availability, the Committee did not identify any issues in its review of SC/50/RMP10 and the supplemented information provided in Sigurjónsson *et al.* (1996) that would have precluded the use of the abundance estimate in SC/50/RMP10 for use within the RMP. However, members of the Committee may wish to conduct additional analyses to verify the acceptability of the estimate for use in the RMP if the data become permanently available.

8.4 Western North Pacific Bryde's whales

8.4.1 Specification of Implementation Simulation Trials

The Scientific Committee completed the Comprehensive Assessment of North Pacific Bryde's whales at its 1996 meeting and recommended development of *Implementation Simulation Trials*; this recommendation was accepted by the Commission (IWC, 1997a, p.32). At last year's meeting, the Committee considered information about stock identity and historical catches of North Pacific Bryde's whales. It identified seven tasks which, if completed during the intersessional period, would assist in the development of *Implementation Simulation Trials*. An intersessional e-mail correspondence group chaired by Punt was established to facilitate completion of these tasks.

8.4.1.1 PROGRESS DURING INTERSESSIONAL PERIOD

The report of the Intersessional Working Group on the Specification of *Implementation Simulation Trials* for the Western North Pacific Bryde's Whales is given in Annex D, Appendix 10.

8.4.1.2 DEVELOPMENT OF TRIALS

The Committee considered the new information regarding stock structure for North Pacific Bryde's whales.

Details of the papers presented (SC/50/RMP9, 11, 13, 18; SC/50/CAWS6 and 13) and discussion of them are given in Annex D, Item 8.4.1.2.

The Committee discussed the limits to the distribution of the local form of Bryde's whale in the western North Pacific. On the basis of inferences from where the local form has been shown to occur, historical commercial catches, sightings from research surveys, and observations based on whalewatching, as described in Annex D, Appendix 11, Hatanaka argued that any Bryde's whales around the Hawaiian Islands, Midway Island, the Kiribati Group, the Caroline Islands, and the Northern Marianas should be considered to be of the ordinary form. Perrin disagreed, noting that no surveys had been conducted near the Hawaiian Leeward Islands and that just because ordinary form Bryde's whales are found near an island does not imply that the local form cannot also occur there. Brownell commented that the situation for Midway Island and the Hawaiian Islands may be quite different from that for the islands in the Indo-Pacific including the other island groups noted by Hatanaka.

Three hypotheses had been proposed concerning the local form of Bryde's whale (SC/50/RMP11): (1) only the ordinary form is found in stock division (b), as defined in the 1996 Comprehensive Assessment (IWC, 1996c); (2) animals of the local form are found around oceanic islands within this division; and (3) Southern Hemisphere Bryde's whales move into division (b) occasionally. Several members raised concerns, described in Annex D, Appendix 12, over the assumption that the local form is not found around oceanic islands and that Southern Hemisphere Bryde's whales never migrate into the North Pacific. Kato noted that previous whaling operations around the Bonin Islands mainly occurred some 150-200 n.miles east of the islands. He further noted that although information from whalewatching can never be equivalent to a systematic survey, the whalewatching association of the Bonin Islands (OWA) has conducted seasonal surveys, which were organised more systematically than most whalewatching operations, in cooperation with the National Research Institute of Far Seas Fisheries. Whalewatching effort now extends to summer and autumn for sperm whales in addition to that in spring for humpback whales. However, no Bryde's whales had ever been seen around the coast of the Bonin Islands during surveys or whalewatching operations.

The Committee was informed that future catches are not envisaged in the following areas: 200 n.mile zones of countries other than Japan; within 20 n.miles of the coast of southern Japan (west of 36ºE, including the Kochi area and Ryukyu Islands); and south of 10ºN (Annex D, Appendix 10, Adjunct 1). This will have the effect of limiting or even eliminating any possible catches of local form Bryde's whales. However, stock structure hypotheses concerning local form Bryde's whales are still important because sightings surveys are planned to include 200 n.mile zones of countries other than Japan. It was also noted that in the event that catches within these areas are subsequently proposed, the *Implementation Simulation Trials* may need to be modified or repeated to take account of any revised assumptions about the location of future catches.

There was neither sufficient time to complete discussion of the plausibility of the three hypotheses given in SC/50/RMP11, nor, therefore, to finalise agreement on how to model the structure of inshore and offshore Bryde's whales in and around major island groups.

The Committee then discussed plausible stock structure hypotheses for offshore Bryde's whales in the western North Pacific from a starting point of the stock area proposed by the Comprehensive Assessment and modified to exclude the area south of 10ºN (Annex D, Appendix 10, Adjunct 1).

Smith and Polacheck expressed a number of concerns based on the available information on catch distribution, and genetic and marking data. First, they queried why there was a gap in the catch distribution between 150° and 160°E. Second, they noted that there were large areas of ocean to the

east of the proposed stock area for which there were no data. Third, having examined changes in catches over time in the area of pelagic whaling, they pointed out that downward trends in catches had occurred at a small spatial scale (5° × 5° block) over short (up to five year) periods of time. This raised concerns about local depletion and the possible desirability of incorporating within-stock spatial structure in the trials.

Hatanaka responded to these three issues. First, he pointed out that the gap in catch distribution between 150°-160°E was a result of catch regulations; the western boundary to pelagic whaling set by the Government of Japan at that time was 159°E and the eastern extent of coastal whaling was restricted by distance from the land station. Second, he noted that although there were no genetic or marking data in the area to the east of 170°E, there were large catches; analyses of biological data had indicated no difference between whales taken by coastal and pelagic whaling. Third, he believed that it was clear from all the available data that there was no within-stock spatial structure latitudinally or longitudinally. Ohsumi added that the observed trends in catches identified by Smith and Polacheck were a result of operational factors such as changes in the range of pelagic whaling grounds and catch quotas.

After considerable discussion of the available data and the areas to which they pertained (summarised in Annex D, Appendix 14), the Committee **agrees** that an appropriate boundary for the western stock of North Pacific Bryde's whales for the purposes of the RMP is as described in Annex D, Appendix 14. This specifically excluded the area to the south of the Hawaiian Islands and east of 180° from which there were no data. The Committee further **agrees** that there should be two sub-Areas in this stock area divided at 180° which would allow the testing of two alternative stock hypotheses:

(1) there is only one offshore stock of Bryde's whales in the western stock area;
(2) there are two offshore stocks present in the sub-Area to the east (sub-Area 2 in Annex D, Appendix 14): the western stock and an eastern stock.

The Committee noted that it was planned that future sightings surveys would cover the entire western stock area as defined over a four year period.

Key questions concerning stock structure that remained include: how to model the interchange between inshore and offshore Bryde's whales in the areas around islands, including the plausibility of the proposed hypotheses; and whether or not operational factors can explain the observed trends in catches at small spatial scales and, if not, whether within-stock spatial structure needed to be considered.

Concerning catch data, key issues that require resolution are: the disagreement last year about how to treat Soviet catches (IWC, 1998b) in the trials; and the proposed locations of future catches. These would need to be resolved after sub-Areas had been fully defined.

To address these and other questions relating to the specification of the simulation trials, the intersessional Working Group from last year was re-established under Punt to work by e-mail and to report to next year's meeting. Hatanaka further proposed that to ensure good progress a workshop should be held before next year's meeting. This had been considered last year but no workshop had been held. The Committee **agrees** that the detailed work of specifying trials is best conducted at a separate meeting and **recommends** that such a meeting take place intersessionally.

8.4.2 Sightings survey planning - report of the intersessional working group

The Report of the North Pacific Sighting Survey Steering Group (NPSSSG), is given in Annex D, Appendix 8. The Steering Group was able to address several of the nine tasks assigned to it and additional material was presented to the Committee relative to the remaining tasks.

SC/50/RMP5 described the revised version of the four year sightings survey plan which took into account recommendations made by the NPSSSG. It outlined the key features proposed for the conduct of the survey. There will be three vessels used and the expected number of sightings is 30 per vessel. One of the vessels will have the capability of an independent observer platform, which will be used in a feasibility study to determine if $g(0)$ is close to one or not.

In discussion, it was clarified that the data being collected are intended for use in both *Implementation Simulation Trials* and implementation of the RMP for North Pacific Bryde's whales. It was suggested that the initial estimate of school size, at the time of sighting, be recorded as well as the actual estimate after closing in order to obtain data for correcting school size estimates during passing mode. Although previous experience with this approach for Southern Hemisphere minke whales was noted to have been unsatisfactory, a further attempt was suggested by some as being worthwhile. Covering an entire latitudinal band in one year was noted to be a good approach.

The Committee considered the requirements for participation of a member of the Scientific Committee in this survey and agreed that Committee representation on the planned surveys should take the form of participation of a scientist with active experience of surveys of the type proposed. The Committee noted that Shimada (who has the relevant experience) will participate in the survey and **agrees** that he is an appropriate scientist to represent the Committee.

The Committee **strongly recommends** that the surveys include waters within the EEZs of the Federated States of Micronesia, the Republic of the Marshall Islands and the USA in order to provide the necessary coverage. The Secretary informed the Committee that he had received a letter from the government of the Marshall Islands granting permission to conduct surveys in their waters. Tillman informed the Committee that the government of the USA had informed the government of Japan that it welcomed the planned surveys and had granted permission for Japan to work in US waters until June 2000. A permit to take biopsies in US waters was required and the government of Japan had been encouraged to submit an application for such a permit. US authorities would assist as required to ensure that this permit could be granted in timely fashion. The Committee **recommends** that the Commission requests the relevant authorities of the Federated States of Micronesia to grant permission for the vessels to operate in their EEZ.

9. COMPREHENSIVE ASSESSMENT OF WHALE STOCKS

9.1 Southern Hemisphere blue whales

9.1.1 Assessments

The Committee noted that it had not been possible to develop revised estimates of blue whale abundance from the IDCR/SOWER cruise programme in time for this meeting. It looked forward to receiving such estimates at its next meeting.

SC/50/CAWS14 reported historical data on blue whales off Namibia. Catches of blue whales off Walvis Bay in the 1920s had been substantial, and size composition data indicated that these were probably true blue whales. Catches peaked strongly in July/August. There were at least six apparent cow-calf pairs included in the catch, and the region had the reputation of being resorted to by particularly large, fat females. If the area is a winter 'breeding ground' for true blue whales, this would offer new opportunities for monitoring their status and could be considered in planning future SOWER cruises. However, assessing the status of blue whales on a breeding ground might not be straightforward, and would have to take into account possible structuring and segregation by sex or reproductive condition.

SC/50/CAWS23 suggested that blue whales seen in the vicinity of the Galapagos Islands during the austral winter or spring might be Southern Hemisphere animals on their wintering grounds. Kato had examined photographs of animals from the Galapagos region, including a sequence showing surfacing behaviour, and, from morphological and behavioural characters, had concluded that these whales resembled true blue whales.

Incidental sightings of more than 60 blue whales from a ferry in a fjord in southern Chile, some apparently feeding at a frontal zone between oceanic and glacial meltwater, were made in January 1998 (SC/50/Rep2). The observers (who had just participated in the blue whale cruise) believed the animals looked similar to the blue whales seen on that cruise and identified as pygmy blue whales by the boatswains.

The Committee stated its concern that reliable distinction between 'true' and pygmy blue whales in the field was becoming increasingly important, given that the results of the 1996/97 SOWER cruise had indicated that the simple geographical separation of the two forms in summer previously used may no longer be entirely valid. This means that sightings estimates in high latitudes in summer may contain some proportion of pygmy blue whales.

The surfacing behaviour of putative 'true' and pygmy blue whales had been recorded on the first two (1995/96 and 1996/97) blue whale cruises, using high-resolution digital video recording. SC/50/CAWS1 analysed 12hrs 56mins of these recordings, representing 4 surfacings by 4 'true' blue whales and 103 surfacings by 45 pygmy blue whales. Seven patterns of surfacing were identified. Although the sample size of 'true' blue whales was small, there appeared to be a difference in surfacing behaviour between 'true' and pygmy blue whales. Whereas pygmy blue whales never exposed the caudal keel (and rarely their dorsal fin), 'true' blue whales seemingly always exposed both. The authors recommended that more data should be collected from 'true' blue whales, that the biological context of different surfacing behaviours should be investigated, and that other morphological features (especially those involving the nasal region of the skull) should be examined.

The Committee welcomed this analysis as an objective approach to investigating behavioural differences between the two forms of blue whale, and looked forward to a fuller analysis next year, in which the results of the 1997/98 blue whale and SOWER cruises would be included. This would *inter alia* increase the sample size for 'true' blue whales. Concern was expressed, however, that the process of closing with the whales to obtain video footage may be altering surfacing behaviour, so that the difference in behaviour seen between the two forms might be partly a result of the 'true' blue whales having been filmed at a greater distance from the vessel. Brownell reported that blue whales in the Maldives, believed to be pygmy blue whales, fluked frequently, even during boat approaches.

SC/50/CAWS29 reported an analysis of sounds recorded in the vicinity of blue whales off Chile on the 1997/98 blue whale cruise. During 8 of 13 approaches to blue whales for biopsy attempts that were acoustically monitored, a total of 20 very low frequency calls was recorded. All were typical of blue whale vocalisations, but were unique in the consistency of the fundamental harmonic and the production of multiple harmonics, creating a harsh, growly quality. Such calls were only recorded on closing for biopsy, and were characteristic of calls made by other animals in a threatening context.

A summary of information from IDCR/SOWER cruises to date on the acoustic distinction between 'true' blue and pygmy blue whales was provided by Clark. All the recordings made in the Antarctic in 1996/97 in the vicinity of putative 'true' blue whales differed greatly from anything recorded on the cruises off Australia in 1995/96, south of Madagascar in 1996/97 or off Chile in 1997/98. Preliminary reports from the 1997/98 Antarctic SOWER cruise suggested that calls similar to those recorded in the Antarctic in 1996/97 had been heard. It therefore appeared that 'true' blue whales may produce different vocalisations from pygmy blue whales. The best documented comparison was between pygmy blue whales sampled south of Madagascar in November/December 1996 and blue whales recorded in the Antarctic the same summer (IWC, 1998d; Ljungblad *et al.*, 1998). These were as distinct as the calls of North Atlantic or North Pacific populations of blue whales. However, Clark had not had access to all the recordings, and a full comparison had not been made. A small group under Clark provided a report (Appendix 2 of Annex E) describing the current situation regarding the quantity, availability and disposition of acoustic recordings from the blue whale and SOWER cruises, and the state of their analyses.

The Committee **recommends** that all blue whale recordings from these cruises should be gathered in one place and put in a format that makes them accessible to researchers. It **agrees** that a working group under Clark would be set up to coordinate the process, which should involve all the stake-holders in the blue whale recordings made to date. The aim would be to provide a properly archived and annotated series of sounds, the analysis of which would be presented at the Committee's next meeting. It was estimated that a sum of £2,000 would be required to cover the costs of analysis, and a total of £2,000 for editing and archiving the sounds onto CD-ROM.

The Committee **agrees** that discrimination between 'true' and pygmy blue whales should be a major topic at the Committee's next meeting. Papers on not only acoustic differences but also genetic differences from biopsy and museum samples and differences in morphology and behaviour as determined from descriptions by topmen and still and video photography would be welcomed.

9.1.2 Reports of the SOWER cruises

The Committee reviewed SC/50/Rep2, the Report of the 1997/98 IWC/SOWER Blue Whale Cruise, the third to be undertaken as part of the IWC's research programme on Southern Hemisphere blue whales. The cruise was conducted in the southeastern Pacific Ocean in identified summer concentration areas off the coast of Chile, during December 1997 and January 1998. The objective of the cruise was, as in the two previous cruises, to obtain scientific information relevant to developing onboard identification

methods for distinguishing between 'true' and pygmy blue whales. Two vessels, *Shonan Maru* and *Shonan Maru No.2*, were used. A total of 389hrs 58mins of searching was carried out by both vessels combined, during which some 4,454 n.miles of trackline were surveyed. In total, 39 sightings of 47 blue whales (and 1 sighting of 1 like-blue whale) were made, of which 37 sightings of 45 animals were identified as pygmy blue whales and 2 sightings of 2 animals as 'undetermined' blue whales. Experimental work included collecting 19 biopsies from blue whales; 462 still photographs and 180.11mins of video footage of blue whales were exposed for individual identification, morphological and behavioural analysis. Dive-time experiments were undertaken for 20 blue whales for a total of 16hrs 20min, and 225hrs 13min of acoustic monitoring was carried out: blue whale calls recorded ranged in frequency from 9 to 44Hz and from 1 to 32 seconds in duration. A list of recommendations for future blue whale cruises is included in SC/50/Rep2.

Identifications of blue and pygmy blue whales on the cruise were provisional and had been made by the topmen. The criteria they had used (e.g. blowhole shape, head shape, etc.) had been systematically recorded on the sightings data sheet. The boatswains on both vessels had also had previous experience with chasing and catching pygmy blue whales before protection. The Committee **recommends** that a paper be submitted to next year's meeting, documenting the criteria used on each of the three blue whale cruises for identifying the two blue whale forms, listing the results and the personnel responsible for making the identifications, and providing an analysis of the photographic and video material in support of the criteria used. It was pointed out that much of this had already been done for the first two cruises (SC/50/CAWS1), and that the 1997/98 cruise material had been preliminarily evaluated.

Blue whale research was also conducted during the 1997/98 IWC/SOWER cruise to Area IIW (SC/50/Rep1) although the primary objective of this cruise had been to estimate the abundance of minke whales. Two of the 30 available research days had been allocated for research on blue whales. Eleven sightings of 18 blue whales were made in the research area; eight of these sightings (14 animals) were identified as 'true' blue whales, two sightings (3 animals) as pygmy blue whales and one sighting (1 animal) as an 'undetermined' blue whale. Research was conducted on 10 groups of blue whales for a total of 14.42hrs, during which time biopsies were obtained from 3 'true' blue and 3 pygmy blue whales, acoustic monitoring was carried out for 13hrs 25mins, dive-time experiments were run for 2.83hrs, there was video-taping of surfacing behaviour for 26mins 47secs, and 8 'true' blue and 2 pygmy blue whales were photographed for identification purposes.

9.1.3 Other

Following problems experienced on previous blue whale cruises with obtaining biopsies from whales that were difficult to approach, Larsen had received IWC funding to develop a more powerful delivery system based on a Remington Rolling Block System rifle, adapted to fire darts of a diameter of 26mm using 9mm blank ammunition (SC/50/O15). The gun also carried an electronic aiming device and a valve for adjusting gas pressure. Field trials on humpback whales off Provincetown had been promising, but it had not been possible to get the gun to Chile in time for the 1997/98 blue whale cruise. The question of using this new system on future blue whale cruises was referred to the Planning Group (see Item 9.9.1).

9.2 Right whales

9.2.1 Report of the Cape Town workshop

The Committee received the report of the Special Meeting on the Comprehensive Assessment of Right Whales that was held in Cape Town in March 1998 (SC/50/Rep4). Bannister, who had chaired the Workshop, provided a summary (Appendix 3 of Annex E) and presented a compilation of the most important recommendations to the Committee. The Committee commended the organisers of the meeting and considered its recommendations. General comments are given in Annex E and incorporated, where appropriate, under Item 9.2.2 below.

9.2.2 Action arising

The Committee **agrees** to endorse all the recommendations contained in the report of the right whale meeting (SC/50/Rep4). However, it gives highest priority to the items listed within the two categories, A and B, below.

A. RECOMMENDATIONS WITH MANAGEMENT IMPLICATIONS

These are particularly important for those stocks for which the Workshop has expressed concern over status. The Committee identified ship strikes and incidental entanglements in fishing gear as the most significant causes of human-induced mortality of right whales.

The Committee's specific recommendations with management implications are given in Annex O.

B. RECOMMENDATIONS FOR RESEARCH

The Workshop had made a large number of research recommendations and the Committee reiterated the value it attaches to all of those recommendations. However, it recognised the need to assign priorities in the context of IWC interest. It agreed with the Workshop that, in particular, this applies to questions associated with the 'trend and condition of whale stocks' and 'measures for the[ir] conservation' (Article IV of the Convention).

In this regard the Committee confirms the view it has already expressed on several occasions (IWC, 1990b) of the extreme importance of maintaining research effort when investigating trends in both abundance and in biological parameters. The Workshop therefore stresses that high priority should be given to the continuation of both demographic photo-identification studies (SC/50/Rep4, item 9) and surveys designed to improve knowledge of absolute abundance and current trends (see SC/50/Rep4, item 10). Similarly, high priority should be given to the processing and analysis of such data. This is particularly important for the western North Atlantic where there are serious concerns over the status of the stock (see SC/50/Rep4, item 11).

In the same regard the Committee notes the need to initiate and improve such studies in areas of identified concentrations where they are either absent or in their infancy. High priority should be given to those areas where it is believed there is most chance of success.

In order to interpret data on trends and abundance it is important to determine appropriate management units. In this context, high priority should be given to stock identification studies that will answer questions believed to be hindering the Committee's ability to address important conservation questions (see SC/50/Rep4, item 7). Genetic sampling programmes should be initiated where needed, and maintained in areas where increased sample sizes are needed for statistical validity.

The Workshop agreed that high priority should be given to research that will lead directly to improved methods of reducing anthropogenic mortality (e.g. reducing ship strikes and fishing gear entanglements) for stocks for which there is

concern over their survival, and to research examining environmental factors that affect the fecundity and mortality rates of right whale populations (e.g. food limitation, pollution; see SC/50/Rep4, item 12). Such research should ultimately lead to improved recommendations for appropriate and effective management action. Comparative studies between stocks that are recovering and stocks that do not appear to be (see SC/50/Rep4, item 10) may be particularly valuable in this context. Studies that improve information on feeding grounds in the Southern Hemisphere will facilitate such comparisons.

From the genetic standpoint, two questions are of high priority:

(1) what are the implications of the low haplotype diversity detected in certain populations; and
(2) is the effective population size of right whales significantly lower than the abundance estimates?

Given these priorities, the Committee **recommends** that the Commission urges member governments to provide the necessary support, including funding, for the particular research items below.

(1) Continuation of existing programmes of photo-identification, surveys, etc. for assessing and monitoring population status and the establishment of new programmes; use of computerised techniques for matching photographs (Item 9.9.3) should be considered as appropriate.
(2) Processing and analysis of data collected under (1).
(3) Development of methodology and application of existing methodology for analysing survivorship and other biological parameters in northwest Atlantic right whales.
(4) Increased efforts to determine the recent population trajectory of the northwest Atlantic population, including, as a matter of urgency, use of more complex, including stochastic, models.
(5) Research to determine the current status of right whales in areas of the Southern Hemisphere which were historically important but for which there is no recent information.
(6) Investigation of two additional Antarctic data sets for trend analysis - JSV sightings data 1965/66-1981/82, and JARPA, 1987/88-present.
(7) Expansion of research efforts to improve understanding of the status of the North Pacific and eastern North Atlantic populations and any human-related problems they may have, including a further dedicated sightings survey in the Okhotsk Sea that follows the Committee's guidelines for surveys (IWC, 1997e).
(8) Comparative studies to try to determine factors to explain the difference between northern and southern hemisphere population reproductive parameters.
(9) Investigation of problems of stock structure, by ocean basin, i.e. for

Western North Atlantic: directed genetic sampling of females on the calving ground, any unsampled animals in Massachusetts Bay and the Great South Channel, and of 'Fundy-none' females; further examination of available information on mitochondrial DNA haplotypes of individual whales to test for heterogeneity in regional resighting probabilities, scarring patterns and reproductive success; acquisition of further historical samples for the central and eastern North Atlantic preferably prior to the nineteenth century;

North Pacific: further biopsy sampling in all regions; additional analysis of historical samples available in Japan;

Southern Hemisphere: additional genetic sampling to characterise regional relationships, particularly the calving grounds; sampling from feeding grounds for more reliable allocation of catches to calving stocks; collection of biopsy samples from vessels in programmes such as CCAMLR, SO-GLOBEC and BAS krill surveys; timely analysis of both extant and future biopsy samples including the large sample from South Africa; where possible, biopsy samples should be collected from a minimum of 20-50 individuals and in calving areas should be repeated in at least each of three consecutive years.

Although the results of the special meeting represented a major advance in understanding the status of right whales worldwide, the Committee noted that there were still a number of outstanding questions regarding the status of the population in the western North Atlantic. Although the population was known to be small (*ca* 300 individuals), and well below its unexploited size, its current dynamics were unclear. At the same time, it was subject to a range of anthropogenic threats, including ship strikes and fishery entanglements, some of which were proving fatal. The Committee therefore **recommends** that the western North Atlantic right whale should be a priority topic for next year's meeting, with the objectives being to establish the current status and dynamics of the population. A three-day intersessional workshop prior to next year's Scientific Committee meeting was proposed. A schedule and a budget that would allow for a number of invited participants to attend was developed by a steering committee established under Clapham (for members see Annex V).

The Committee noted that if it is judged that insufficient progress on required analyses has been made in advance of the special meeting for it to be held, they expected that at least relevant papers on progress to date would be submitted to next year's Scientific Committee meeting.

9.3 Southern Hemisphere humpback whales

9.3.1 Progress in catch and marking data coding

Allison reported that no catch data had been coded since the last meeting, and it appeared that most individual catch data available for southern humpback whales had been coded already. Coding of marking data for the 1930s is continuing.

9.3.2 Establishment of Southern Hemisphere directory and Antarctic catalogue

The Committee **recommends** that the IWC Secretariat continue with arrangements to create the directory of Southern Hemisphere humpback whale identification photographs, as recommended last year (IWC, 1998b).

Last year, the Committee had also recommended that Carlson be nominated and funded to undertake certain tasks related to the establishment of a centralised catalogue of humpback whale identification photographs from the Antarctic. Carlson reported that she had undertaken these tasks and had also approached the College of the Atlantic to determine whether they would be interested in taking on the responsibility for such a catalogue. Their specific proposal is contained in Appendix 4 of Annex E.

The Committee **recommends** that the Commission should proceed with arrangements for a contract to be drawn up with the College of the Atlantic to create an IWC Antarctic

catalogue of humpback whale photographs, provided that such a contract contains written specifications of (a) how the catalogue is to be made available to researchers, under what conditions and in what format, and (b) what protection will be afforded for the proprietary rights of any contributors to the catalogue. The Secretariat will negotiate these specifications in consultation with potential contributors.

9.3.3 Progress towards assessment

9.3.3.1 ABUNDANCE AND TRENDS

SC/50/CAWS8 analysed humpback whale sightings (548 primary sightings; 1,065 individuals) in Area IV during JARPA 1997/98. For the first time, humpback whales were the dominant species throughout the region surveyed by JARPA. Indices of abundance suggested an increasing density of humpback whales from 1989/90 to 1997/98.

The Committee was informed that it was unwise to calculate a rate of increase from the JARPA abundance indices at present because there may have been undersampling of high density areas. This problem has also arisen with minke whale abundance indices from the same surveys, and is the subject of a current IWC contract.

SC/50/CAWS16 presented an analysis of sightings results from Area IV during the 1995/96 summer. Sightings were made from the Australian ice-breaker *Aurora Australis,* which was carrying out a krill acoustic survey. Searching was in passing mode only, and data collection and analysis were in accord with standard double-platform line transect methodology. The estimate for humpback whales was 900, with a CV of 0.46. This estimate was significantly different in the strictly statistical sense from the estimate of 3,309 (CV 0.445) from the second set of circumpolar IDCR cruises (SC/50/CAWS37). A number of factors that might have combined to reduce the estimate of abundance were identified: different survey timing, 'additional variance', possibly lower $g(0)$, use of passing mode (which would have produced a tendency to underestimate group size), and particularly strict criteria in accepting a sighting as identified.

It was reported that future surveys would use 'big-eye' binoculars to improve species identification during passing mode. The utility of these estimates would be greatly improved if they could be incorporated with other data in a Generalised Linear Modelling (GLM) approach to obtain better estimates of population size and particularly trend. 'Additional variance' could be evaluated. The Committee **agrees** that the evaluation and comparison of such sightings data would be greatly facilitated if the distributions of both angles and radial distances to sightings were given. The Committee referred the issue of using such surveys to obtain estimates of trend to the workshop on Planning Joint GLOBEC/SOWER/CCAMLR Surveys (see Item 12.3.1).

During the 1997/98 summer, sightings surveys were carried out in the Antarctic Peninsula area from the Brazilian Antarctic supply ship *Ary Rongel,* using line transect methodology (SC/50/CAWS36). Densities of humpback whales were obtained and 54 individuals photo-identified (including one match between 27 January and 7 March, suggesting that some individuals might be resident for substantial periods during the summer).

An analysis of the sightings of humpback whales made on two and an incomplete third circumpolar IDCR/SOWER survey, covering the period 1978/79 to 1995/96 was considered (SC/50/CAWS37 and Appendix 5 of Annex E). Analytical details are considered in Annex E. The results indicated an increase from 7,500 humpback whales in the first set of surveys to 11,800 in the second set and 15,700 whales in the third (as yet incomplete) set of surveys.

The Committee noted that conclusions on possible rates of increase should not be based on comparisons by Area, as these estimates had large CVs and were subject to possible additional variance due to inter-survey shifts in distribution. Estimates based on sets of circumpolar surveys were more reliable, but CVs for the estimates in Appendix 5 of Annex E had not yet been calculated, and it was not considered appropriate to use them for estimating rates of increase as yet. Additional variance, such as the effects of high-ice/low-ice years, could be taken into account, possibly using a GLM approach, and this might bring the associated CVs down.

It was noted that future analyses of the IDCR/SOWER data for humpback whales should take into account the new feeding ground on the borders of Areas II and III.

SC/50/CAWS25 was prepared in response to a recommendation last year. Catches of humpback whales by modern whaling in the Southern Hemisphere were reviewed, along with the number of catcher vessels operating in each of a number of whaling grounds. Data were obtained from both published and unpublished sources, but did not include the undeclared catches of humpback whales by either the Soviet fleets or the *Olympic Challenger.* Crude catch per unit effort (CPUE) indices were calculated as annual catch per catcher vessel for each ground. Most grounds showed marked declines in the initial 10 years of whaling followed by either (1) closure of the ground, with some subsequent recovery of the stock, or (2) low catches until the cessation of humpback whaling in October 1963. Estimates of abundance and population trends from after 1963 show Southern Hemisphere populations to be undergoing some recovery in all areas where surveys have been undertaken.

Last year the Committee agreed on a number of options for dividing feeding ground catches into putative breeding 'stocks' (IWC, 1998c, fig.1) and for allocating high latitude catches to them; no changes to the stock division were proposed. The Committee accepted the following plan of action for a preliminary assessment next year.

Modelling of the pre-exploitation size of stocks will be carried out as recently done for southern right whales (SC/50/Rep4). The population model used in the *Catch Limit Algorithm* of the RMP (IWC, 1993b) will be run for stocks where some recent population estimates have been determined (stocks C, D and the east Australian component of stock E). Low latitude catches of humpback whales reported in SC/50/CAWS25 can be assigned to these stocks except for those from the Kerguelen Islands. For the purposes of these analyses the undeclared Soviet catches for which no catch position data are available will be assigned on a pro rata basis. Catches from Kerguelen will be equally divided between C and D. Initial declines from the model can be compared with the CPUE indices in SC/50/CAWS25. These analyses are intended as preliminary; both the population model used and options for allocating catches can be refined in the light of initial results obtained. An intersessional working group under Best (see Annex V) was established to progress the work before the next meeting.

9.3.3.2 STOCK STRUCTURE

Two genetic papers were considered. In Baker and Medrano-Gonzalez (1998) the distribution and worldwide diversity of humpback whale mtDNA lineages was described. Differentiation of mtDNA lineages was weakest

(although statistically significant) among the four wintering grounds of the Southern Hemisphere. A phylogenetic reconstruction of the control region sequences suggested that each ocean is dominated by one clade. In the North Pacific and North Atlantic, a secondary clade seems to be the result of gene flow from the Southern Hemisphere. Only the Southern Hemisphere includes lineages from all three clades.

SC/50/CAWS35 presented a preliminary analysis of mtDNA variation and geographic structure of humpback whales from several wintering grounds. A hierarchical analysis of molecular variance (AMOVA) also showed significant differences among four historical stocks or whaling management areas. However, an analysis of haplotype frequencies was not significant for stocks ($p = 0.059$), but showed more differences between pair-wise comparisons of wintering regions. Most pair-wise comparisons between wintering grounds were consistent with geographic distance or stock divisions in the haplotype analysis. Notable exceptions were the absence of difference between Madagascar and Western Australia, and the absence of difference between both these regions and New Caledonia. Further analysis of a larger dataset is planned.

Some of the apparent inconsistencies in the results can probably be explained by inadequate sample size. The high degree of variation suggests that large sample sizes are needed to obtain adequate resolution. A larger segment of the control region may need to be analysed, and the possibility of inadvertent resampling of individuals on breeding grounds should be investigated. The need to use a number of statistical techniques to analyse such data was stressed, because reliance on only one model might produce misleading results.

More genetic samples from both sides of the South Atlantic and from feeding areas are required. A total of 88 samples from humpback whales in the Antarctic are now available from JARPA, most of which have been analysed (SC/50/O3), and an additional 10 biopsies had been collected from 10 humpback whales during the 1997/98 SOWER cruise (SC/50/Rep1).

In November 1997, 43 sightings of 72 humpback whales had been made in 22 days during a seismic survey offshore from Oman (SC/50/CAWS21). Available data support the hypothesis that these whales are resident year-round in the northwest Indian Ocean, although their abundance off the coast of Oman appears to decline in summer. The recent status of the species in the area, following the Soviet catch in 1966, was in doubt.

The Committee **recommends** that dedicated surveys should be carried out to establish the status of humpback whales in the northwest Indian Ocean, and that these should include the collection of biopsy material from which the genetic relationships of this interesting stock could be investigated.

9.3.3.3 FURTHER INFORMATION ON CATCHES

SC/50/O18 detailed several previously unreported mark recoveries from the Soviet factory ship *Slava* in the Southern Hemisphere. From 1955-66, 51 recoveries (25 humpbacks) had been found: only six of the humpback records had been reported previously. These are probably only a small fraction of the number of recoveries actually made. The need to obtain further information on mark recoveries and marks fired under the Soviet scheme (of which Mikhalev had access to about 1,000) was stressed. The Committee thanked Mikhalev for his efforts, and **urged** him and his colleagues to continue their invaluable work in retrieving catch and marking data from previous Soviet whaling operations.

Borodin requested that the following statement appear in the report. 'For the last few years (IWC, 1997b, p.82; IWC, 1997c, pp.137-8; IWC, 1998b, p.77) 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 again our statement and the need for it to be included in reports.'

SC/50/CAWS30 was a response to a request last year for information on Brazilian whaling. Whaling had started in 1602 and continued up to the end of the 19th and into the beginning of the 20th century. Species were usually not reported, but descriptions and circumstantial evidence suggest that the catch was mainly right whales. No complete catch series exists but Ellis (1969) estimated that at least 2,664 whales were taken between 1761 and 1819. This contrasts markedly with Richards' (1993) estimate of 14,904 right whales killed by shore stations from 1772 to 1814. This is probably due to an under-representation of shore stations in Ellis (1969). Only three humpback whales are known to have been taken, in 1801. Modern whaling in Brazil started in 1910 and continued (intermittently) until 1974. Although catch statistics are not always complete, and sometimes contradictory, at least 1,334 humpback whales were taken between 1910 and 1963. SC/50/CAWS30 does not include catches from a Brazilian open-boat fishery taking humpback whales because no records were found in the archives of government departments in Brazil. The original source of the information (mentioned in Tonnessen and Johnsen, 1982) should be consulted.

9.3.4 Future special meeting

The Committee noted progress in a number of areas in the assessment of Southern Hemisphere humpback whale stocks, as reported above. While work is still required to complete many of those tasks, it noted that little or no action has yet been possible, given the short interval between the annual meetings and for other reasons, on a number of other tasks recommended last year.

(i) *Acquisition and entry of revised Soviet catch data* (Item 9.3.1) - Secretariat - no new data have been acquired.
(ii) *Investigation of the availability of original Soviet scheme marking data* (Item 9.3.3.3) - Secretariat - ongoing.
(iii) *Creation and maintenance of a centralised directory of Southern Hemisphere humpback whale photo-identification catalogues* (Item 9.3.2) - Secretariat - action required.
(iv) *Collection of biopsy samples from three main strata: breeding ground, feeding ground, migratory corridor* (Item 9.3.3.2) - national groups - some action.
(v) *Monitoring of abundance to continue or be initiated where no survey programme exists* (Item 9.3.3.1) - national groups - new survey data have been reported this year.
(vi) *Inclusion of humpback whales as targets for biopsy and photo-identification in future Antarctic survey expeditions in the South Georgia region* (Item 9.3.3) - national groups - no action reported.

(vii) *Researchers in photo-identification programmes to evaluate the likelihood of obtaining estimates of biological parameters* (Item 9.3.3) - national groups/individual scientists - no results reported.
(viii) *Comparison of currently observed increase rates to be considered in conjunction with a review of demographic parameters for Southern Hemisphere humpbacks and a comparison with information on increase rates and demographic parameters for North Atlantic and (North Pacific) populations* (Item 9.3.3) – Scientific Committee - no action.
(ix) *Progress report on retrieval of detailed Soviet catch data* (Item 9.3.3.3) - relevant scientists - no action reported.

The Committee established an intersessional working group under Clapham to consider (viii) (see Annex V).

As regards (vii), the Committee felt that the most appropriate approach would be to encourage individual members to consult with researchers concerned with photo-identification on humpback whales in their region for this information.

In light of these outstanding matters requiring action the Committee **agrees** that it would be in a better position at next year's meeting to decide when a Comprehensive Assessment might occur. Experience gained during the preliminary assessment to be considered at that meeting should also assist in identifying important issues to be settled before the Comprehensive Assessment could take place.

9.4 North Atlantic humpback whales

The Committee received an update on the status of information on the North Atlantic humpback whale (Annex E, Appendix 6). Considerable progress had been made, including papers published, in press or in preparation on abundance, trends, population structure, migration and breeding grounds, and catch data. The most important papers from the YONAH project are expected to be available by the end of 1998. Many other analyses are substantially developed, but the likely time frame of their availability is unclear; these include some critical areas such as analyses of trends in abundance and clarification of population structure, especially as it refers to specific breeding grounds. It was stressed that while every effort would be made to construct as comprehensive a catch history for the North Atlantic as possible, it was likely that the total catch will never be known completely, and this would constrain what could or could not be done in the comprehensive assessment.

Apart from an incomplete catch history, two main gaps for an assessment were identified: (1) lack of information on the distribution and abundance of humpback whales in the southeast Caribbean (Windward Islands) and off the Cape Verde Islands, and (2) their relationship to humpback whales in the rest of the North Atlantic. In regards to the former, SC/50/CAWS28 summarised individual identification photographs available for nine humpback whales from the eastern Caribbean. These photographs were compared to the approximately 5,000 animals in the North Atlantic humpback whale catalogue and the approximately 3,000 individuals in the YONAH catalogue. Two of the nine had been matched, one with Puerto Rico and the other with Newfoundland, while there was a third possible resighting in Greenland. The sample was too small and spatially and temporally diffuse to draw any meaningful conclusions; further photographs, biopsy samples and song recordings were required to address these questions.

SC/50/CAWS11 summarised information on the status and stock origin of humpback whales in the Windward Islands (the area in which subsistence hunting occurs, see Item 11.5). Densities appear low, although it was a principal whaling ground in the 19th century. The apparent failure to recover in this region raises the questions about the location of the feeding grounds for these whales and their relationship with whales that use the breeding range to the north. The author proposed a number of research items to examine the question (Annex E, Item 7.1).

The Committee believed that such a research programme would have a greater chance of success if it was carried out in cooperation with regional governments.

Acoustic data from the SOSUS fixed hydrophone arrays collected since 1993 revealed that detection rates for singing humpback whales in the southeast Caribbean in winter were about one-third to one-half of those in the high density areas. Recent Hawaiian fieldwork combining visual and acoustic methods showed that it was possible to locate individual singers acoustically out to 5-6 n.miles, and then to direct a boat with a GPS to the whale so that it could be photographed and biopsied on surfacing. This technique might be especially useful in low density areas such as the southeast Caribbean.

In regard to the situation of the Cape Verde wintering ground, or the eastern North Atlantic stock, SOSUS data collected since 1996 suggested the presence of an eastern component. Singing humpback whales could be heard in the Norwegian Sea in winter, while others proceeded south past Ireland towards Spain. The number of animals involved was small, in the tens per day. The Committee noted that this remnant population remained uncharacterised by photo-identification or genetic information. The possibility of further research was being considered, including a logbook survey in the Cape Verde Islands and an integration of all published information on humpback whales in the eastern North Atlantic as a whole.

The Committee encouraged these initiatives. It **recommends** that the possibility of collaborative research on humpback whales in the southeast Caribbean be explored with national authorities in the area, and the use of combined acoustic and visual methods be investigated to facilitate the collection of abundance and individual identification data.

Given the progress noted above, and the likely time frame for the availability of other analyses, the Committee **recommends** that a Comprehensive Assessment of North Atlantic humpback whales be carried out in 2000. Since this population is subject to a small aboriginal take at Bequia in the West Indies and has in the recent past been subject to an aboriginal hunt in Greenland, there is justification in giving the Comprehensive Assessment of this stock priority over other humpback whale stocks.

9.5 North Pacific humpback whales

SC/50/CAWS31 provided a summary of the status of the North Pacific Humpback Whale Fluke Catalogue maintained by the National Marine Mammal Laboratory, Seattle. It contains over 24,000 photographs and 1,010 resights of individual whales from at least a 5-year period have been found, with resights spanning 20 years. The catalogue is being used to examine calf mortality and average reproductive interval.

Calambokidis *et al.* (1997, cited in Annex E, Item 8) provide mark-recapture for North Pacific humpback whales from the years 1991-1993. The paper itself was not available to the Committee. Although the results are accompanied by caveats, the authors present an estimate for the whole North

Pacific between 1991 and 1993 of approximately 6,000, considerably higher than those previously received by the Committee.

The Committee **encourages** the submission of papers or reports on the above work when it next considers this population.

9.6 Sperm whales

9.6.1 Report of the intersessional group

The Committee received the report of the intersessional sperm whale group set up at last year's meeting to review plans for a Comprehensive Assessment of sperm whales (Annex E, Appendix 7). The group recommended starting with a focus on North Pacific sperm whales. The following studies were proposed:

(a) a review of mark-recapture data and joint US-Japanese genetic studies;
(b) a preliminary abundance estimate for the western North Pacific, based on sightings;
(c) a review of past abundance estimates and models;
(d) a review of historical catch data;
(e) a review of sperm whale regulation in the North Pacific;
(f) life history, social behaviour, ecosystem considerations and current anthropogenic mortality.

9.6.2 Action arising

A number of papers relevant to the studies recommended in the report of the intersessional group were presented.

SC/50/CAWS9 gave estimates of current abundance and distribution of large male sperm whales in Antarctic Areas IV and V using sightings data from JARPA surveys, 1989/90 to 1995/96. These covered the area from 60°S to the ice edge and from 70°E to 170°W. Sperm whales were widely distributed each year, with a high density area from 70°E to 100°E, and they were rarely found within Prydz Bay and the Ross Sea. Abundance estimates for sperm whales in Area IV ranged from 2,946 to 4,289 and for Area V from 2,207 to 3,146 animals. These results are consistent with those from the second and third IDCR/SOWER Antarctic circumpolar surveys. Estimates of abundance were roughly tripled by correcting for animals missed on the trackline using a $g(0)$ value of 0.32 from simulation studies by Kasamatsu and Joyce (1995).

SC/50/CAWS37 analysed IDCR/SOWER sperm whale sightings between 1978/79 and 1995/96, the first, second and third (incomplete) circumpolar sets of surveys. The estimated effective search half width was different for the first set of surveys, from the latter two, for unknown reasons. Annex E, Appendix 5 updated these estimates to take into account the different area coverage between circumpolar sets and produced corrected values of 7,900 (first circumpolar) 13,000 (second) and 14,300 (third, incomplete) whales respectively. These estimates could be considered negatively biased since they only represented large males and also assumed that $g(0)$ was 1.0. The apparent increasing trend was noted, but caution was expressed over its interpretation.

The Committee agreed that although it was highly unlikely that $g(0)$ for sperm whales was 1.0 given their diving behaviour, it was not appropriate to adopt a lower value until the assumptions behind its calculation had been thoroughly examined. It was also probably not advisable to apply a $g(0)$ estimate from one geographical region to the species as a whole. These papers had illustrated two general problems with sightings surveys of sperm whales: the value of $g(0)$ and segregation by sex and size class of the species. A further difficulty noted was the estimation of mean school size, especially where there was a loose association of individuals/pods.

SC/50/CAWS2 responded to a request of the intersessional group to analyse sightings data obtained from Japanese sighting vessels in the North Pacific between 1982 and 1996 (1,412 sightings of 5,310 sperm whales). If analysis was confined to the area 20°-50°N, 130°E-180°, and if data for 1994 and 1996 were excluded because of low effort, a significant rate of increase (11% a year) was obtained. A line transect estimate for the western North Pacific, uncorrected for $g(0)$ or loose associations of single animals, was 25,816 (CV 0.11). A correction for association increased the estimate to 32,676. This is still negatively biased without a correction for $g(0)$.

SC/50/CAWS20 described a combined visual and acoustic survey for sperm whales conducted in the eastern temperate North Pacific between March and June 1997. A total of 60 acoustic detections was made using a towed hydrophone array during 14,500km of searching. Visual survey was carried out for 8,080km, resulting in eight sightings (excluding those originally detected acoustically). The estimate of $f(0)$ used in the visually-based estimate of abundance was based on sightings from previous surveys in the area. The small number of sightings precluded integration of the visual and acoustic data. The acoustically-based estimate of 39,200 (CV 0.60) sperm whales was not significantly different from the visual estimate (assuming $g(0) = 0.87$) of 24,000 (CV 0.46) whales. Acoustic techniques increased the number of sperm whales detected by increasing the range of detection and allowing night survey, but could not replace visual methods for estimating group size.

In discussion, acoustic estimation of school size was considered. Gillespie (1997) described a computer programme for separating vocalisations from individual sperm whales, allowing the number of vocalising whales to be counted. Alternative methods using estimated click rates per individual also exist. Despite identified possible difficulties, the Committee recognised the potential value of acoustic techniques in estimating sperm whale abundance and **recommends** that researchers cooperate and integrate their results to the greatest extent possible; it **encourages** the submission of further papers on the topic to future meetings.

SC/50/CAWS39, Childerhouse and Dawson (1996) and Childerhouse *et al.* (1995) described research on sperm whales at Kaikoura, New Zealand. Mark-recapture (photo-identification) and acoustic surveys were used to study distribution and abundance. Almost all sperm whales encountered are single males, and all can be photographically identified. Of 135 identified individuals, about half are seen repeatedly; the other half apparently transited through the area and have only been seen in one season. Mark-recapture models will be developed to take account of this population structure.

Acoustic surveys off Kaikoura have used directional and omnidirectional hydrophones. This work can be used to complement, or as an alternative to, the towed hydrophone array methods described in SC/50/CAWS20. Directional hydrophones are used from small vessels, thereby allowing small-scale work on distribution, abundance and movements and the tracking of individuals to study diving and acoustic behaviour. A computer program has been developed to count the number of clicks in a sperm whale recording. Work is continuing to calibrate and ground-truth acoustic surveys by

recording individual whales for complete dive cycles, estimating the click rate per individual, and estimating the range of the hydrophones.

On the subject of photo-identification, the Committee stressed the importance of evaluating photographs separately and quantitatively for quality and distinctiveness. It was suggested that a compilation of photo-identification efforts on sperm whales should be considered, and this was referred to the ongoing intersessional group.

It was agreed that a major topic of the Comprehensive Assessment should be a discussion of the best method of assessing sperm whale abundance.

SC/50/CAWS19 provided a progress report on genetic data for North Pacific sperm whales. The mtDNA control region and six microsatellites were being investigated in historical samples from the Japanese whaling industry and in contemporary samples, for example from biopsies and strandings. Analyses at La Jolla, are concentrating on the eastern North Pacific. Preliminary results indicate a clear subdivision between samples taken within about 300km of the coast and those offshore as far east as Hawaii. However caution is required as the offshore samples were collected 20 years earlier than the coastal samples, and nuclear gene frequencies may change quite rapidly given sperm whale social structure and the likely effects of relative male depletion. A number of recommendations for future work were made in the report (see Annex E).

The Committee **recommends** that the use of sperm whale teeth for genetic analysis be examined further, and that the collection of material from mass strandings of sperm whales be strongly encouraged.

SC/50/CAWS40 described Soviet catching of sperm whales in the Arabian Sea and biological information from the catch. Two Soviet expeditions took a total of 954 sperm whales including 750 females over four seasons (1963-66), but only reported a catch of 424 whales including 75 females to the Bureau of International Whaling Statistics (BIWS). Evidence was presented that this population was separated from the rest of the Indian Ocean. Although extensive marking of sperm whales had occurred in the area, there had been no recoveries in the data available to the author. Little biological material remained from these catches.

Yagi referred to his earlier comment on the accuracy of such data (see Item 4.3.2).

SC/50/CAWS27 summarised information on USSR pelagic catches of sperm whales in the North Pacific between 1949 and 1979. Yearly fleet summaries for some seasons were provided by the late Dr A.A. Berzin to the authors, relating to the period 1963-79. A comparison with official catch statistics submitted to BIWS by the Soviet authorities revealed serious inconsistencies. The total USSR catches for six years (1966, 1967, 1970, 1971, 1972 and 1973), for instance, were officially declared as 37,275 whales, whereas the Berzin data indicated 66,950 sperm whales, with the female catch for the first four years 9.6 times greater than the official records. The authors believed that similar under-reporting of sperm whale catches occurred on other Soviet whaling expeditions in the North Pacific, at least until 1972, when the International Observer Scheme (IOS) came into effect. They estimated that about 180,000 sperm whales may have been taken by Soviet whaling expeditions between 1949 and 1979, or about 60% higher than the officially reported catch.

In discussion, it was noted that some under-reporting may have continued even after the IOS was introduced. There was no information on the locations of the undeclared catches or on the availability of biological data.

SC/50/CAWS12 reviewed the history of Japanese regulatory measures for sperm whaling in the North Pacific. Regulatory measures were introduced as early as 1909, and included, in turn, limitations on effort, catch (by whaling classification), minimum (and later maximum) size, catch of lactating females, season, and whaling ground. The Committee welcomed this paper, and **recommends** to the Commission that member nations be urged to supply similar compilations of their regulations and restrictions (including enforcement) governing the taking of sperm whales, especially as they concern the period prior to the adoption of international regulations on sperm whaling.

SC/50/CAWS10 reported that there was evidence of statistical manipulation in the Japanese coastal sperm whale fishery. Official length composition data frequently featured an unrealistically large number of individuals at or just above the minimum length, and the sex-ratio in samples of whales examined by biologists differed greatly from that in the official statistics, with females being markedly under-represented in the latter in ten seasons between 1959 and 1985. Two catcher-boat logs examined differed from official figures for the numbers of whales killed by the company concerned. The author concluded that the extent of such discrepancies was probably sufficient to render the catch statistics from coastal sperm whaling unreliable for the purposes of the comprehensive assessment. He stressed the need for further effort to discover independent sources of statistical information.

In discussion, some members recalled that other papers had suggested that there were suspicions about the validity of some aspects of Japanese land station data for sperm whales (see Balcomb and Goebel, 1977; Allen, 1980; Cooke *et al.*, 1983; Kasuya and Miyashita, 1988; Kasuya, 1995; and Brownell and Balcomb, 1998).

Some members of the Committee were not convinced that the information provided in SC/50/CAWS10 was any more reliable than the official statistics or that it represented the whole time series of catches. At this stage they considered that it was essential that these allegations should be thoroughly investigated before any conclusions were drawn. Nevertheless, other members welcomed this report. Ohsumi pointed out that some features of the official statistics were similar to those seen in statistics of other nations taking sperm whales, and that for the purposes of the Comprehensive Assessment it was necessary to recognise when such data were inaccurate and to make appropriate adjustments. A number of speakers agreed that if there was to be progress with the Comprehensive Assessment of this stock, then efforts should be directed at attempting to compile as accurate a catch series as possible. If exact figures could not be found, then realistic upper bounds should be sought to express the range of uncertainty. It had been intended that an intersessional correspondence group should be established to work towards developing a suitable catch series. The members of the group (Ohsumi, Brownell, Kasuya) were unable to reach consensus on items 1-3 of the 6 terms of reference proposed by the Chairman of the Group (Ohsumi; see Annex O). The Committee therefore agreed not to re-establish a group at this time.

There was considerable discussion on the issue of the reliability of whaling statistics. Best (1989) had commented on a number of potential problems in BIWS records from his experience with the whaling industry from 1957/58 to 1978/79. Two types of problem were identified: those that were evident from close inspection of the data (e.g. stretching of whale lengths, rounding errors in foetal lengths, unreliable stomach contents) and those that were not (e.g.

under-reporting of catches, incorrect species identification). Best (1989) also referred to two cases of under-reporting where the USSR had not reported catches of humpback and right whales (Chittleborough, 1965; Best, 1988). At that time, the Committee had stated (IWC, 1989) that

> Users of the data base should be made aware of such problems, and it was suggested that others familiar with the data collection process for their national industry (or that of another region) should be encouraged to provide specific information as had been done in SC/40/O 20 [i.e. Best, 1989].

The database referred to is the IWC catch database held by the Secretariat.

Subsequently, evidence of a major falsification of Soviet catch records has emerged (Yablokov, 1994; Zemsky *et al.*, 1995b;) and a review of the true USSR Southern Hemisphere pelagic records was presented to the Committee in 1994 (Zemsky *et al.*, 1995a; b). At that time the Committee (IWC, 1995b, pp.62-3)

> expressed its appreciation for the efforts of Zemsky and his colleagues in locating and securing these extremely important records that go back for many decades

and

> encouraged the Russian scientists to provide the Commission with a report that provides the general background to the Soviet whaling operations and the revised catch statistics.

At this year's meeting a number of papers presenting new information on falsified sperm whale catch records were discussed (SC/50/CAWS27, 40, 10 – see above). Under Item 4.2 the Committee agreed that the official Soviet Southern Hemisphere catches should be removed from the IWC database.

After considerable discussion, two views on how to address this issue emerged.

(1) Some members believed that the Committee should repeat its suggestion of 1988 (given above) with respect to the provision of information similar to that given in Best (1989). They added that although such information should, where possible, be quantitative and if possible identify sources, even data in a less specific form could be useful for evaluating catch series. They noted that there were circumstances in which it would be unreasonable for the names and primary sources to be made openly available because of possible negative consequences for the individuals providing the information.
(2) Other members strongly opposed such an approach, stating that it was inappropriate for the Committee to encourage individuals from a member nation to report alleged infractions by that nation to the Commission. They stated that such allegations should, along with the primary data, first be submitted to the member government concerned, so that an independent and official investigation of the allegations could be undertaken.

Despite this disagreement, the whole Committee **agrees** to request the Commission again, as they had in IWC Resolution/ 1994-6 (IWC, 1995a), to invite member governments to examine data on their past whaling operations for inaccuracies or falsification, and provide any revised data to the Commission.

The Committee **agrees** that work should continue on resolving questions regarding the catch history since catch data that were as accurate as possible would be needed for the eventual assessment.

Considering the many difficult tasks that must be completed before a Comprehensive Assessment of the North Pacific sperm whale stock will be possible, the Committee agreed to consider sperm whales next in 2000 (abundance estimation methods) and 2001 (stock structure).

9.7 Southern Hemisphere minke whales

Appendix 8 of Annex E describes progress on work to address outstanding issues regarding JARPA that had been raised at last year's meeting. This included developing methods to correct bias in abundance estimates, stock definition, statistical analysis of mtDNA, a pilot study on nuclear DNA, availability of low-latitude genetic material, analysis of morphometrics, examination of stock boundaries between Areas IV and V, a segregation study, recalculations of biological parameters by biological stock, a mesoscale survey plan for ecosystem and environmental change. In addition, the Committee had discussed the availability of samples from past commercial whaling for stock identification analysis and the problem of representativeness of samples. Although the interval since the last meeting had been unusually short, the Committee found it helpful to receive the progress report, and looked forward to more detailed responses at its next meeting.

The Committee received SC/50/Rep1, the Cruise Report of the 1997/98 SOWER Antarctic Cruise in Area IIW (60-30°W, S of 60°S). Japan had supplied two research vessels and for the first time four researchers were carried on each. A total of 200 primary sightings of 422 minke whales was made in about 3,000 n.miles searched. Survey coverage was affected by the ice edge. A large (approximately 100,000 n.mile^2) area of open water in the southern Weddell Sea which the survey vessels could not enter because of an ice barrier might explain the fewer than expected number of minke whales seen.

The Committee expressed its thanks to the Japanese Government for the generous provision of these vessels for both this cruise and the SOWER blue whale cruise, and to the participating researchers for their efforts.

SC/50/CAWS8 reported on the 1997/98 JARPA survey which had been conducted in Area IV and the eastern part of Area III. One dedicated sighting vessel and three sighting/sampling vessels were engaged in a closing mode sightings survey. The sighting vessel covered 5,136 n.miles and made 127 primary sightings of 243 minke whales, while the three sighting/sampling vessels searched a total of 16,462 n.miles and made 545 primary sightings of 1,130 minke whales; 438 whales were sampled. The proportion of sexually mature animals was very low amongst the females (22.7%) in Area IV, and immature females dominated in the southern stratum. It was suspected that most of the mature females had moved into ice-free waters inside the pack ice edge where the research vessel could not enter. It was suggested that one of the probable reasons for the character of the present survey results was the different shape of the ice edge.

In discussion, the question of the implications of the apparent environmental effect on the observed maturity rate in females was raised, particularly as it related to the success of the JARPA programme in obtaining representative samples. Nishiwaki replied that it was not known whether the trend would continue, and further study was needed to compare the data with previous results.

Field characters for distinguishing between the two forms of southern minke whale were described and illustrated in SC/50/CAWS15. This was important if abundance estimates from sightings surveys were to be correctly allocated.

The results of RFLP analysis of the mitochondrial DNA in minke whales from Areas V and VI sampled during the 1996/97 JARPA survey were presented in SC/50/CAWS4. Samples were divided into three longitudinal sectors and two time periods. A total of 361 whales was examined (VW late $n=98$; VE early $n=67$; VE late $n=105$; VIW early $n=91$). For comparison the group VIW early of the 1985/86 commercial season was used ($n=134$). Quantification of the mtDNA differentiation among area/time groups was carried out using the Analysis of Molecular Variance (AMOVA). No significant differences were found among the area/time groups of the 1996/97 survey. The combined sample of the 1996/97 survey showed significant differences from a standard sample of the 'western stock' but not from a sample of the 'core stock'. The same results were found when each of the area/time groups of the 1996/97 survey and the group VIW early 1985/86 were compared with the standard samples. A comparison between survey seasons for different area/time groups suggested that yearly variation seems to occur in Area IIIE and Area IVW.

The Committee noted that this study confirmed that the 'western' stock was different from the others studied, which were all similar.

A preliminary examination of mitochondrial DNA heterogeneity in Antarctic minke whales considering temporal, longitudinal and latitudinal (distance from the ice-edge) factors was presented in SC/50/CAWS7. A total of 563 samples from Area IV taken during the 1989/90 and 1991/92 JARPA surveys was used in the exercise. AMOVA was used to test for (a) the latitudinal factor in total Area IV (dividing offshore and ice-edge samples by a line at 60 miles from the ice-edge), (b) the longitudinal (Area IV western and eastern) and latitudinal factors, and (c) for latitudinal, longitudinal and temporal (early and late period in the survey season) factors. The only source of mtDNA heterogeneity was attributed to minke whales from the western part of Area IV taken in offshore areas in the early period of the survey season.

The Committee noted that this study concluded that the differences in the 'western' stock were attributable to an early, offshore component, and that because the commercial catch had been mainly near the ice edge, the analysis of past commercial catches would not be particularly useful for stock identification.

SC/50/CAWS32 examined VPA analyses of Southern Hemisphere minke whales in Areas IV and V by Butterworth *et al.* (1999). The authors had concluded that there was an increasing trend in recruitment in this stock prior to the period of exploitation. SC/50/CAWS32 investigated the effect of changing two key assumptions in the VPA formulation of Butterworth *et al.* (1999), those concerning selectivity and separability among the older age classes during the period of the commercial catches. The investigation was carried out by replacing these assumptions with the assumption that there was no temporal trend in recruitment prior to exploitation, and by examining whether the data on current abundance could be fitted under this assumption and whether the resulting apparent selectivities for the commercial catches were plausible. If the assumption of no temporal trend proved to be inconsistent with current abundance data or if it led to implausible selectivity curves, this would support the conclusions of Butterworth *et al.* (1999).

SC/50/CAWS32 concluded that constant pre-exploitation recruitment was consistent with the basic input data and population dynamics model of Butterworth *et al.* (1999). A lack of pre-exploitation recruitment trend implied a dome-shaped selectivity curve for the commercial catches with a decrease after age 17-26. The results of Butterworth *et al.* (1999) also implied a dome shape and a decrease in catch at older ages. However, the peak in the selectivity curves occurred at somewhat older ages (23-29). SC/50/CAWS32 discussed factors affecting realized selectivities that could have led to the estimated selectivity curves. These included the possibility that older animals found refuge in portions of Areas IV and V where there was little whaling effort or in the pack ice where whalers could not follow.

SC/50/CAWS32 also concluded that the VPA modelling framework, by itself and given the available data, appeared unable to resolve the issue of the pre-exploitation trends in recruitment. The estimates were critically dependent upon assumptions either about trends in past recruitment or selectivities and separability in the commercial catch. Within the VPA context, a resolution would require convincing external evidence favouring a specific selectivity pattern. Polacheck suggested that a way forward would be a more detailed examination of the spatial/temporal pattern of the age composition data from the catches than had yet been carried out and more complete tests of sensitivity to assumptions than were reported in Butterworth *et al.* (1999).

Butterworth responded that the selectivity assumptions in Butterworth *et al.* (1999) had been motivated on two independent grounds, biological and statistical. On the biological front, increasing selectivity with age was suggested by the whalers' desire to take larger, hence older, animals and the fact that whaling took place close to the ice edge where older animals tended to predominate. He drew attention to table 4 of Butterworth *et al.* (1999), which showed an increasing trend in the age of animals caught in Area IV by degree latitude from 61º to 66ºS. He noted, in response to suggestions in SC/50/CAWS32, that differential male/female availability might be confounding the results, and that Butterworth *et al.* (1999) had shown that key results were essentially unchanged when analyses were conducted on a sex-disaggregated basis. He considered that the possibilities suggested by Polacheck to explain the age-selectivity curves resulting from the assumption of no trend in recruitment prior to exploitation were inadequate to explain the large fraction of otherwise takeable whales implied to be unavailable by these curves.

On the statistical front, Butterworth noted that the conclusions of Butterworth *et al.* (1999) regarding the historic increase in recruitment were unchanged when the slope of the commercial selectivity at age from ages 22 to 30 was treated as an estimable parameter. He agreed with Polacheck that this analysis was conditional on the assumption that the maximum in commercial selectivity with age would occur beyond age 21. He believed that other runs of the model, not reported in the analysis, had led to rejection of alternative assumptions regarding that maximum age on the basis of likelihood ratio tests. However, the relevant outputs would have to be checked, and that was not possible in the time available at this meeting. Furthermore, the analyses of SC/50/CAWS32 made no allowance for any pattern in selectivity in the commercial catch as is conventional in the application of VPA to fisheries, and hence ignored the information content of these data with respect to the historic recruitment trend.

Hatanaka noted that the low selectivity for older ages in SC/50/CAWS32 is inconsistent with the actual situation. He anticipated that these analyses using age data can elucidate the real trend of recruitment, and emphasised that such valuable data are obtained only by lethal sampling.

Ohsumi noted that the assumption of SC/50/CAWS32 that there was no temporal trend in recruitment prior to exploitation was contradicted not only by the analyses of Butterworth *et al.* (1999) but also by analyses of Kato (1987), Kato and Sakuramoto (1991), Thomson *et al.* (1997) and Butterworth *et al.* (1997), that showed a decline in age at sexual maturity, and by anecdotal reports from whalers. Polacheck reiterated that his results do not indicate that there was no trend but rather that the VPA modelling framework without selectivity assumptions similar to those in Butterworth *et al.* (1999) is unable to resolve the question. He noted that if data on encounter rates over time were available, an analysis incorporating these data into the VPA framework might provide evidence for a trend. Polacheck also noted that the same data used in Butterworth *et al.* (1999) to indicate a latitudinal trend in age near the ice edge also showed as high a mean age between 59° and 61°S as at the ice edge. Polacheck further noted that the role of and dependence on the selectivity assumptions in Butterworth *et al.* (1999) were substantially different from those in most conventional fisheries applications. This is because of the low cumulative fishing mortality rates and the small amount of external information available for fitting the VPA model in this case.

Smith noted that new information presented under Item 10.1 of Annex E supported the possibility of animals being south of the pack ice edge. Large areas of open water existed during the periods of the SOWER and JARPA surveys, unavailable for sampling. He also noted that the factory vessels apparently tended to be 5-20 n.miles north of the ice edge. Thus the possibility of age selectivity within 60 n.miles of the ice edge needed to be further explored. This general issue also raises the possibility that JARPA age samples are not representative for older animals, as has previously been shown for younger animals.

The Committee agreed that, although some analyses of age and sex distributions of minke whales as a function of latitude had been conducted, the accumulating JARPA data permitted the examination of age and sex gradients approaching the ice edge on a finer scale (e.g. within 60 n.miles) than had been undertaken so far. Longitudinal effects in these distributions could also be further examined. It was agreed that conducting such analyses should be added to the list of tasks identified for JARPA. The analyses might shed some light on what assumptions regarding selectivity of the commercial catch are most reasonable.

The Committee also agreed that additional sensitivity tests encompassing a wide range of selectivity patterns might help to resolve this issue. Since there was no time to complete and consider them, the Committee was unable to reach agreement on whether or not the selectivity assumptions of Butterworth *et al.* (1999) were supported.

The Committee therefore **recommends** that (a) age and sex distributions as a function of latitude and longitude on a fine scale and (b) sensitivity tests encompassing a range of selectivity patterns should be considered further at its 1999 meeting. Polacheck noted that Committee members would need access to the JARPA data to carry out the recommended analyses. Fujise reminded the Committee of Japan's policy in this regard. Scientists must apply to the Institute of Cetacean Research (ICR), describing the data they need and the purpose for which they will be used. A legitimate request could be rejected if Japanese scientists responsible for the data had not completed their primary analyses. In that case, the responsible Japanese scientist would need to be contacted directly for permission; the IWC Secretariat has the contact list. It was noted that ICR would provide a written summary of these rules and procedures.

In SC/50/CAWS34 minke school density was obtained from the first six IWC/IDCR independent observer (IO) surveys from 1985/86 to 1990/91, using methods which model heterogeneity due to covariates such as school size and sea state in addition to perpendicular distance. Incorporating these covariates reduces bias in estimated density by about 15% compared with the case in which the IO data are analysed using only perpendicular distance. However, comparison with standard line transect results indicates that the estimates of density obtained from the analysis of IO data remain substantially negatively-biased even when heterogeneity due to school size and sea state is modelled. The IO analysis methods are vulnerable to bias from heterogeneity in school surfacing patterns if both platforms search the same region of sea simultaneously. Plots of first sighting distances ahead of the vessel by the two independent platforms show that they do search the same region at the same time, and this is believed to be the primary source of bias in the IO analysis. The authors concluded that if unbiased estimates of density are to be obtained from IWC Antarctic surveys in the future without assuming certain detection on the trackline, it is important to separate the regions that the two independent platforms search. In particular, consideration should be given to using the search procedure suggested by Buckland and Turnock (1992).

In discussion, Butterworth drew attention to the fact that the implications of SC/50/CAWS34 were that the design of IO experiments on the SOWER cruises needs to be reconsidered. The Committee **agrees** to refer this issue to the proposed SOWER planning meeting in Tokyo and to consider it further at its 1999 meeting. It was suggested that an immediate and comprehensive change in procedure may be undesirable, in that it could cause problems of comparability with previous estimates. The Buckland-Turnock Method might be used experimentally for some component of the IO mode survey.

The Committee noted that GAM-based abundance estimation from JARPA minke survey data (SC/50/CAWS33) will also be considered at its 1999 meeting.

9.8 Other species and/or stocks

Information on a number of species off Brazil (SC/50/O5) was welcomed but not discussed owing to lack of time.

9.9 Other issues

9.9.1 Future SOWER cruises

9.9.1.1 REPORT OF INTERSESSIONAL GROUP

The report of this group was considered by the small group under Kato (Item 9.9.1.2).

9.9.1.2 PLANNING FOR 1998/99 SEASON

A small group under Kato was formed to consider this item and it provided a report (Annex Q). The Committee **recommends** that the 1998/99 cruise should take place principally in Area IV south of 60°S, with a blue whale component taking place for 12 days in the southeastern part of Area III where relatively high concentrations of blue whales had been confirmed by past IDCR cruises and JARPA surveys. The Committee **recommends** that there should be a specialist planning meeting for this cruise in Tokyo in October. Financial implications are considered

under Item 19. Kato agreed to act as convenor and a Steering Group (Bannister, Best, Brownell, Donovan, Ensor and Kato) was established.

9.9.2 Acoustics – report of intersessional correspondence group

Swartz reported on progress made by this group since the last meeting (SC/50/O14). The Committee endorsed the proposal that a library of whale sounds be compiled, with a view to archiving representative samples and making copies available to interested researchers: the preferred format was digital, for ease of exchange. The working group was encouraged to continue its work during the coming year and to expand the scope of the acoustic methods considered.

9.9.3 Mathematically-based techniques for recognition analysis

The Committee was informed that the computerised right whale matching programme originally developed by Hiby under an IWC contract had now been completed with financial help from IFAW; it had been demonstrated at the right whale workshop. Hiby was now investigating a similar possible system for humpback whale flukes. The Committee was disappointed that no further progress had been made on recognition analysis since the last meeting, although there had been problems in getting the appropriate people to this meeting as invited participants. It recognised that as photographic catalogues increase in size, the need for computerised matching increases. It therefore **recommends** that the Commission's attention again be drawn to the need to include scientists with relevant expertise among those nominated by member governments to attend Scientific Committee meetings. DeMaster agreed to convene an intersessional e-mail group to facilitate communication among researchers interested in this work (Annex V). The group would provide the Chairman with a list of potential participants for discussion on this topic at last year's meeting. The Chairman undertook to inform the relevant Commissioners.

9.9.4 Biopsy sampling – collection of behavioural data – report of intersessional group

Clapham reported on the results of the intersessional working group established last year. A draft data form had been designed which standardised collection of the necessary information. This was submitted to the Committee for comment. In discussion it was stressed that the form was mainly intended for genetic analysts who required associated behavioural information, and that other researchers were free to modify it to suit their species/area of interest. However the form contained the basic information required, and while items could be added, none should be deleted. The Committee **recommends** that the basic form should be adopted (once comments had been incorporated) and that consideration should then be given to making the form available electronically through the Secretariat.

10. ABORIGINAL SUBSISTENCE WHALING MANAGEMENT PROCEDURE (AWMP)

The report of the Standing Working Group (SWG) on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP) is given as Annex F. The Committee's deliberations, as reported below, are largely a summary of that Annex. Last year, the Commission had reiterated the importance it attached to the development of the AWMP and endorsed the Committee's workplan. A glossary of terms is given as Annex F, Appendix 2. For ease of reading, unless another reference is given, 'Last year' refers to the report of the SWG from the 1997 meeting (IWC, 1998e).

The Committee recalled the (summarised) objectives given by the Commission:

(1) ensure that the risks of extinction to individual stocks are not seriously increased by subsistence whaling;
(2) enable aboriginal people to harvest whales in perpetuity at levels appropriate to their cultural and nutritional requirements, subject to the other objectives; and
(3) maintain the status of stocks at or above the level giving the highest net recruitment and ensure that stocks below that level are moved towards it, so far as the environment permits.

It noted that highest priority shall be accorded to the objective of ensuring that the risks of extinction to individual stocks are not seriously increased by subsistence whaling.

10.1 Action arising from 1997 meeting and Commission's considerations

Last year, the Committee had agreed that it was appropriate for the Chairman of the SWG to present its work to the Commission. The Committee appreciated the Commission's answers to its questions (IWC, 1998a, pp.25-27), noting that some would be considered further by the Commission this year. These replies, and other comments by Commissioners, have been taken into account in the discussion below.

10.2 Future work

10.2.1 Common Control Program

The Common Control Program is the computer code used by developers to run the *Initial Exploration Trials* for scenarios that involve a single[2] stock (IWC, 1998b, p.84). Allison completed the changes to the Common Control Program specified last year, but owing to the short intersessional period, it had not been possible to complete it in time for the developers to use in papers for this year's meeting. The Committee **approved** a change to the specifications that reflected that the gestation time for baleen whales is considered to be one year, rather than the two years that had been inherent in last year's specification.

10.2.2 Statistics

In response to comments made in SC/50/AWMP6, the SWG had adopted a new statistic that better captured features of need satisfaction. The statistic, termed N9 – the average need satisfaction, which is a variant of the N1 statistic agreed previously - avoids giving greater weight to satisfying need when need is large. The Committee **agrees** that N9 should become a mandatory statistic and that the current N1 statistic should become optional. It further **agrees** that for future *Initial Exploration Trials*, the catch would be constrained to be no larger than the level of need. The list of performance statistics currently under consideration is given in Table 3.

The question of the trade-off between the satisfaction of current and future need was considered. Neither the N1 or N9 statistics capture this. As they measure need satisfaction over the full 100-year simulation period they thus only marginally represent current need satisfaction. The Committee **agrees** however, that use of statistics based on a 20-year management period should allow an evaluation of how well need is satisfied in the short term (and see Item 10.8.2).

[2] This remains the case until the Secretariat validates the multi-stock code presented by Punt and used in SC/50/AWMP3.

The format in which simulation results should be presented, in order to facilitate comparison and evaluation, was discussed. The Committee **agrees** that developers must at least include the 5% and median values for the D1 and the N9 statistics in documentation and bring encoded versions of all of the mandatory statistics to meetings so that these can be discussed if the SWG or Committee wishes.

None of the present performance statistics directly assess performance in terms of the variation over time in strike limits. Such statistics can be developed after consideration of Commission comments this year (see Item 10.8.3).

10.2.3 Performance plots

Interpretation of the vast quantity of results of simulation trials is greatly facilitated by standardisation of their graphical presentation. The Committee welcomed the offer of Zeh to work with Allison to revise and update the software she developed last year and ensure that the output from the Common Control Program can easily be integrated with plotting software.

10.3 Review of simulation framework

The SWG reviewed a number of modelling issues previously identified to determine progress. Details of these are given in Annex F (Item 2.3). Some of these issues are also discussed below.

(1) DENSITY DEPENDENT SURVIVAL RATE

The Common Control Program assumes that density dependence acts on fecundity and the calf survival rate. In principle, this can lead to oscillatory population trajectories although the results examined to date do not indicate that this is a severe problem. Such problems would be avoided by allowing density dependence to act on the non-calf survival rate. Work on this will be carried out intersessionally.

(2) COMPONENT TO WHICH MSYL APPLIES

The SWG considered this issue in considerable detail at its 1997 meeting (IWC, 1998e). The Committee had agreed that to progress its work in the short term, developers should carry out the *Initial Exploration Trials* using only the 1+ component (the component which, on balance, appears scientifically preferable). Trials using the mature component will be postponed until further in the development process when candidate *SLA*s are more fully specified and comparison with the RMP is more appropriate and rewarding.

(3) DENSITY DEPENDENCE ON THE MATURE RATHER THAN 1+ component

Last year, it was agreed that density dependence would act on the mature female rather than the 1+ component. The features of this decision are being investigated and additional information is expected next year.

(4) BLOCK QUOTAS AND CARRYOVER

Last year, Denmark, Norway and the USA emphasised that block quotas and carryover provisions were extremely important and should be incorporated as design features in any *SLA*. The Committee acknowledges the importance of incorporating this feature into the final *SLA*s. In terms of the present development process, however, the Committee **agreed** that considering strike limits on an annual basis will provide sufficient information.

(5) MULTI-SPECIES ISSUES

Greenland's need request is expressed as tons of whale meat, with need not assigned to species. Last year the Committee asked the Commission for advice on this issue and Denmark was strongly of the view that a multi-species model should be considered and developed as a priority. The Committee reiterated that it **recognises** the importance of this issue. It is discussed further under Item 10.8.1.

(6) SURVEY FREQUENCY

The frequency of future surveys required or used by an AWMP is an important issue, both for AWMP development and testing, and also as part of a broader aboriginal subsistence management scheme which would include certain data requirements. At present, the Committee **agrees** to consider survey frequency on a stock-specific basis (details are given in Annex F, Appendix 3).

10.4 Facilitating AWMP comparison and tuning

Each candidate *SLA* is likely to achieve a different balance among the objectives specified by the Commission for an AWMP. This makes it difficult to compare candidate *SLA*s. Tuning, or rather more specifically *equivalence tuning*, is a

Table 3

Performance statistics for use in the *Initial Exploration Trials*.
(1+ and mature refer to those components of the population to be reported for the Depletion and Recovery statistics).

ID	Mandatory	Optional	Name	Comment
D1	1+, mature		Final Depletion	Agreed in 1996
D2	1+, mature		Lowest Depletion	Agreed in 1996
D6	1+	mature	Trajectories 1 and 2	Agreed in 1996
D7	1+	mature	Pointwise Quantile Trajectories	Agreed in 1996
N1		Yes	Total Need Satisfaction	Demoted to optional (1998)
N2	Yes		Longest Shortfall	Rescale to 0-1; must convert to years for interpretation by Commission - agreed in 1996
N3		Yes	Severe Shortfall Frequency	Demote to optional (1997)
N4		Yes	Shortfall Frequency	Agreed in 1996
N5	Yes		Block Need Satisfaction	Agreed in 1996
N7		Yes	Percent Need Satisfaction Pointwise Quantile Trajectory Plot	Agreed in 1996
N8		Yes	Percent Need Satisfaction Trajectory Plot	Agreed in 1996
N9	Yes		Average Need Satisfaction	See Item 10.2.2
R1	1+, mature		Relative Recovery	To be redefined
R2		1+, mature	Relative Probability of Recovery	Agreed in 1996
R3		1+, mature	Time Frequency in Recovered State after Recovery	Agreed in 1996
R4		1+, mature	Relative Time to Recovery	Agreed in 1996

way to provide *SLA* developers with the opportunity to adjust their *SLA*s to strive towards a pre-specified balance of risk, catch, and recovery.

The SWG spent considerable time discussing the relative merits of *depletion tuning* and *H-tuning*, the details of which are given in Annex F. *Depletion tuning* aims to achieve a pre-specified median final depletion on a trial, whereas *H-tuning* aims to match a pre-specified set of strike limit trajectories for a collection of trials.

The Committee **reiterates** that it found *H-tuning* a promising idea and **agrees** to the revised specifications included in Annex F, Appendix 3. The SWG agrees that at present, results should be presented for both *depletion tuning* and *H-tuning*. It was also agreed that the approach presented in Appendix 4, which does not give additional weight to trials in which the catches under *H* are high should be adopted.

With respect to comparison of the AWMP with the RMP, the Committee reiterated its view of last year that its primary purpose was to develop an AWMP that fulfils the Commissions's objectives. It noted that simulation trials could be developed in the future for purely comparative purposes with the RMP, although these may not reflect real situations for which the AWMP is implemented.

The Committee also noted that some work has already been carried out (e.g. Givens and Thomas, 1997; Givens *et al.*, 1996) to enable comparison of future *SLA*s with a characterisation of the approach given in Para. 13(a) of the Schedule. This will continue although the developer who began this work noted that it will not be his highest priority.

10.5 Description of fishery type 3

Last year, arising out of discussions of multi-species fisheries, it was agreed that it would be valuable to begin consideration of an additional type of fishery. This fishery, called fishery type 3, referred to populations that were small, although the question of how small was left to be discussed.

This year, the Committee **agrees** that for exploratory purposes, it will initially examine the situation where the current population size is ~300 (loosely based on considerations of the size of the West Greenland humpback whale feeding aggregation, the lower confidence interval of the abundance estimate for fin whales in the West Greenland area and possible sizes of some Canadian stocks of bowhead whales) where demographic and environmental variability may have an impact on recovery times. Initial trials for fishery type 3 would need to consider cases in which the population is depleted to a small fraction of its pre-exploitation size and ones where it is close to this size. The SWG's initial attempts to address this problem are detailed in Annex F, Appendix 3.

10.6 Initial Exploration Trials

10.6.1 Fishery type 1

The Committee (IWC, 1997n, p.243) has defined fishery type 1 as a 'case where there is relatively little available information and stock identity problems (e.g. West Greenland minke whales) and where the Committee has had considerable problems in providing advice under Para. 13(a).'

Progress with the existing trial structure and in particular with the first attempts to consider the stock identity problem were reviewed (Annex F). The results in SC/50/AWMP3 revealed relatively poor performance that depended primarily on the value for the *MSY* rate.

The Committee **agrees** with the decision of the SWG to combine the single stock and multi-stock trials for fishery type 1 to be able to distinguish the impact of *MSYR* from that of uncertainty in stock identity. It accepted the revisions to the trial structure shown in Table 4. A further four trials to those agreed last year were specified, such that a 1% and a 7% MSYR trial were carried out for all combinations. These trials are to be carried out with and without information about stock identity. Need is taken to be constant in all these cases and a further three trials consider increasing need.

In order to investigate whether poor performance in cases of low stock size combined with high MSYR can be improved by more frequent surveys, it was **agreed** that two trials (of the combinations low stock size/low MSYR and high stock size/high MSYR) should be carried out with biannual surveys for the first ten years followed by surveys every ten years thereafter. These trials represent the first step at addressing this issue and further robustness trials will be considered in the future. The issue of data availability and the ability to develop a successful *SLA* for fishery type 1 is discussed further below.

Table 4

The set of trials agreed for fishery type 1.

Trial	$MSYR_{1+}$	Initial population	Catch in Area 1	Need	Survey interval	Stock structure
MM1	0.01	High	0	Const.	10yrs	Boundary between Middle and 2
MM1a	0.07	High	0	Const.	10yrs	Boundary between Middle and 2
MM2	0.01	High	0	Const.	10yrs	Boundary between 1 and Middle
MM2a	0.07	High	0	Const.	10yrs	Boundary between 1 and Middle
MM3	0.07	High	0	Const.	10yrs	Mixing in Middle Cell
MM4	0.07	High	Yes*	Const.	10yrs	Mixing in Middle Cell
MM5	0.01	Low	0	Const.	10yrs	Boundary between Middle and 2
MM5a	0.07	Low	0	Const.	10yrs	Boundary between Middle and 2
MM6	0.01	Low	0	Const.	10yrs	Boundary between 1 and Middle
MM6a	0.07	Low	0	Const.	10yrs	Boundary between 1 and Middle
MM7	0.01	Low	0	Const.	10yrs	Mixing in Middle Cell
MM8	0.01	Low	Yes*	Const.	10yrs	Mixing in Middle Cell
MM9	0.01	High	0	Inc.	10yrs	Boundary between Middle and 2
MM10	0.07	High	0	Inc.	10yrs	Mixing in Middle Cell
MM11	0.01	Low	0	Inc.	10yrs	Mixing in Middle Cell
MM12	0.01	High	0	Const.	2-10yrs[2]	Boundary between Middle and 2
MM13	0.07	High	0	Const.	2-10yrs[2]	Boundary between 1 and Middle

* Catches set using RMP. [2] Surveys every 2 years until year 10, and every 10 years thereafter.

10.6.2 Fishery type 2

The Committee has defined (IWC, 1997n, p.243) fishery type 2 as a case where there is a relatively large amount of information and Para. 13(a) has largely been met (e.g. Bering-Chukchi-Beaufort Seas whales).

The Committee reviewed progress with the existing trial structure and in particular problems related to conditioning (see SC/50/AWMP2). Conditioning is the process of selecting specifications/parameter values for case specific trials to ensure that they do not conflict with already existing data. After considerable discussion in the SWG, an agreed revised method for conditioning was developed. The Committee **agrees** with the method described in Annex F, Appendix 3.

The Committee **agrees** that a move to introduce demographic and environmental stochasticity into fishery type 2 trials was desirable. It **agrees** to the specifications for the stochastic model given in Annex F, Appendix 3, noting that the introduction of stochasticity will require some exploratory work. The assumptions in the trials agreed last year (Table 5) remain unchanged; except that, as a result of the new conditioning approach, the initial population ($=P_{1993}$) is no longer fixed.

The Committee also **agrees** that the matter as to whether uncertainty should be expressed using a large number of trials with little within-trial variation or a small number of trials with greater within-trial variation required further consideration.

10.6.3 Fishery type 3

Trials for fishery type 3 (limited information, small stock size of ~300) should be based on stochastic population dynamics models that allow for variation in the birth-death process and possibly depensation. It was **agreed** to focus on the former and to consider three kinds of model (see Annex F, Appendix 3):

(i) simple demographic stochasticity (on survival and birth rate);
(ii) demographic stochasticity plus environmental stochasticity without auto-correlation;
(iii) same as (ii) but with auto-correlation.

Some initial simulations and explorations are needed to determine feasible and reasonable combinations and ranges of parameter values but the focus is on low population size (~300 whales) and either a K value close to the population size or much higher. MSYR values of 1%, 4% and 7% will be considered for each of the three types of stock model. The initial attempts to address this problem are detailed in Annex F, Appendix 3.

10.7 Planning for future selection of *SLA*s - strategies for optimising and merging *SLA*s

At last year's meeting, the SWG encouraged further work on methods for optimising *SLA*s, noting that the ideas in Givens (1997) appeared highly promising. In SC/50/AWMP5, several potential AWMP *SLA*s were reviewed and enhanced, including the likelihood approach referred to under Agenda Item 4.2 and the Punt-Butterworth (1997) *SLA*. The focus was on an optimisation method for improving the performance of existing *SLA*s and for creating enhanced, merged *SLA*s from existing candidates. The Committee welcomed this work and a number of aspects of it are discussed further in Annex F.

One *SLA* examined at this meeting had been tuned so that the strike limit was a polynomial function of its nominal strike limit and the calendar year. Some concerns were raised as to whether this constituted an inappropriate management strategy but given that the primary objective is good simulation performance, regardless of the intricacies of the *SLA*, and that several RMP candidates had successfully used the time variable, it was **agreed** that no restriction regarding its use should be adopted at this stage.

10.8 Dialogue with Commission and hunters

The Committee reiterated the importance it attached to continuing dialogue with the Commission and hunters throughout the development process (IWC, 1997b). It agreed that the procedure adopted last year, i.e:

(1) a presentation by the Chairman of the SWG of its report and a less technical Chairman's discussion paper;
(2) informal discussions with interested Commissioners;

had proved successful. It **recommends** that the procedure be repeated this year.

The Committee **agrees** that the Commission should be specifically requested for comments on the following issues this year.

10.8.1 Multi-species considerations

The SWG noted the importance which some delegations placed on developing a multi-species operating model. It reiterated that it recognised this and is starting to develop such a model. As a first step in this process, trials are being constructed for fishery type 3. In addition, it is examining options involving multi-species *SLA*s superimposed on top of the upper catch limits of underlying single species *SLA*s (SC/50/AWMP7). Such *SLA*s can fulfil larger needs than single species *SLA*s, and can optimise the recovery rates of the multiple species when need is satisfied. A number of

Table 5

Initial Exploration Trials for fishery type 2.

Trial no.	$MSYR_{1+}$	Initial population P_0	Need		Data quality				Comments
			Initial level	Final level	CV_{est}	$\gamma_{12.9}$	$\lambda_{12.9}$	Bias B_A	
B1	0.025	8,200	68	68	0.25	0	1	1	1996
B2	0.025	8,200	68	68	0.125	4	2	1.5	Replace (7a)
B3	0.04	9,400	100	200	0.25	0	1	1	Deleted 1997
B4	0.04	9,400	68	68	0.25	0	1	1	Deleted 1997
B5	0.01	9,400	100	200	0.25	0	1	1	1996
B6	0.01	9,400	68	68	0.25	0	1	1	1996
B7	0.01	7,200	100	200	0.25	0	1	1	1996
B8	0.01	7,200	68	68	0.25	0	1	1	Deleted 1997
B9	0.04	7,200	100	200	0.25	0	1	1	Deleted 1997
B10	0.04	7,200	68	68	0.25	0	1	1	1996

features of this approach will require input from the Commission and hunters, as can be seen in the discussion under Annex F, Item 4.3. In particular, Commission comment is **requested** on various options for suitable principles for the design of such algorithms, for example species ranking, even catch, even exploitation, even recovery, even risk of extinction or relative productivity.

10.8.2 Need satisfaction

At present, need satisfaction is considered over 20, 50 and 100 year periods. Commission comment is requested on whether greater emphasis should be placed on satisfying current rather than projected future need.

10.8.3 Catch variability considerations

At last year's meeting, the SWG requested that the Committee ask the Commission to provide it with a general indication of the importance of variability in catches. For example, would it prefer an AWMP that achieves a slightly higher level of total need satisfaction averaged over a longer time period at the expense of greater variability in strike limits or would it prefer to sacrifice some satisfaction of total need to ensure less variability in catches? The Commission had agreed to give consideration of this during the year. The Committee **agrees** that resolution of this issue was important for its work. It **agrees** that the Chairman of the SWG should request information on catch variability by presenting the Commission with a series of time trajectories of strike limits which reflect the trade-off between need satisfaction and variation in strike limits.

10.9 Workplan (including computing needs and financial implications)

At its 1996 meeting, the Committee had agreed that the *Initial Exploration Trials* should be case-specific rather than generic because there are a limited number of cases for which aboriginal subsistence harvesting is likely (IWC, 1997b). However, it did not reach consensus on whether the AWMP should include a generic *SLA* or case-specific *SLA*s.

At this meeting, the Committee **agrees** that there were three alternatives:

(1) an *SLA* which is completely generic;
(2) a generic core *SLA* with case-specific modifications; and
(3) completely case-specific *SLA*s.

The Committee **agrees** that it in principle it would be preferable to have a single generic *SLA*. However, the primary task of the AWMP is to satisfy the management objectives established by the Commission to the greatest extent possible for the fisheries of concern.

The Committee **agrees** that given the results so far, and the well-documented differences between the fisheries in terms of data availability, stock identity complexity and the nature of the fisheries themselves (e.g. the multi-species nature of the Greenlandic case), it was extremely unlikely that a single *suitable* generic *SLA* could be developed. It is therefore clear that either alternatives (2) or (3) are most likely to enable the Committee to satisfy the Commission's objectives. It **draws this to the attention** of the Commission. It **agrees** that to the extent possible it would be preferable to follow option (2).

Thus, a likely potential scenario is that the Commission might establish an Aboriginal Whaling Scheme that comprises the scientific and logistical (e.g. inspection/observation) aspects of the management of all aboriginal fisheries. Within this, the scientific component might comprise some general aspects common to all fisheries (e.g. Guidelines and requirements for surveys and for data c.f. the RMP) and an overall AWMP within which there will be common components and case-specific components.

An important implication of this is that given the different degrees of difficulty, it will be possible to develop *SLA*s for some stocks before others. The Committee **agrees** that it could best fulfil its role of providing the Commission with advice on stocks subject to aboriginal whaling if it presented available components of the AWMP to the Commission as and when they were ready. It **draws this to the attention** of the Commission. This is considered further below.

The Committee reaffirmed that its aim was to produce an AWMP that satisfactorily meets the Commission's objectives as quickly as possible. The SWG noted that improvements beyond this point would not be justified in terms of time and cost.

10.9.1 Short-term (1 year)

The Committee identified a number of tasks that required work during the coming year, including computing tasks for the Secretariat. These are given in Table 6. The SWG had recommended that the highest priority be accorded to these computing tasks, stressing that the pace of the development process was critically dependent on the appropriate software being available as soon as possible. This is discussed further under Item 18.

The Committee recalled that last year, it had noted that the SWG would probably require an intersessional meeting between the 1998 and 1999 meetings. In order to give developers as much time as possible and to ensure that adequate time is available for the SWG to consider the results of their work, the Committee **recommends** that the work of the SWG commences three days immediately prior to the next Scientific Committee meeting. It also **noted** the SWG request that invited participants be invited on more than a one-off basis.

The Committee noted the importance of continuity to its work. It therefore **recommends** that Donovan act as co-ordinator of its intersessional activities during the coming year.

10.9.2 Medium-term funding

During the development of the *RMP*, the Commission had established a fund to help support the work of some developers. Last year the Committee had requested that the Commission should consider establishing a similar scheme for AWMP development. The Committee **recommends** that such a fund be established. It **agrees** that the fund should initially be established at a level of £5,000 with a maximum of £1,500 available annually to each developer. It is envisaged that the fund should carry over from year to year, such that each year it begins with £5,000. Developers wishing to draw on the fund should apply to the Secretariat. The decision to approve the application should be taken by the Chair of the Standing SWG and the Chair of the Committee.

10.9.3 Long-term

The SWG noted the steps it had previously identified in the development of the AWMP (see e.g. IWC, 1998e):

(1) summarise existing data for stocks harvested by aboriginal whalers (completed);
(2) clarify management and performance objectives of the *AWMP* ([may require] additional input from the Commission and hunters [as work proceeds]);

Table 6

Aboriginal Whaling Management Procedure work to be carried out in the coming year.

Task		Estimated time/by
Secretariat computing		
(1)	Revise the program to implement the multi-stock trials for fishery type 1 as detailed in Annex F, Appendix 3.	1 month
(2)	Implement the stochastic dynamics model (including the 3 methods given in Annex F, Appendix 3) and apply the stochastic backwards method to obtain input parameters for fishery type 2. This may require iteration through the AWMP correspondence group. As a first step, modify the control program to input rather than pre-specify P_0 and apply the deterministic backwards method to obtain input parameters for fishery type 2 that can be used until the task is completed.	2 months
(3)	Modify the common control program to implement and run trials to investigate the effects of three different methods of incorporating stochasticity into fishery type 3 trials.	
(4)	Finalise the plotting program (in collaboration with Zeh).	
Other		
(1)	Software distribution questions (Annex F, Item 1.7).	Secretariat
(2)	Incorporate density dependence on the survival rate for juveniles into the common control program and present trajectories (Annex F, Item 2.3.1).	Punt
(3)	Additional information on density dependence on the mature rather than 1+ component (Annex F, Item 2.3.3).	Punt
(4)	Begin work on gray whales (Annex F, Item 8.3).	DeMaster

(3) specify performance measures (on-going);
(4) specify simulation trials (on-going);
(5) specify candidate *SLA*s (on-going);
(6) subject candidate *SLA*s to stock-specific simulations trials and compute performance measures under a range of scenarios;
(7) if required, modify candidate *SLA*s in light of simulation results and repeat simulation trials;
(8) recommend *SLA*s to the Commission.

In the light of its discussions above, it reiterates that it believes that it is most appropriate to provide the Commission with recommended *SLA*s for different fisheries at different times.

The Committee is not in a position to develop a precise timetable for its work but believes it will be in a stronger position to do so at its next meeting. It therefore confined itself to:

(1) an elaboration of the process above by which it would arrive at recommended *SLA*s;
(2) general comments on a timetable on a fishery by fishery basis.

With respect to (1), it identified that the following types of trials are necessary.

Evaluation Trials. Such trials would be used for formal comparison of candidate *SLA*s. Their number would be limited, compared to the number of *Robustness Trials*. Development of *Evaluation Trials* would commence prior to that of *Robustness Trials*. More than one round of such trials is likely before a favoured *SLA* is identified. Developers would be able to adapt their efforts accordingly.

Robustness Trials. Trials to examine *SLA* performance for a full range of plausible scenarios. These would be applied to the restricted set of *SLA*s found to perform well in *Evaluation Trials*. The number of such trials would be potentially large. Results will be used to fine-tune *SLA*(s) for acceptable performance. Again, more than one round may be necessary.

With respect to (2) the Committee made the following general comments:

GREENLAND FISHERIES

The Committee **agrees** that providing advice on the Greenlandic fisheries was a matter of the highest priority. It concurred that given the present state of knowledge, developing a *Strike Limit Algorithm* for the Greenland Fisheries that would fulfil all the Commission's objectives will be an extremely difficult, if not impossible task.

It **strongly recommends** the proposal with respect to research on Greenland stocks given in Annex P.

The Committee **agrees** that it would be in a stronger position to provide advice on a timetable for providing the Commission with a recommended *SLA* for this multi-species fishery when the results of the research programme begin to become available.

BERING-CHUKCHI-BEAUFORT SEAS STOCK OF BOWHEAD WHALES

The Committee noted that last year the Commission had established catch limits for this stock until the year 2002. It therefore **agrees** that it would be highly desirable if it could be in a position to recommend an *SLA* for this fishery to the Commission by that year. It hoped to be able to give the Commission more advice on whether this was achievable after its next meeting.

EASTERN STOCK OF GRAY WHALES

Although the fishery type 2 *Initial Exploration Trials* have been based on the bowhead whale situation, the SWG **agrees** that the eastern stock of gray whales is essentially a fishery type 2 stock. It believed that it was likely that a single *SLA* (or minor variants) would be applicable to both stocks. The Committee **agrees** that consideration of this fishery should begin in the near future. DeMaster indicated that such work may be undertaken within the USA. The Committee noted that last year the Commission had also established catch limits for this stock until the year 2002. It therefore **agrees** that it would be highly desirable if it could also be in a position to provide a recommendation to the Commission for this fishery by that year. It hoped to be able to give the Commission more advice on whether this was achievable after its next meeting.

ST VINCENT AND THE GRENADINES HUMPBACK WHALES

The SWG has not yet considered this fishery in any detail. The Committee is intending a major review of North Atlantic humpback whales at the 2000 meeting that will be relevant to the development of an *SLA* for this stock.

10.10 Other

The Committee has in the past expressed concern over the status of the Baffin Bay-Davis Strait and Hudson Bay-Foxe Basin stocks and this was re-iterated in Annex G this year. It also noted the kill of one whale in 1996 from the Hudson Bay-Foxe Basin stock that Canada, a non-member nation,

had authorised up to two strikes in 1998 from the Baffin Bay-Davis Strait stock.

DeMaster indicated that he was planning to begin exploratory work on developing a management procedure for these stocks. The Committee **agrees** that, provided it does not interfere with its priority work to develop *SLA*s for those stocks that the Commission is managing directly, it would be prepared to review and comment on work on other stocks.

11. ABORIGINAL SUBSISTENCE WHALING STOCK ASSESSMENTS

11.1 Bowhead whales

11.1.1 Bering-Chukchi-Beaufort Seas Stock

A thorough assessment of this stock of bowhead whales was carried out in 1991 (IWC, 1992b), and in-depth discussions have taken place in the Scientific Committee in subsequent years. This occurred especially in 1994 (IWC, 1995b), following the successful census in 1993, and in 1995 (IWC, 1997b), following the identification of a possible serious theoretical difficulty with the Bayesian synthesis method used for stock assessment since 1993. Extensive sensitivity analyses in subsequent years have not identified a strong effect for the bowhead assessment. However, in 1997 (IWC, 1998b) it was agreed that at least one solution to the theoretical difficulty was to use standard Bayesian analysis, rather than the specific Bayesian synthesis method. Debate has also occurred regarding the merits of two standard Bayesian analysis methods. In one, a prior distribution is specified for K (carrying capacity) and the population model is projected 'forwards' to the current time. In the second, a prior is specified for current abundance, and the model is projected 'backwards' to find the value of K that would be necessary for this value of current abundance. An alternative standard Bayesian solution was also developed, which involves the geometric pooling of multiple prior distributions. The Committee is pleased to note that this approach has resolved the previously identified theoretical difficulties that have been extensively discussed in recent years.

11.1.1.1 ASSESSMENT

SC/50/AS3 reported bowhead whale sightings data collected around Chukotka from 1994-96. Whales winter in leads and polynyas along the southwestern shore of Chukotka, in the Anadyrskiy Gulf, with some remaining throughout the year. In May, some whales migrate north along the southeastern shore of the peninsula. By August or September they are seen along the northern shore. Whales migrate east along the northern side of Chukotka, still feeding, before the ice begins to freeze. The timing and numbers of whales observed along this coast have varied between years, related to the ice conditions in the Chukchi and perhaps Beaufort Seas. The authors also noted that the origin of the whales arriving along the north coast of Chukotka in Autumn is unknown; they speculated that they could be animals migrating out of the Beaufort Sea.

SC/50/AS4 considered the morphology of the bowhead whale eye and the author concluded that the bowhead whale probably has significant eye mobility.

In SC/50/AS10, age was estimated for 42 animals using the aspartic acid racemisation ageing technique. The racemisation rate for aspartic acid was estimated using data from earlier studies of humans and fin whales. Age at sexual maturity and growth rate estimates accord with those from photogrammetry and baleen ageing techniques. Growth slows markedly for both sexes at about 40-50 years but does not cease. Age estimates for four males were considerably greater than 100 years. These results generally confirm those from other ageing methods, which suggest slow growth, great longevity and high survival rates. Six 'traditional' Eskimo harpoon points (four of stone) have been recovered from the Eskimo whale harvest; stone tools appear to have been generally out of use for over 100 years. That the five oldest animals were male may reflect a higher survival rate for males or be a residual effect of the commercial fishery which may have been directed toward large females.

In SC/50/AS11, the possibility that bowheads in the Okhotsk Sea were derived from the Bering-Chukchi-Beaufort Seas population was examined by genetic analysis of tissue samples collected from the Okhotsk Sea ($n=25$) and off Barrow ($n=29$). Small but significant differences between the two groups were found, suggesting that the sampled animals are from separate gene pools.

SC/50/AS14 attempted to (1) quantify genetic variability in the Bering-Chukchi-Beaufort Seas stock using mtDNA control region sequences and (2) determine the likelihood of a potential genetic bottleneck in this stock as a result of commercial whaling. The level of genetic diversity was found to be much higher than for some other marine mammal populations. The results suggest that (1) any reduction in total population size would result in only a negligible loss of diversity and (2) the expected pre- and post-bottleneck levels of diversity are not significantly different from each other.

SC/50/AS9 summarised information on the 1997 Alaskan hunt; 66 whales were struck and 48 were landed, for an efficiency of 73%. Of the landed whales, 29 were female (10 considered mature based on their length) and 19 male. One animal had a 409cm foetus. Preliminary analysis of weather and harvest records at Barrow confirm the hunters' belief that hunting success is greatly influenced by wind direction and wind speed.

SC/50/AS12 provided information on the value of acoustic methods in the bowhead census, especially for quantifying the proportion of whales further than 4km offshore. It also described a relatively new method for collecting recordings of whale sounds with possible application to the bowhead census and to the remote acoustic sampling of blue whales in the Southern Ocean.

An intersessional e-mail group had clarified an agreed reference set of prior distributions, for use in comparing the results of the different proposed assessment methods, and had clarified details of calculations, catch history, and abundance estimates.

SC/50/AWMP1 gave the full technical specifications of the BALEEN II population dynamics model. It was agreed that a revised version should be available as Annex R. The model forms the basis for the assessments reported in SC/50/AS1 and SC/50/AS6 and a variety of methods for parameterising the model are described.

SC/50/AS1 addressed four methodological aspects of the Bayesian approach to this assessment. (1) It suggested that the prior on MSYR be replaced by one on the rate of increase at low population size, as this (rather than MSYR) was the parameter for which basic data were available from other stocks. (2) It developed several approaches to include abundance information in the analysis, particularly the N_4/P_4 time series and its relationship to absolute abundance (including the authors' preferred approach of taking account of correlations in the N_4/P_4 series). (3) It developed a basis to commence the analysis in a more recent year than 1848

when commercial catching started and thus to avoid problems with uncertainty about 19th century catch levels and possible changes in parameters such as the carrying capacity *K*. (4) It expressed preference for the 'backwards' over the 'forwards' approach on the basis of simulation test results.

SC/50/AS6 continued to examine the difference between the forwards and backwards results. It applied the full pooling method, which resolves the difference, to the bowhead assessment. Results were intermediate between those using the forwards and backwards methods. Full pooling creates a joint prior that reflects relationships between parameters determined by the population dynamics model. It thus circumvents the independence assumptions of both methods while simultaneously yielding a unique solution.

SC/50/AS7 implemented the reference set of priors and the likelihoods using a forwards method. The analysis was based on the age- and sex-specific Leslie matrix model with density-dependence in the fecundity term. Two methods were used to sample from prior distributions. The first put a prior distribution on λ_{max}, the maximum growth rate of the population, and the second was the 'reference' case where a prior was put on MSYR. In discussion, it was noted that although the results for the two methods were similar for λ_{max}, this was not true for some other parameters of interest.

SC/50/AS8 investigated the sensitivity of the bowhead assessment to certain assumptions. The particular implementation of the assessment was a forwards projection from *K* in 1848. Two versions were used, one with a prior on λ_{max}, with juvenile survival and MSYR then calculated, and another with a prior on juvenile survival, with λ_{max} and MSYR then calculated. In general, the two versions gave similar results. The assessment was not found to be sensitive to (1) the marginal prior distributions for adult survival and age at sexual maturity or (2) the data on the fraction mature and the fraction calves in the population. However, it was strongly influenced by the rate of increase (ROI) data. An additional analysis fitted a Leslie matrix (with no density-dependence) projected from 1975-1998 to the data; it confirmed that the marginal prior distributions for the life-history parameters could closely agree with the observed data on ROI. Finally, it was found that even if there was substantial bias in the recorded harvests in the 19th century, there was little effect on the estimated catch-related quantities, although estimates of depletion level were, as expected, much lower.

SC/50/AS2 examined the likelihood of the direct and indirect data relevant for the bowhead asessment. The indirect component of the likelihood is constructed from the prior distributions (Schweder and Hjort, 1997). It is argued that several of the prior distributions are only weakly supported by data, and should be disregarded. The likelihood is in each case concentrated on a narrow curved band in the 7-dimensional parameter space of the BALEEN II model. The model fits the data well, which is not surprising since the number of free parameters equals the number of data points or is slightly less. The parameter of interest, the 1998 replacement yield, is a rapidly varying function of the basic parameters of the model. This sensitivity makes it difficult to find confidence intervals for replacement yield. In discussion, the method being developed was noted to be interesting, and further work was encouraged. The interpretation of prior distribution as confidence intervals that might be derived using bootstrap methods, was questioned. Therein followed the usual frequentists *versus* Bayesians thrust and parry, *sans touché*.

The Committee **agreed** on the basic data required for an assessment. The catch data are complete up to 1997 and thought to be generally reliable. However, the suggestion that the commercial fishery preferentially took larger females (see above), raised questions about the sex ratio in the historic catch. This was identified as an issue for future sensitivity investigations. Abundance data included the 1993 Bering-Chukchi-Beaufort Seas abundance estimate (8,200, SE = 564) and a series of estimates termed N_4/P_4. In order to combine these estimates, the time series of absolute abundance estimates N_4/P_4 was treated as a series of relative abundance estimates, and an abundance series with covariances was calculated. Aerial photographic data were used to estimate length distributions for the proportions of calves and matures and the rate of adult survival. The next abundance survey is planned for 1999.

In discussion, concerns were raised over technical difficulties encountered in estimating parameters of interest in some situations for several of the proposed assessment methods. The cause of these difficulties and their implications for the present assessment were discussed. Subsequently, possible ways of minimising or avoiding such difficulties in the future were identified. There was disagreement over whether some of these difficulties were related to the specific parameterisations being used, (especially dependencies among parameters to over-parameterisation given the data) or to inadequacies in the underlying population dynamics model.

There was general agreement that although there may be concerns over the underlying population dynamics model and its parameterisation, these difficulties did not preclude sampling from the posterior distribution in the Bayesian analyses presented. These issues should be addressed in the future.

The Committee compared the three basic methods of fitting the models, termed forward, backward, and full pooling. After considerable discussion (see Annex G) it was **agreed** to reject the forwards method, conduct an assessment using the backwards method and to examine the results from the full pooling method.

The Committee reviewed the previously used prior distributions and **agreed** appropriate values for use in the present assessment, although for some parameters (maximum calving interval, MSYR, adult survival rate, age at transition between adult and juvenile survival rates, carrying capacity), there were no direct data available to help set prior distributions.

Consideration was given to the implications for the assessment of the fact that 10% of the sample of animals considered in SC/50/AS10 was estimated to be older than 100 years and in particular to the way the mortality rates for older animals were handled. After some discussion it was agreed that for this assessment it would be sufficient to explore the issue by considering two alternative calculations, one involving not setting a maximum age and constraining adult survival rate to be less than 0.995, and the other retaining the maximum age but allowing survival to be as high as one. A number of other matters were identified that should be addressed in the future (see Annex G).

Assessments using the methodologies of SC/50/AS1 and SC/50/AS6, making the assumptions agreed, were presented. Both included calculations using the 'backwards' method using the two alternatives above. The results of the full pooling method under these two cases were presented.

The posterior distributions of several statistics summarising the assessments were reported, including the replacement yield and a similar quantity Q_0, that accounts

for the situation when the population might be above MSYL. This quantity is defined as 90% of MSY when a population is above MSYL (IWC, 1998j, pp. 241-42).

11.1.1.3 MANAGEMENT ADVICE

The best estimates of replacement yield (RY) from the above agreed alternative assessments ranged from 184 to 210. The Committee **agreed**, as in the last bowhead assessment, to use the lower 5th percentiles of the posterior distributions of RY and Q_0 to provide management advice. The Committee recognised that this was a conservative approach and that the AWMP currently under development will probably provide a better approach. The relevant 5th percentiles, along with the best estimates (medians) of depletion, are shown in Table 7. Depletion has been expressed in terms of the 1+ population as this is the component of the population that is hunted.

Table 7

Lower bounds (5th percentiles) of replacement yield (RY) and Q_0 for 1998, and the median estimated depletion in terms of 1+ population size for four combinations of assessment method from the two assessments of the status of the Bering-Chukchi-Beaufort bowhead population. The alternate case results are from the backward method from the combinations of assumptions considered that resulted in the lowest values among the alternates considered of RY and Q_0, namely assuming no upper bound on life span and comparing the results to the population size including calves.

	SC/50/AS6 Poole and Raftery (1999) methodology		SC/50/AS1 Punt and Butterworth (1999) methodology	
Quantity	Full Pooling	Backwards	Backwards	Alternate case
RY	108	119	123	113
Q_0	102	114	120	110
Depletion	61%	68%	68%	66%

The results of the backwards method as implemented by the two groups of authors were noted to be similar, as would be expected given that the method is the same. The differences reflect expected levels because Monte Carlo methods are used. The full pooling method gives lower values of the 5th percentile of replacement yield (108) and of the quantity Q_0 (102) than were obtained using the backward methods. The other cases considered resulted in values intermediate between the backwards and the full pooling methods.

The differences of management concern in the estimates of the values are relatively small. It was agreed that the management advice would be the same regardless of the methods used. The population appears to be near MSYL, and will probably increase under catches of up to 108 animals.

In terms of Para. 13(a) of the schedule, appropriate catch levels in these circumstances should not exceed 90% of MSY. The calculations reported therefore indicate that it is very likely that a catch limit of 102 whales or less would be consistent with the requirements of the schedule.

11.1.2 Other stocks

11.1.2.1 BAFFIN BAY/DAVIS STRAIT AND HUDSON BAY STOCKS

A brief description of the distribution, current abundance and status of the two putative stocks of bowheads in eastern Canada - the Davis Strait 'stock', which is known to be shared with Greenland, and the Hudson Bay/Foxe Basin stock - was given in IWC (1992c, pp.138-139). Pertinent new information available since 1991 is summarised in the following paragraphs.

The Committee noted that Canada has agreed to the request by Nunavut Wildlife Management board for Inuit hunters in eastern Baffin Island to strike up to two and catch up to one bowhead whale from the Baffin Bay/Davis Strait stock in the summer of 1998. This planned hunt follows the initiation of legal hunting on the Hudson Bay/Foxe Basin stock in 1996. An estimate of 270 (CI 210-331) for the northern Foxe Basin part of the Hudson Bay/Foxe Basin stock's summer range in August 1994 has been published (Cosens *et al.*, 1997). In addition, Innes referred to an estimate of 59 (CI 20-120) for the northwest Hudson Bay part of this stock's range in August 1995 (Cosens *et al.*, 1998). Both estimates are from systematic aerial survey.

No recent information on absolute abundance or trend is available for the Baffin Bay/Davis Strait stock. The statement in IWC, 1997b (p.90) that both stocks have been conservatively estimated at 450 whales each, citing Zeh *et al.* (1993), is incorrect. Zeh *et al.* (1993) estimated that there were at least 450 whales in the two stocks, combined. Of this total, about 350 were estimated for Baffin Bay/Davis Strait and 100 for Hudson Bay/Foxe Basin.

SC/50/AS15 presents observations of bowheads at Isabella Bay, northeast Baffin Island for 11 autumn seasons between 1983 and 1997. Except in 1983, bowheads were observed on most days. The study indicates that up to 99 bowheads can be present in Isabella Bay at one time during the autumn.

For both of these stocks the Committee expressed appreciation for the recent studies on abundance and distribution, using traditional knowledge, sightings surveys, photography and biopsy samples, and **encourages** additional work along these lines. Given the apparent interest in continuing harvests from these two stocks that were depleted by commercial whaling, additional knowledge of their status is crucially needed.

The Committee **remains concerned** for the viability of the Hudson Bay-Foxe Basin stock because of its small size, especially in light of the aboriginal harvest of one whale in 1996 (IWC, 1998b, p.92). The Committee also **expressed concern** about the approval for up to two strikes of whales in 1998 from the Baffin Bay/Davis Strait stock because of its small size and lack of information on trend.

11.1.2.2 OKHOTSK SEA STOCK

SC/50/AS11, which included information on this stock, was discussed under Item 11.1.1.1. Previously reported estimates for this population are 50-300 whales but they were not based on quantitative surveys. SC/50/AS11 suggested that the population size might be estimated using a genetic mark-recapture study.

11.1.2.3 OTHER STOCKS

The Committee **remains concerned** about the status and apparent low abundance of the Spitzbergen stock, about which little is known (Burns *et al.*, 1993). It **encourages** additional studies on abundance and distribution.

11.2 North Pacific gray whales

11.2.1 Eastern stock

SC/50/AS13 reported on observation studies in Mechigmenskiy Zaliv, Chukotka, and adjacent waters from 1984-96. Most sightings of gray whales in this area occurred between June and November with peak numbers occurring

in August or September in most non-El Niño years. During the years influenced by El Niño, peak numbers occurred in June.

Borodin reported that in 1997, the Russian State Committee on Environment issued an allowance to the Chukotka Autonomous Okrug for the harvest of 140 gray whales, which is within the catch limit set by the IWC. In accordance with the requests it received, the Okrug Administration distributed an allowance of 101 whales between nine settlements. During the 1997 hunting season, 79 whales were harvested: 48 males and 31 females.

The hunting was conducted from whaling boats and sea kayaks under the direct control of fishery inspectors from the Chukotka Regional Fisheries Inspection Agency. In the majority of settlements, rifles were used during the hunt. In 1997, 20 darting guns with bombs, received as humanitarian aid from Alaskan Eskimos, were used for the first time in the gray whale harvest. Using the darting guns, 17 shots resulted in 16 catches (i.e., one animal was shot twice with the darting gun).

In regard to a recommendation from last year, Pérez-Cortés stated that studies in the gray whale breeding lagoons were continued and expanded to most of the wintering range of this stock in Mexican waters (SC/50/ProgRep Mexico). Although no detailed information is available owing to the short period between the end of the field season and this meeting, preliminary information suggests that whales were present in fewer numbers in the southernmost breeding lagoon in Baja California (Magdalena Bay) in this el Niño year, and that they left that location earlier than observed in other years.

The Committee has no changes to the management recommendations made last year (IWC, 1998b).

11.2.1.1 CURRENT STATUS, INCLUDING STOCK MONITORING - REPORT OF THE INTERSESSIONAL GROUP

Brownell reported that no detailed work was conducted by the intersessional group, owing to the short intersessional period. However, the Committee **agrees** to a proposal that the group continue its work over the next two years, its terms of reference being to review the current status of the stock, including a review of past monitoring and recommendations for future monitoring.

11.2.2 Western stock

SC/50/AS5 summarised the location and year of sightings, strandings, and catches of gray whales in Chinese coastal waters. The Committee thanked the authors for their efforts in summarising this information. Given the severely depleted nature of the stock, this information is important in establishing base lines for sighting and stranding studies that may be used to infer trends in abundance in the future.

The Committee **strongly urges** that scientists from other countries with an interest in or within the range of these whales identify and conduct research on this stock, and consider measures required to maximise the chances of this stock recovering.

11.3 Greenland minke whales

There were no papers submitted on the two management stocks of minke whales that occur off Greenland. Born reported that in 1997 a total of 146 minke whales (99 females, 42 males and 5 with sex undetermined) were landed in West Greenland. Additionally, two whales were struck and lost. A total of 65 samples was collected from the catch (see SC/50/ProgRep Denmark).

Born also reported that eleven minke whales (10 females, 1 male) were landed in East Greenland in 1997. Three whales were struck and lost. The question of management advice is discussed under Item 11.6 and in Annex P.

11.4 West Greenland fin whales

At last year's meeting the Committee agreed that population structure and abundance must be more thoroughly understood before the Comprehensive Assessment process begun in 1991 (IWC, 1992a) can continue.

There were no papers submitted on this stock. Born reported that in 1997 eleven fin whales (5 females, 5 males and 1 of undetermined sex) were taken. Four samples for genetic analysis were collected from the catch (see SC/50/ProgRep Denmark). The question of management advice is discussed under Item 11.6 and in Annex P.

11.5 Humpback whales off St Vincent and the Grenadines

Hester reported that on 26 February 1998, two humpback whales were taken and landed at the whaling station on Petit Nevis. The whales were landed after 1700hrs. As the Fishery Officer did not receive word immediately, he did not arrive until the following day, after the smaller whale had been butchered and distributed. It was described to him by the fishermen to have been a male 4-6m in length. He measured, photographed and examined the remaining whale, which was in the process of being cut up. It was a non-lactating female 15.3m in length. Information regarding other data and samples that may have been collected will be released at a later date.

There was some discussion by the Committee about the 4-6m male. Carlson noted that photographs of both animals landed as well as skin and blubber samples collected by locals were available. Clapham and Brownell commented that, based on information from the Southern Hemisphere and North Pacific, animals of 4m are close to the average length at birth for humpback whales; average length at weaning is typically 8-9m. Clapham undertook to provide information at the next meeting on the size distribution of calves of this species, particularly in the North Atlantic.

During the Committee's review of its discussions on this matter, Hester asked that information on the location of the tissue samples be included in the report. He expressed concern that scientific samples were collected but no information could be provided. He therefore enquired how these samples were collected and archived, and what was the intention for their final disposal.

Joseph, Walters, Lawrence, Yagi and Komatsu noted that unauthorised marine scientific research in the eastern Caribbean is creating considerable problems for the governments in the region. They stated that this was underscored by what they felt was questionable reporting with regard to the above two whales by members of the Scientific Committee engaged in cetacean research in the EEZ of eastern Caribbean states. They stated that illegal marine scientific research is a growing problem in the eastern Caribbean and can create much embarrassment to the Scientific Committee if research reports cannot be substantiated. Such illegal activity undermines the sovereignty of these independent states and also the integrity of the Scientific Committee. Committee members desirous of undertaking research in the Caribbean are urged to seek the requisite approval of their research activities by respective states before engaging in any such activities in order to avoid unpleasant controversies.

Brownell, Donaghue, Slooten, Reijnders, Thiele, Berggren, Perrin, Stachowitsch, Tillman, Reilly, Deimer and Kock noted that during the discussion of this item in the full Committee, Carlson had reported that she had photographed the two dead whales at the whaling station whilst on vacation. It was their view that most members of the Committee did not believe that these opportunistic photographs constituted scientific research as noted by Joseph.

Regarding advice to the Commission concerning management, the Committee has no changes to the recommendations it made during last year's meeting. The Committee **draws attention** to its intention to undertake a Comprehensive Assessment of North Atlantic humpback whales at its meeting in 2000. Further, additional information on the status of humpback whales in the North Atlantic can be found in Annex E.

11.6 Long term priorities

The Committee noted the actions by the Commission last year in approving five-year aboriginal catch limits for Bering-Chukchi-Beaufort Seas bowhead whales before a new assessment had been completed, and in approving coincident 5-year aboriginal catch limits for both bowheads and eastern Pacific gray whales, west and east Greenland minke whales and west Greenland fin whales. It noted that the time required to complete a new assessment for a stock precludes undertaking more than one assessment during an annual meeting. The Committee therefore **agrees** that it does not appear necessary, and is not in any event feasible, to match the time between assessments with the time period of catch limits.

Recognising the Commission's request that the Committee keep the stocks under annual review in any event, and that in the development of the AWMP intervals between assessments of up to six years are being considered, the Committee **agrees** it will give attention to the more important of the stocks subject to aboriginal harvest every six years. It also noted that in Item 9.4 it recommends that it undertake a Comprehensive Assessment of North Atlantic humpback whales in the year 2000. Further, the Committee noted its own concerns this year about other stocks of bowhead whales. Finally, it **encourages** pursuit of proposals for future work to improve the Bering-Chukchi-Beaufort bowhead assessment model.

The Committee noted that it has never been able to provide satisfactory scientific advice on either fin or minke whales off Greenland. This is a matter of **great concern**, given that the provision of management advice on stocks subject to whaling is a high priority task assigned to the Committee by the Commission. The Committee **strongly recommends** the proposal to develop a research programme for the Greenland stocks outlined in Annex P.

Based on these developments, the Committee **recommends** that, while keeping all stocks subject to aboriginal whaling under review annually, primary attention be given to continuing work on the aboriginal whaling management procedure and to intensive assessments of stocks at future meetings as given in Table 8.

Table 8

Timetable for stock assessment consideration at future Annual Meetings.

Year	Stock to be considered
1999	Greenlandic research programme; stocks of bowhead whales other than the Bering-Chukchi-Beaufort stock
2000	North Atlantic humpback whales
2001	Fin whales off Greenland
2002	Minke whales off Greenland
2003	Eastern and western Pacific gray whales
2004	Bering-Chukchi-Beaufort Seas bowhead whales

12. ENVIRONMENTAL CONCERNS

The Committee's discussions were structured to reflect last year's discussions and IWC Resolution 1997-7.

12.1 Pollutant and contamination issues

12.1.1 Review of progress on research initiative

Last year, the Commission adopted a resolution (IWC Resolution 1997-7) endorsing the Scientific Committee's recommendation to initiate a research programme to establish pollutant cause-effect relationships in cetaceans (SC/49/Rep6) and to hold and fund a Planning Workshop as the first phase in implementing the proposal. The Committee established a Steering Group to organise the Planning Workshop (Reijnders, Aguilar, Bjørge, Donovan). The Workshop, which will last 3-4 days, will be held in November 1998 in Barcelona, Spain. The Steering Group has identified and will soon contact persons representing institutions or organisations that might be interested and potentially involved in the analyses and/or sample collection and funding. In addition, advisory experts on specific subjects, e.g. toxico-pathology, will be invited.

It was stressed in the original proposal that the programme was intended to address specifically the main recommendation of the IWC Pollution Workshop. Further, researchers were encouraged to address the other recommendations of that Workshop and consider other species and sources of samples. The priorities of the research programme were not meant to imply that other approaches were untenable, including the opportunistic collection of data from stranded animals, although data from such sources were likely to be subject to the concerns identified at last year's Committee meeting (IWC, 1998b).

In this context, it was noted that the Parties to ASCOBANS at their 2nd Meeting in Bonn in November 1997, expressed strong support for the research programme and recommended that the Parties should seek ways to facilitate its execution (SC/50/SM10; Annex L).

The Committee was informed that sufficient funds were available for the Planning Workshop, at which further discussions regarding the financing of the entire research project would take place. It was reiterated that sufficient funding for the overall Programme has not yet been secured and potential funding sources are **encouraged** to consider supporting the project.

The Research Programme is expected to last at least four years. Its products will include an integrated report of all the programme's components, a set of guidelines to assist others who wish to pursue similar research projects, and a summary of the entire programme in terms of the identified parameters that may be indicative of the health of cetacean populations.

12.1.2 Other documents on pollutants and contaminants

The committee reviewed three documents related to pollutants and chemical contamination.

SC/50/E5 presented an analysis of contaminant levels in bowhead whale tissues. Resulting mean levels of metals in bowhead liver and kidney samples were considered low or

normal compared to most mysticete species. Overall, bowhead tissues had relatively low levels of most natural and anthropogenic contaminants of the inorganic, organochlorine, and radionuclide classes when compared to other marine mammal species. From a subsistence perspective, kidney samples represented a significant source of cadmium which requires further investigation.

SC/50/E6 reported an opportunistic study of organochlorine and mercury concentrations in tissues from a sample of cetaceans from the northeastern Atlantic. The available data indicate that levels in small cetaceans in this region are high and suggest that the eastern Irish Sea might be a 'hot spot' of contamination.

SC/50/SM11 reported on the progress of toxicological and pathological investigations of harbour porpoises from the North and Baltic Seas and from waters around Greenland. Contents and patterns of chlorinated contaminants in harbour porpoise blubber samples indicated significant variation between the three areas, suggesting that the contaminant levels might indicate separate populations.

In addition to these three documents, the Committee reviewed briefly, and endorsed the protocol for, skin/blubber biopsy collection for study of chemical pollutants presented in Annex H, Appendix 2. It **recommends** that this be forwarded to the planning meeting for the SOWER cruises (see Annex Q).

12.2 Climate change and habitat

12.2.1 Review of progress on SOWER 2000 planning

REPORT OF E-MAIL GROUP

Reilly reported that the SO-GLOBEC small-scale process study originally planned for 1999/2000 has been delayed until 2000/2001 because of ship scheduling conflicts. Consequently, SO-GLOBEC's small-scale process study will not occur concurrently with CCAMLR's large-area synoptic survey to estimate total krill biomass. Re-iterating the unique opportunity that the research activities planned by SO-GLOBEC and CCAMLR present for the IWC to conduct research on the distribution of whales in relation to their environment and prey, the Committee discussed alternatives regarding IWC participation in these CCAMLR and SO-GLOBEC research activities. The Committee **agrees** to proceed with the existing proposal to work with CCAMLR in 2000 by having IWC observers conduct whale sightings during CCAMLR's synoptic krill survey in Area 48. After discussing the implications of the one year delay in the SO-GLOBEC small-scale process studies, the Committee re-confirmed its decision to work with SO-GLOBEC despite the delay. Thus, the Committee **reiterates** its support for the collaborative research activities with SO-GLOBEC and CCAMLR, which were originally proposed at last year's meeting and subsequently endorsed by the Commission.

12.2.1.1 CCAMLR

SC/50/O11 identified several areas of mutual interest between SC-CAMLR and the IWC Scientific Committee (IWC/SC):

(1) coordination of CCAMLR and IWC research activities;
(2) analysis of historical and recent datasets;
(3) CCAMLR surveys as platforms of opportunity for whale sightings;
(4) consideration of re-establishing minke whales as a monitoring species in the CCAMLR Ecosystem Program (CEMP);
(5) annual exchange of information.

To achieve greater collaboration between CCAMLR and IWC, the formation of a liaison group with IWC/SC and SC-CAMLR was suggested. The Committee noted that the establishment of such a group has been previously endorsed by the Commission. A Working Group was established to facilitate collaboration with CCAMLR, and form the basis for IWC representation in the liaison group. The Committee suggested that the following persons from countries participating in the CCAMLR Area 48 krill survey should communicate with their national CCAMLR representatives regarding these collaborative efforts: Hammond (United Kingdom), Kato (Japan), Reilly (USA), Thiele (Australia), Findlay (South Africa) and Slooten (New Zealand).

Two CCAMLR meetings are scheduled for June 1998 in La Jolla, California: a workshop on retrospective analysis of physical and biological data for CCAMLR Area 48, to provide the scientific context for the 2000 synoptic krill survey; and, a planning meeting for that krill survey. IWC participation was encouraged in both. IWC data have been requested for use in the retrospective analyses. Allison reported that there are two categories of relevant data: IWC catch data, which are available without restriction and have already been transferred to CCAMLR; and data for which restrictions exist. Shimadzu stated that full Japanese catch records will be made available to CCAMLR through the IWC, including biological data (except age and reproductive status); scouting boat data will also be accessible to CCAMLR.

12.2.1.2 SO-GLOBEC

Hammond presented his observer's report of the SO-GLOBEC Planning Group meeting in March 1998 (Annex H, Appendix 3). Three items recommending IWC action were identified:

(1) participation in SO-GLOBEC regional planning meetings;
(2) input on preferred measurements for small-scale process studies to increase overall the comparability of data by defining standard core measurements and methods;
(3) nominations of IWC participants for SO-GLOBEC working groups on data management and modelling.

Hofmann, Chair of Southern Ocean GLOBEC, presented a GLOBEC report (Hofmann, 1998) which outlined the updated implementation plan for the 2000/2001 small-scale process studies. One recent change was a narrowing of the project's focus in terms of target species and location, although an ecosystem approach of studying habitat, predators, prey, and competitors was still intended. The modifications to the existing plan include the following:

(1) selection of Antarctic krill (*Euphausia superba*) as the primary target species, including a focus on habitat, prey, predators, and competitors of this species;
(2) temporal expansion of the plan to a year-round study, with an emphasis on austral winter processes.

Two primary field sites were identified: the Antarctic Peninsula region (the major component) and 70°E and the surrounding area. The former will be studied year-round through a multi-national, multi-ship effort. In addition, associated programmes were identified that support SO-GLOBEC-related research. For example, the Australian Southern Pelagic Monitoring Cetacean Programme includes cetacean sightings throughout the Antarctic 'season' on all voyages, including a multidisciplinary winter polynya voyage (July-September 1998) and a fine-scale krill survey

(1999/2000). It was suggested that the IWC could use the data from the 1999/2000 fine-scale survey as a pilot study to test data collection methodologies in preparation for its participation in the CCAMLR 2000 and SO-GLOBEC 2000/2001 projects. Given this suggestion, the importance of discussing optimal research methodologies at the planned St Andrews Sightings Workshop (see Item 12.3.1) was stressed. The first regional planning meetings for the SO-GLOBEC programme will occur in the next six months and the IWC is encouraged to participate.

A working group was established to facilitate collaboration between the IWC and SO-GLOBEC. Annex H, Appendix 4 lists five SO-GLOBEC planning activities that will require IWC input in preparation for the 2001 field programme. Individuals to represent the Scientific Committee in these activities will be identified in consultation with the Chairman.

12.2.1.3 HABITAT

The Committee reviewed several documents related to habitat. SC/50/E1 investigated minke whale sightings in relation to sea surface temperature in Area II (Weddell Sea) of the Antarctic using data from IWC/IDCR cruises from 1981/82 and 1986/87. In SC/50/E2, interspecific density relationships among whales on Antarctic feeding grounds were examined using sightings data from the Japanese Antarctic Research Program (JARPA) from 1989/90 to 1995/96 and the IWC/IDCR cruises from 1978/79 to 1987/88. SC/50/E3 reported on oceanographic sampling during the IWC/SOWER/Blue whale cruises in 1995/96 and 1996/97.

The Committee noted discussion in Annex H of inter-annual variability in the location and extent of the marignal sea ice zone (SC/50/E7). The work is relevant to questions arising in Annex E about the representativeness of the JARPA samples. The Committee **encourages** additional attention to this topic.

SC/50/CAWS18 addressed critical habitat and abundance of right whales in the southeast Bering Sea based on data collected during a survey in the summer of 1997. In conjunction with retrospective analyses of sightings data since 1985, the results suggest that right whales predictably occupy the middle shelf and near-Inner Front regions of the Bering Sea shelf during summer. The Committee noted a recently published paper regarding the ecological importance of the Southern Boundary of the Antarctic Circumpolar Current (Tynan, 1998). Historical data on cetacean distribution and krill catches were used to show the importance of this boundary to the complex and predictable Southern Ocean food web.

12.3 Other concerns and activities

12.3.1 Future workshop – report of the intersessional group

As agreed at last year's meeting, an intersessional workshop is being planned to develop sighting and analysis methods for cetacean components of multidisciplinary research programmes. It is scheduled for late March 1999 and will be held in St Andrews, Scotland. The Committee noted the importance of having GLOBEC and CCAMLR participants at the workshop, especially in light of the sampling and analytical methodologies that may be common to all three groups. A steering group was established to complete planning. The proposal, draft budget and planning schedule are given in Annex H, Appendix 5. The Committee **strongly recommends** funding for this workshop (see Item 19), which it views as essential preparation for the SOWER 2000/1 field programs on baleen whale habitat and prey. The results will also be of more general value to future efforts to study cetaceans in a multidisciplinary context.

12.3.2 SOWER cruise activities

These are discussed in Item 9.9.1 and Annex Q.

12.3.3 Noise

SC/50/E8 and E9 provided overviews of the complex topic of noise in the oceans and its potential significance for marine mammals. Both papers considered established sources of marine noise as well as new and potentially important sources, including seismic surveys, sonar systems such as the US Navy's SURTASS-LFA system, and other sources such as the Acoustic Thermography of Ocean Climate (ATOC) experiment. During its discussion of these papers and additional information presented by Clark (Annex H, Appendix 6), the Committee noted the difficulty of assessing the potential impact of various sources of anthropogenic noise on marine mammal populations. Two important considerations were identified when designing studies to try to measure the impact of noise on marine mammals: (1) the need to identify appropriate measurable variables and apply statistically sound analytical techniques and (2) the need to identify ways to determine the biological significance of any response. The latter requires a more comprehensive evaluation of the relevant sources of noise and their frequency ranges. Given the potential of noise pollution to affect right whales, the Right Whale Workshop (SC/50/Rep4) had recognised the importance of understanding the anatomy and physiology of right whale hearing. It noted that such studies are being undertaken by D. Ketten (Woods Hole, USA). It had recommended that, where possible, suitable samples (frozen or fixed middle and inner ears) be collected for Southern Hemisphere animals, following the protocol given in Blaylock *et al.* (1995).

This led to a general discussion of how to measure short- and long-term behavioural responses of cetaceans, a question which also arose in consideration of whalewatching (see Item 15 and Annex J) and at the Right Whale Workshop (SC/50/Rep4). The Committee noted the broad scope of any attempt to assess the impact of noise (both anthropogenic and non-anthropogenic) on marine mammals. While recognising that this issue is relevant and important, it **agrees** that attempting a major initiative on the impact of noise on cetaceans was not advisable at this time.

12.3.4 Ozone depletion

SC/50/E4 summarised the mechanisms by which ozone is destroyed, the recent trends in ozone depletion in polar regions, and the sources of ozone and UV/B measurement in the Arctic. The 1997 polar-averaged, column-integrated ozone depletion was approximately 21% of historic levels, and comparable to depletions observed during the previous four winters. Potential ecological consequences of ozone depletion include altered trophic interactions, reduced biomass production, changes in species composition and diversity, and alterations of biochemical processes.

12.3.5 Physical and biological habitat degradation

The Workshop on the Comprehensive Assessment of Right Whales (see SC/50/Rep4) made the following statement with respect to habitats:

> The Workshop recognised the importance of quantitative studies of right whale habitats. It noted the increasing importance that the Scientific Committee has placed on environmental change and habitat studies (e.g. IWC, 1998k). In this context it **recommends** that

the Committee considers convening a workshop to develop approaches to quantify key features of whale habitats, including trophic structure; right whales should be considered as a potential key species. Such a workshop would involve a variety of disciplines.

With respect to right whales, particular attention should be paid to comparative studies between the Northern and Southern Hemisphere populations. Such studies should: (1) identify the most important parameters characterising right whale habitats and standardise methods to measure them; (2) assess 'threshold' levels of disturbance (including noise, temperature, food availability); and (3) identify potential sources of disturbance.

The above recommendation was endorsed by the Committee (Item 9.2.2).

The Standing Working Group on Environmental Concerns (SWGEC) received a proposal for an intersessional workshop on habitat degradation and its possible effects on cetacean populations. There was considerable discussion of this proposal, after which it was **agreed** that a preferable course of action would be to develop a revised proposal that incorporated the recommendation from SC/50/Rep4. Initial informal discussions led to a slightly revised proposal (Annex H, Appendix 7) being presented for information. The Standing Working Group had believed that this required further work and it was **agreed** that interested scientists should continue informal discussions with a view to presenting an agreed revised proposal to the Committee during the meeting for consideration. In the event, no agreed proposal was submitted. The Committee **agreed** that this should be considered further next year.

12.3.6 Effects of fisheries

Kemper and Gibbs (1998) reported on marine mammal entanglements in tuna farms in South Australia. The Committee noted that there are proposals to build similar fish farms in other countries; such facilities provide another potential source of marine mammal mortality and should be monitored.

12.3.7 Disease and mortality events

O'Hara *et al.* (1998) presented results of a viral serologic survey of bowhead whales in Alaska. The Committee **agrees** that such studies are important to provide a scientific basis for understanding effects on cetaceans of complex environmental problems, and **encourages** similar studies. SC/50/E7 reported on potential new opportunities for collaboration arising from recent international developments, particularly those relating to the 'Year of the Ocean', and identified some major perturbations in the marine environment that have occurred since the last meeting. Simmonds (1997) suggested a framework for considering cetacean strandings. The Committee noted that such attempts to improve understanding of the meaning of cetacean strandings were important, albeit ambitious. Nevertheless, it was recognised that information gathered from strandings, when viewed from a larger context and considering possible environmental effects, could help build a basis for understanding these events.

12.4 Arctic issues

The subject of environmental concerns in the Arctic was discussed primarily under Item 12.5. The Committee **agrees** to establish an e-mail group to address this subject, and members interested in participating were instructed to contact DeMaster or O'Hara (see Annex V).

12.5 Longer-term priorities and directions

In discussion of Arctic environmental issues, it was agreed that a research initiative focussing on Arctic cetaceans may be appropriate at some time in the future. Some members noted that focus on white whales and narwhals in 1999 might provide an impetus for the Committee to also focus on environmental concerns for those species. The Committee **agrees** that Arctic issues and the habitat definition/degradation initiative would be of lower priority in the coming year than the two ongoing research initiatives.

The Committee was informed by Slooten, Simmonds and von Bismarck of the formation of an informal information review group that would collect and review intersessional developments in the marine environment likely to impact cetaceans. That group intended to submit to the Committee an 'Annual State of the Cetacean Environment Report'. The Committee was also informed that that group might collaborate with the Emergency Task Force of UNEP's Marine Mammal Action Plan (Item 5.6; IWC, 1998b, item 5.8).

After considerable discussion, the Committee **agrees** that its priorities for the near-term and mid-term can be summarised as follows.

(1) The two ongoing research initiatives should be accorded the highest priority:
   (a) significance of pollutants and chemical contaminants on cetaceans;
   (b) baleen whale habitat and prey studies in the Southern Ocean, related to climate change (with CCAMLR and SO-GLOBEC).
(2) The following two projects were considered lower in priority:
   (a) developing a mechanism for identifying and evaluating the parameters defining cetacean habitats, and the use of those to evaluate the effects of physical and biological habitat degradation on cetaceans;
   (b) investigating effects of environmental change on populations of Arctic cetaceans.
(3) The Committee identified a number of other issues it considered important, but that were not identified as priority items for the forthcoming year. They include:
   (a) investigating the impact of environmental factors found in individual cetaceans for consequences on population level;
   (b) investigating the possible impact of oil pollution on cetacean health.

12.6 Intersessional Work Plan

The following intersessional activities are planned, with estimated costs given in brackets.

Pollutants and Contaminants

(a) Prepare and hold the Planning Workshop (Barcelona, November 1998[3]) related to the pollutant and contaminants research initiative (no new funds required).

Climate Change and Habitat

(a) Complete planning and conduct the Sightings Workshop (St. Andrews, March 1999) (£25,000).
(b) Continue planning activities in conjunction with CCAMLR and SO-GLOBEC for the SOWER 2000/2001 programme (£7,000).

[3] *Editor's note*: for logistical reasons, the 'POLLUTION 2000+' Workshop was held in March 1999.

Other Concerns

(a) Develop an agreed proposal for a workshop on habitat definition/degradation.

Arctic

(a) Identify potential issues and activities related to assessing environmental effects on Arctic cetaceans, through the established e-mail group (Annex V).

13. SMALL CETACEANS

13.1 Action arising from the 1997 meeting

The Committee has on several occasions expressed great concern about the perilous status of the vaquita, which is endemic to the upper Gulf of California. Last year it welcomed information that the Mexican Government had convened an International Committee for the Recovery of the Vaquita (ICRV). It looked forward to receiving a report on further developments at this meeting.

The Committee was informed that the ICRV had not met in early 1998, as had been expected, but that it would do so in October 1998. At that time it will consider the following topics: a temporal assessment of the unusual age structure of samples from bycatches; a spatial analysis of bycatches, incorporating age, sex, date and the geographical boundaries of regulatory areas; a description of fishing grounds and perhaps fishing effort; a review of the most recent estimates of abundance; initial formulation of a recovery plan, incorporating socio-economic factors. The Committee once again offered to assist the ICRV in its work in any way possible.

13.2 Review of small cetaceans in the Indian Ocean and Red Sea, with special reference to the Middle East

Reflecting the information available to it in presented papers, the Committee limited its discussion to the northwestern part of the Indian Ocean, and in particular waters bordering the Arabian Peninsula. Three geographical zones were arbitrarily defined within this region and considered in turn:

(1) the shallow, semi-enclosed Arabian (Persian) Gulf;
(2) the Arabian Sea including the Gulfs of Oman and Aden; and
(3) the Red Sea.

The Red Sea and Gulf of Aden had been considered to some extent last year when cetaceans in the coastal waters of Africa had been discussed as a priority topic.

Detailed discussions at this meeting on this topic are given in Annex I. Included here is a summary, with emphasis on conservation concerns and recommendations for further study.

The quantity and quality of data on small cetaceans in the Middle East region are strongly biased towards the few areas where experienced researchers have spent time. Coastal waters of Oman have been relatively well studied, and surveys of a portion of the Saudi sector of the Arabian Gulf coast were conducted following the 1991 Gulf War. Otherwise, little is known about the cetacean fauna of the northern (Iran) side of the Arabian (Persian) Gulf, the Arabian Sea coast of Yemen or the Gulf of Aden and Red Sea.

13.2.1 Arabian (Persian) Gulf

The Arabian (Persian) Gulf is connected to the Gulf of Oman by the Strait of Hormuz. Most of the water flowing into the Gulf enters on the north side of the strait. Circulation is poor with a turnover time of about 3-5 years for water entering the Gulf (SC/50/SM1). Average water depth is only 35m. The high salinity, high turbidity and pronounced seasonal flux in water temperature make the Gulf a 'naturally stressful environment' for cetaceans and other fauna (SC/50/SM1).

Only three species can be considered common in the Gulf. All common dolphins (*Delphinus*) observed at sea and examined in museum collections have been of the long-beaked form. Hump-backed dolphins (*Sousa chinensis*) appear to be widely distributed throughout the Gulf, albeit mainly in waters less than 30m deep. Bottlenose dolphins (*Tursiops*), all considered to be *aduncus*-type animals, are relatively abundant. A fourth species, the finless porpoise (*Neophocaena*), is of major concern because of its limited distribution, vulnerability to bycatch and likely susceptibility to disturbance from coastal development, land reclamation and vessel traffic. It seems to occur in the Gulf in low abundance.

The three other species definitely recorded from the Gulf – false killer whales (*Pseudorca crassidens*) (5-6 records), pantropical spotted dolphins (*Stenella attenuata*) (1-2 records) and spinner dolphins (*Stenella longirostris*) (2-3 records) – are probably rare.

13.2.2 Arabian Sea, including the Gulf of Oman and Gulf of Aden

This region is much larger and more diverse than the Arabian (Persian) Gulf. The shelf off northern Oman is generally more than 50km wide; water in the central part of the Gulf of Oman is more than 1,000m deep, and in some areas more than 3,000m deep. From Ra's al Hadd southwestwards, the shelf is narrow, and a strong seasonal upwelling supports kelp communities and extensive fisheries. Off the central coast of Oman, from Masirah Island and south to Shuwaymiyah, the shelf is relatively wide (~20-50km), compared to other areas, such as Ra's al Hadd itself and near Salalah where water depths exceed 1,000m, 5-10km from shore.

In Omani waters of the Gulf of Oman and the Arabian Sea, the following species have been confirmed (SC/50/SM6): dwarf sperm whale (*Kogia simus*), Cuvier's beaked whale (*Ziphius cavirostris*), melon-headed whale (*Peponocephala electra*), false killer whale, killer whale (*Orcinus orca*), rough-toothed dolphin (*Steno bredanensis*), Risso's dolphin (*Grampus griseus*), Indo-Pacific hump-backed dolphin, *Delphinus* sp., bottlenose dolphins (reportedly two forms), pantropical spotted dolphin, striped dolphin (*Stenella coeruleoalba*) and spinner dolphin. The most frequently encountered species in Omani coastal waters are *Delphinus* spp., *Tursiops* spp., and hump-backed and spinner dolphins (SC/50/SM6).

Common dolphins are widely distributed and abundant in the northwestern Indian Ocean (SC/50/SM6). All those observered by Ballance and Pitman (1998) were long-beaked and judged to be the '*tropicalis*' form; they had a *delphis*-type colour pattern. Bottlenose dolphins, understood to include at least *Tursiops* c.f. *aduncus* and possibly also *T. truncatus*, are relatively abundant in Omani waters (SC/50/SM6). LeDuc and Curry (1996) have shown from cytochrome B genetic analysis that the nominal species *Tursiops aduncus* is a separate species from *T. truncatus* and that they are not even sister taxa. Collection of tissues for DNA analyses is especially **encouraged** to help resolve questions as to which species are present in the Indian Ocean.

False killer whales are reported relatively often in offshore waters of the Gulf of Oman, sometimes in association with yellowfin tuna (*Thunnus albacares*). The Indo-Pacific

humpbacked dolphin is a coastal, shallow water species. There is a gap in the records between the Strait of Hormuz and Ra's al Hadd. To the south and west of the latter, the distribution may be continuous along the coast all the way to the Gulf of Aden and Red Sea (SC/50/SM6). The pantropical spinner dolphin is widely distributed in the Gulf of Oman and along the Arabian Sea coast of Oman and southwards into Yemen (SC/50/SM3 and SC/50/SM6). Two colour morphs have been observed in Omani waters.

13.2.3 Red Sea

Last year, it was noted that at least eight small cetacean species are known to inhabit the Red Sea (IWC, 1998f), of which the Indo-Pacific hump-backed dolphin, the bottlenose dolphin (*aduncus* form and other larger form in the Gulf of Suez) and the pantropical spotted dolphin are the most common. Spinner dolphins, rough-toothed dolphins, Risso's dolphins, killer whales and false killer whales are also present. No new data from the Red Sea were presented to the Committee.

13.2.4 Conservation problems

Several concerns have arisen with respect to the status of small cetaceans in the region. There is a dearth of information about cetacean interactions with the substantial fisheries in the Arabian Peninsula region, although they are known to have expanded rapidly in recent decades, at least in some areas (Esseen, 1996). Incidental takes certainly occur (SC/50/SM6), and their impact could be severe, but insufficient information is available to allow assessment of their importance to cetacean populations.

Pollutants are another major concern in the region. The poor circulation in the Arabian (Persian) Gulf, particularly, means that contaminants remain concentrated for long periods (SC/50/SM1). Not only has the Gulf experienced two very large-scale oil spills in recent years (Nowruz in 1983 and the Gulf War in 1991), but it is also estimated that some 1,500,000 tonnes of oil are released in the Gulf each decade as a result of normal oil production and transport (Michel *et al.*, 1986, cited in SC/50/SM1). In 1983, after the Nowruz spill, at least 38 dugongs, 33 cetaceans and thousands of fish were found dead, but no direct link was established between the oil spill and these mortalities. The 1991 spill in the northwestern Arabian Gulf was the largest in history. Between January and May that year 600,000 to 1,000,000 tonnes of crude oil were intentionally released, covering some 500km of coastline between southern Kuwait and Abu Ali Island, Saudi Arabia. A large die-off of marine mammals occurred, including at least 57 bottlenose dolphins, 13 hump-backed dolphins, one finless porpoise and seven unidentified animals. A large die-off also occurred in the Gulf in 1986, when at least seven dead dugongs and some 520 dead cetaceans (including *Tursiops* sp. and *Sousa, Delphinus* and *Neophocaena*) were observed on the beaches of Qatar, Saudi Arabia, Bahrain, Iran, Kuwait and the UAE (Anon., 1986; Preen, 1991). Its cause was never established.

Detailed studies are needed to elucidate the primary cause(s) of the observed die-offs. They should include investigations of the role of bio-toxins, diseases and pollution with respect to both direct impacts on the cetaceans and indirect effects via their food-chain. Particularly relevant are pathological studies of cetaceans, focussing on the chronic toxicity of e.g. poly-aromatic hydrocarbons (PAHs), to assess the general health state of cetaceans in that area with respect to oil contamination.

A third potential concern is the possibility that there may be some directed hunting in the region. Archaeological evidence summarised in SC/50/SM6 indicated human consumption of dolphin products in Oman as long ago as 5000BP. Recent observations of a very small number of butchered animals on beaches (SC/50/SM6) suggests that there may still be some use of cetacean products in some areas in the region. It is unclear whether the animals concerned were naturally stranded, the result of incidental capture in fishing gear or the result of direct capture. Anecdotal evidence suggests that there may be some limited sporadic hunting in some areas of the region, but there is no confirmed evidence for this[4].

A final, more generalised concern is that habitat degradation and loss may have already had a substantial impact on coastal cetaceans in the region. For example, there are references to declining abundance of hump-backed dolphins in the Arabian (Persian) Gulf, where the finless porpoise is thought to be rare. Both species may be affected by coastal development (e.g. land reclamation, dredging, intensive motor vessel traffic).

13.2.5 Recommendations for further study

(1) No formal abundance estimate is available for any population of small cetaceans in the region. In the light of concerns about bycatch and the possible effects on cetacean populations of pollution and other forms of habitat degradation and loss, the Committee **recommends** that governments initiate studies of stock identity and field surveys for stock assessment. Initially, these should focus on coastal populations of hump-backed, bottlenose and common dolphins. The possibility of using data from systematic aerial surveys of dugongs (past and future) to obtain estimates of bottlenose and/or hump-backed dolphin abundance should be investigated.

(2) The Committee agreed that the few records of cetacean bycatch in fisheries probably substantially under-represent actual bycatch levels. Everywhere else in the world where gillnet fishing occurs and cetaceans are present, there is some bycatch, and virtually all species of cetaceans are susceptible (Perrin *et al.*, 1994). The Committee **recommends** that programmes be established to monitor the species and numbers of cetaceans caught. Self-reporting is not adequate, so observer programmes will be necessary. Information on fisheries techniques and effort should also be obtained to enable evaluation of results of bycatch studies.

(3) Papers submitted to the meeting demonstrated the usefulness of museum collections in providing basic knowledge about what species occur in the region. The Committee **recommends** that further work on specimen collection and curation be supported by appropriate governmental and non-governmental agencies. This should include the establishment of networks to detect, record, examine and collect biological samples from

[4] This paragraph is a modified version of that originally agreed by the Committee. The Commission agreed that it should be incorporated into this report for clarification. The original paragraph read: 'A third concern, in addition to bycatch and pollution, is directed hunting. Data summarised in SC/50/SM6 indicate a long history of human consumption of dolphin products in Oman. Recent observations of butchered animals on beaches (including common, bottlenose, spinner and hump-backed dolphins in Oman) shows that there is still some demand for cetacean products in the region.'

stranded cetaceans on a systematic basis. One value of such networks is that they provide measures of background stranding frequency. Specimen collection should include biopsies and other tissue samples for genetic analyses of population structure and pollutant assays (see following recommendation).

(4) The waters of the Arabian Gulf are highly polluted by oil, and at least three recent die-offs of cetaceans and other animals (1983, 1986, 1991) have been documented. The causes of these die-offs were not adequately investigated and therefore remain uncertain, although two were coincident with major oil spills. The Gulf could not be bettered as a site to study the effects of chronic exposure of hydrocarbon contaminants on cetacean populations. Little or no work has been done to measure contaminant burdens of cetaceans in the Gulf or elsewhere in the Middle East. The Committee **recommends** that such studies be carried out.

(5) The Committee drew particular attention to the need for detailed studies of the conservation status of hump-backed dolphins and finless porpoises in the Middle East and **recommends** that such studies be carried out. Continuation and expansion of studies of the systematics of spinner, bottlenose and humpbacked dolphins are also **strongly encouraged**. For these and other studies the Committee emphasised the importance of training and involving local scientists from range states in the region.

13.3 Further consideration of the criteria for assessing the status of harbour porpoise populations

Last year the Committee agreed that no one algorithm for assessing the conservation status of small cetacean populations was likely to be appropriate in all circumstances. It also recognised that simulation studies, taking into account uncertainty in stock identity, would likely provide a way forward in resolving the question of which algorithms might best be used on a case by case basis. Because insufficient resources were available to the Committee during its annual meetings to develop this approach, a group had been set up under Bravington to work intersessionally and report back in 1998. At this meeting it was reported that Bravington's group had made limited progress, due largely to time constraints, but that a final summary report was expected by August 1998.

The Committee considered a report from ASCOBANS (SC/50/SM12), the multi-lateral agreement with conservation responsibilities for small cetaceans in the North and Baltic Seas. It has recently refined its aim as 'to restore and/or maintain biological stocks of small cetaceans at the level they would reach when there is the lowest possible anthropogenic influence', and its interim conservation objective is 'to restore populations to, or maintain them at, 80% or more of the carrying capacity'.

The Committee has recommended under Item 5.1.1 to establish a joint working group with ASCOBANS to consider scientific matters relating to the status of harbour porpoises in the eastern North Atlantic. It was **agreed** that membership of the IWC component and terms of reference should be as proposed in Annex I, Item 6.

The Committee **agrees** that the joint working group should meet intersessionally, and that the work should begin by e-mail. The Committee proposed that the meeting should occur in February 1999, allowing the completion of project BY-CARE which includes an investigation of harbour porpoise population structure in the North Atlantic. An example of one of several scientific approaches that ASCOBANS might find helpful in achieving its objectives is given in Annex I, Appendix 2.

13.4 Review of other presented information

SC/50/SM7 noted that although the trend data were not quantitative, porpoises appeared to have significantly declined across the Baltic region. Even minimum bycatch estimates exceeded the calculated sustainable mortality limit. Very few data on bycatches are available from the region and the situation is likely to be even worse than indicated in SC/50/SM7. It was noted in SC/50/SM12 that ASCOBANS has commissioned a study to review research options for Baltic Sea harbour porpoises. This is currently being reviewed by an ASCOBANS working group.

Recalling its recommendation of last year that work should continue to accurately assess the status of franciscana populations and bycatch levels, the Committee reviewed SC/50/SM10, which described an attempt to use gastrointestinal parasites to discriminate ecological stocks of the species. The author concluded that the different prevalence of these biological markers indicated that the franciscanas in these two regions could, at least during spring, be considered separate ecological stocks. Unfortunately, it was not possible to stratify the sample of franciscanas by age to determine whether ontogenetic variation in parasite loads might exist, because age information was not available for the Uruguayan or Argentinian samples. Pinedo emphasised the value of using these biological tags as a tool to assist in defining ecological stocks. Kasuya underscored the importance of knowledge of residency time of these gastrointestinal parasites in their hosts, as it could also influence the results of such geographical comparisons.

Estimates of bycatches of small cetaceans in two California gillnet fisheries were described in SC/50/SM2 and SC/50/SM5. In the driftnet fishery for swordfish and sharks, 692 sets were observed (approximately 27% of total fishing effort), in which 41 small cetaceans of 7 species were taken. No direct observations were made of the set net fishery for halibut and angel sharks, so mortality was estimated using data on bycatch rate obtained in previous years. Of particular interest to the Committee were the results of an experiment to test the effectiveness of acoustic alarms in the driftnet fishery. The observed rate of entanglement in driftnets with acoustic alarms (0.028 small cetaceans per set) was significantly lower than the corresponding value for nets without alarms (0.11). The success of the experiment had resulted in the mandatory use of acoustic alarms in the fishery, in addition to other mitigation strategies. This was the first successful demonstration of the use of acoustic alarms for species other than harbour porpoises, although a reduction was not observed for all species.

The potential uses of passive acoustic techniques in surveys of small cetaceans, as described in Gordon *et al.* (1998), were reviewed. The equipment consists of a single high frequency hydrophone, towed behind a survey vessel. Porpoise clicks, which are narrow band pulses centred around 130kHz, are detected automatically or recorded by an operator. The approach could be used alone or as an adjunct to human observers using visual survey techniques. Limitations include the difficulty of estimating distance and bearing to porpoise groups and determining how many animals are present in a group. Some of these problems (resolving distance and bearing) may be partially overcome by the use of multiple hydrophones in a towed array.

One particularly promising application of this technology is the use of acoustic monitoring to make primary detections of porpoises in conjunction with a tracker team using visual techniques. It may be difficult to match groups identified by acoustic and visual techniques, and variation in click production due to environmental conditions, time of day and behavioural state still needs to be addressed. Despite these limitations, however, the Committee **agrees** that the approach holds considerable promise, particularly for small cetaceans in low densities.

SC/50/SM9 discussed passive acoustic surveys of striped dolphins in the Ligurian Sea between 1994 and 1996. Hydrophone arrays were towed behind survey vessels and one-minute recordings were made at regular intervals. In general, striped dolphins were found throughout the area, although densities increased in offshore waters. Detection rate dropped with increasing wind speed and sea state and increased at night, suggesting that striped dolphins may be more active at night than during the day.

The Committee's attention was drawn to an apparent increase in takes of Dall's porpoises in Japanese waters from 12,396 in 1995 to 18,540 in 1997 (Annex I, Appendix 3). Okamoto commented that the annual quota of Dall's porpoises in Japan had been set at 17,700 and that this had remained unchanged. As explained in SC/50/ProgRep Japan, however, the Japanese Fisheries Agency (FAJ) changed the quota period for Dall's porpoise fisheries in 1996. Thus, although statistics in Annex I cover the period from 1 January to 31 December 1997, catches made during this period fall into two periods for the reporting purposes of the FAJ. Catches of Dall's porpoises between 1 August 1996 and 31 July 1997, for example, were 16,723, less than the quota of 17,700. Thus, the apparent increase in the harvest of Dall's porpoise in Japanese waters represents a combination of changes in the quota period and inter-annual variation in catch levels.

Brownell raised the question of the magnitude of catches of Dall's porpoises and other cetaceans in the Japanese salmon drift net fishery operating inside the EEZ of Russia, specifically the former research fishery and the commercial fishery since 1992. Okamoto responded that, at present, no data were available. The Committee **encourages** the government of Russia to provide information on the size of bycatches in this fishery. Because of the Committee's past concerns over the status of various Dall's porpoise stocks in the western North Pacific, all available by-catch data should be presented to it to aid in its future review of the status of these stocks. Komatsu stated that since the IWC does not have competence over the management of small cetaceans, Japan would not consider it appropriate to formally provide information related to the management of small cetaceans including Dall's porpoises in fisheries, including the Japanese salmon fishery in the EEZ of Russia.

The Committee discussed the adequacy of information contained in Annex I, Appendix 3. It noted that this was incomplete, and therefore potentially misleading, and that both direct and indirect takes of small cetaceans were known to occur in several countries but were not included because of the lack of quantitative information. The missing data compromised the Committee's ability to do the work asked of it by the Commission (e.g. in IWC Resolution 1997-8). The Committee suggested that situations where it believes catches occur, but where no quantitative information exists on their magnitude should be noted in Annex I, Appendix 3, and again **urges** that member countries not contributing information be reminded of the Commission's Resolutions.

13.5 Future priorities and directions

After a wide-ranging discussion, the Committee **agrees** that the current process of setting small cetacean priority topics for discussion is sound. The Committee will therefore continue to identify topics that generally involve the assessment of conservation status of particular taxa, where such assessments are useful and appropriate. These topics may focus on methodology for assessing conservation status, on a geographical region, on one or more species, or on a subject matter with relevance to many species (such as interactions with a type of fishery). The topics should be chosen on the basis of one or more stated criteria, for example (a) recent research progress in a given field, (b) particular concern about conservation status due to levels of directed takes, bycatch or mass mortalities, or (c) the geographical location of the meeting. Once decided, priority topics should not be changed unless there are sound scientific or logistical reasons for such a change, or if so instructed by the Commission. The Committee considered that the manner in which it conducts its work was appropriate and should be continued, including proposing priority topics up to three years in advance. However, occasional intersessional meetings may offer a more effective way of dealing with some areas of work and reducing the current backlog.

It was **agreed** that the two priority items identified last year for the 1999 meeting should be maintained: status of white whales and narwhals, and recent advances in bycatch mitigation measures (specifically acoustic deterrents). The Committee proposed a new priority topic for discussion at its meeting in 2000 – a review of the status of freshwater cetaceans. For the purposes of the review, these were defined as the boto, baiji, Indus and Ganges susus, tucuxi and freshwater populations of the Irrawaddy dolphin and finless porpoise, noting that comparison with marine populations of the latter two species may be of value. Bycatch reduction measures should continue as a priority topic in that year. The Committee **agrees** to delete the global review of the genus *Lissodelphis* from its list of priority topics for discussion in 2001 and beyond, as the primary threat to this taxon (entanglement in high seas driftnets) has been greatly reduced. A review of the status of small cetaceans in the Caribbean region was agreed upon as a replacement topic. Thus, the schedule for priority topics is given as Table 9.

14. SCIENTIFIC PERMITS

14.1 Advice on the effect on stock(s) of scientific permit catches

This Item had been kept on the Agenda but not discussed last year (and see IWC, 1997, p.93). In the absence of documentation it was again not discussed but kept on the Agenda.

14.2 Review of results from existing permits

14.2.1 Japan - Southern Hemisphere

Last year, the Committee had undertaken a detailed review of the JARPA programme and had identified a number of areas for future work. Progress on that work is given in Annex E, Appendix 8 and is reviewed in Item 9.7.

A number of documents relating to the JARPA programme were presented to the meeting (SC/50/CAWS 4, 7, 8, 9, 32, 33, SC/50/E2 and SC/50/O3). They are discussed in Annex E and Annex H.

Hatanaka introduced SC/50/O12. He believed that the Commission's Resolution last year (IWC Resolution 1997-5; IWC, 1998a, p.47) and related comments by the

Table 9

Priority topics for discussion on small cetaceans.

Year	Topic	Justification
1999	Status of white whales and narwhals	Magnitude of directed takes; evidence of decline in exploited population; availability of new research results
	Bycatch mitigation measures (acoustic deterrents)	Large amount of new research results
2000	Status of freshwater cetaceans	Poor conservation status and continuing threats
	Bycatch mitigation measures	Large amount of new research results
2001+	Status of Dall's porpoises	Continuing catches; lack of recent assessment
	Systematics and population structure of *Tursiops*	Large amount of new research results
	Status of ziphiids in the Southern Ocean	Lack of previous assessment
	Status of small cetaceans in the Caribbean Sea	Lack of previous assessment; continuing catches and bycatches

Commission had misrepresented the Committee's advice with respect to JARPA's contribution to management by quoting only the first part 'JARPA results were not required for management' of the relevant sentence without the subsequent clauses referring to its potential to improve management in a number of ways. In SC/50/O12 he elaborated on how he believed JARPA results contributed to the management objectives agreed by the Commission (IWC, 1990, p.18) particularly with respect to estimating MSYR. He believed that in order to avoid misunderstandings, it was important for the Committee to bring to the Commission's attention the fact that JARPA provides information that is critically important for management.

Goto concurred with Hatanaka's viewpoint and added that he believed that the combination of genetic, morphological, age and sex segregation information coming out of JARPA with respect to stock structure in Areas IV and V was essential for *Implementation Simulation Trials* in the RMP.

In discussion, it was noted that the Commission's Resolution did include information on the potential for JARPA to improve management. However, for clarity, the Committee **agrees** to repeat its full statement from last year on this matter:

> 'while JARPA results were not required for management under the RMP, they had the potential to improve it in the following ways: (1) reductions in the current set of plausible scenarios considered in *Implementation Simulation Trials*; and (2) identification of new scenarios to which future *Implementation Simulation Trials* will have to be developed (e.g. the temporal component of stock structure). The results of analyses of JARPA data could be used in this way perhaps to increase the allowed catch of minke whales in the Southern Hemisphere, without increasing the depletion risk above the level indicated by the existing *Implementation Simulation Trials* of the RMP for these minke whales.'

Smith commented that the RMP only requires data the Committee believe can be reliably measured, i.e. abundance and catch data, although he now noted that in some circumstances there is uncertainty about the latter. He believed that not only is additional information on MSYR not required, but that incorporation of such information would entail far more extensive modifications to the RMP specifications than he thought the Committee had envisaged.

14.2.2 Japan - North Pacific

A number of documents incorporating information from JARPN were presented (SC/50/RMP7, 8, 12 and SC/50/O3). These are discussed in Annex D.

14.3 Review of new or revised proposals

14.3.1 JARPA – Southern Hemisphere

SC/50/O1 presented the 1998/99 JARPA research plan. This is a continuation of the programme that has been extensively discussed previously by the Committee. It is the 10th full-scale survey of a 16-year research programme. The survey will cover Area V and the western half of Area VI to focus on the issue of stocks within the framework of the four major objectives of the programme. The need for elucidation of stock structure and clarification of stock definition has been discussed previously by the Committee (and see Item 7.5). Details of the programme's findings in this regard have been presented in papers to the Committee, e.g. SC/50/CAWS4. In order to clarify matters suggested by that analysis, it is proposed to again survey the western part of Area VI. In response to comments from some Committee members, it is planned to carry out a feasibility study on a revised sampling protocol in part of the area.

The survey period is the same as in previous years and the sample size is 400±10%. One research vessel, three sampling/sighting vessels and one dedicated sighting vessel will be used. Participation by international scientists is welcomed.

Smith expressed appreciation of the work outlined in Annex E, Appendix 8, and particularly the initiative with respect to stock definition (see Item 7.5) and to the response to Taylor's proposal (SC/49/SH28) given in SC/50/CAWS7. He also encouraged the proposers to pursue the meso-scale survey possibilities.

However, Smith expressed concern about the problem of decreasing selectivities with age, noting that SC/50/CAWS32 suggests that this possibility requires further attention. In this regard the Committee was pleased to note that Polacheck, Butterworth and Punt intended to work towards presenting a joint paper on VPA analyses to the next meeting.

Smith also noted the importance of examining the age distribution data in terms of distance from the ice-edge at a relatively fine spatial scale and taking into account inter-annual variability. In addition, distribution patterns of minke whales within the pack-ice could provide information on this problem. He identified additional data (e.g. other surveys for seals and birds, satellite information on pack-ice) that could be useful.

He believed that the above investigations of the representativeness of the JARPA samples were important and of direct relevance to the likelihood of JARPA meeting its objectives. Slooten concurred with this view.

In response, Fujise expressed his appreciation for the comments and suggestions made by Smith. He reported that pack ice information had been already taken into account during the JARPA survey. He noted that the southern

stratum of the JARPA survey is based on the ice edge. It is defined as the area within 45 n.miles north of the ice edge (excluding the Prydz Bay and Ross Sea regions). However, since pack ice is not firm and is always moving, he noted that it is difficult to measure the distance from the ice edge, particularly as it is only relatively recently that more precise satellite information on the pack ice has become available.

Fujise reiterated that the pack ice data were used in the analyses presented to last year's JARPA Review Meeting. Studies of the body fat condition of minke whales have also been examined in relationship to geographical variations of the pack ice. He concluded that this work would continue and would take into account Smith's comments.

Polacheck noted that SC/50/CAWS32 had no direct relevance to the question of non-random samples in the JARPA catches as the analyses in that paper were concerned with selectivity patterns in the commercial catches. However, if the presence of minke whales in the pack-ice has a large effect on the selectivity pattern in the commercial catch, it would also be expected to be the case for the JARPA catch. SC/50/CAWS37 reported a low proportion of sexually mature females in the JARPA samples from Area IV in 1997/98 compared to previous JARPA samples and attributed this to a large number of animals inside the ice-edge where the research vessel could not enter. This implies that large differences in the ages of the samples are likely depending on the extent of the ice-edge. Similar annual variations in sex ratio due to the effects of the ice-edge were commonly noted during the period of the commercial catch (e.g. Shimadzu and Kasamatsu, 1983).

Polacheck also noted that genetic analyses of the stored commercial biological samples would be extremely valuable for determining the stocks from which the commercial catch had come in the context of the VPA analyses (IWC, 1998b, p.103). Shimadzu stated that Japanese scientists were planning such analyses.

The Committee noted that the addition of quantitative echo-sounder equipment to the dedicated sighting vessels this year will provide the added capability of determining the distribution and abundance of food species including Antarctic krill. The effect of using such equipment on sighting surveys was briefly considered in Annex H.

Some members noted that information provided by JARPA could be of significant value for the elucidation of the effects of environmental change on whales and the Antarctic ecosystem.

In closing, Shimadzu expressed appreciation for the constructive comments provided by the Committee.

14.3.2 Japan – North Pacific

SC/50/O2 described the continuation of a programme begun in 1995 after a feasibility study in 1994, to examine (1) whether sub-stocks exist of the Okhotsk Sea-Western Pacific stock (O stock) of minke whale, (2) whether an additional stock (W stock) exists in the central part of the North Pacific, and if it does, the rate of mixing with O stock. One hundred animals will be sampled in two or three areas among sub-Areas 7, 8, 9, 11 and 12.

With regard to the sampling area in the 1998 survey, it was reported that as it seems difficult to get permission from the Government of Russia to operate in their waters, sub-Areas 7 and 8 (in May and June) and 11 (in July) were to be covered among three options in SC/49/NP1.

The Committee noted that it had not reviewed this proposal in detail since 1994. Some members further noted that subsequent proposals have not been updated since the initial proposal, particularly with respect to sample sizes, in the light of results obtained thus far. In this context, they referred to the development of a high-powered biopsy gun (SC/50/O15), noting that the potential of using this non-lethal method to meet some of the goals of the programme should be evaluated. Other members referred to previous unresolved discussions on the issue of lethal versus non-lethal research methodology. It was noted that a more detailed proposal was needed for the Committee to carry out a thorough review.

Hatanaka commented that at the meeting to specify North Pacific Minke Whale Trials held in 1996, Smith had noted that the information from JARPN had been helpful (IWC, 1997b, p.96). Hatanaka pointed out that the results from comprehensive analyses using JARPN data should be used for reconsidering the specifications of North Pacific trials.

Shimadzu responded that the research proposal would have been presented more fully had more time been available between the return of the cruise and the start of the subsequent IWC meeting. He reiterated that sample size questions and the issue of non-lethal alternatives had been effectively addressed in the initial research plan. However, he further noted that the estimated sample size requirement could be refined with additional data.

Komatsu stated that the programme could be terminated after the completion of the 1999 cruise if the Committee agreed that the research objectives had been adequately met by that time. The programme had been designed to examine whether or not (1) sub-stocks exist in the 'O' stock and (2) 'W' stock exists in the central part of the North Pacific. If the latter is true, it is necessary to estimate the rate of mixing with O stock. The first assumption was rejected in 1996. If the Committee reached an agreement on the W stock issue (i.e. rejection of the W stock hypothesis) by 2000, this would mean that the research objective had been met in a timely fashion. He also referred to the need to complete work on the research objective to elucidate the mixing of J and O stocks using the data obtained up to and including the 1999 cruise.

After some discussion, the Committee **agrees** that a comprehensive review of JARPN should be planned for 2000. If the programme is extended to the year 2000 or thereafter, a detailed and thorough research proposal should be submitted for review.

Komatsu further stated that the Government of Japan would elaborate the programme for 1999, taking into account the constructive comments made during the meeting and analyses of the 1998 data; it would circulate this to Committee members prior to departure of the cruise.

15. WHALEWATCHING

In 1996 the Scientific Committee (IWC, 1997b, p.106) identified four priority areas for consideration in future meetings:

(a) a more detailed review of the approach distances, effort and activity limitations in place in existing operations for a range of species, and information on the basis for such controls;
(b) an assessment of current studies of the effects of different approach distances and platforms;
(c) a review of the quantitative methods used to assess the short-term reactions of cetaceans and the basis for judgements of adverse effects;
(d) comparative studies on different approaches/distances and other controls which may be required on areas important for feeding, resting and reproduction.

Last year, (IWC, 1998b, p.113) the Scientific Committee noted the paucity of submitted information and recommended that all items of the Agenda be retained as

priorities for this meeting. In addition the Committee looked forward to reviewing the report on the adverse impact of feeding of dolphins at Monkey Mia, Australia, this year.

15.1 Action arising from the 1997 meeting, including Commission's response

No new resolution was made by the Commission in 1997. An updated version of world-wide whalewatching guidelines by Carlson (1996) was submitted. The Committee recognised that this was part of an ongoing review. Individual members were asked to comment on the draft where appropriate. The Committee thanked Carlson for her work.

15.2 Priority items

15.2.1 Review of guidelines

The Committee reviewed a number of submissions on guidelines and management from Australia including: management of swim-based whalewatching (SC/50/WW1); changes to national guidelines (SC/50/WW2); the formation of an industry association (SC/50/WW3); and the role of research in whalewatching management (SC/50/WW5). The Committee also received information on research and management of whalewatching in New Zealand (SC/50/WW6), Iceland (SC/50/WW7) and Norway (SC/50/WW8). There was some discussion as to which aspects of whalewatching should be considered by the Scientific Committee. The Secretary noted that not all items identified in the Commission's Resolution on whalewatching were applicable to the Committee. Arising out of discussions under this Agenda Item, the Committee **recommends** the formation of an Intersessional Correspondence Group (chaired by Carlson) to review (especially in the context of focussing the work of the sub-committee on whalewatching):

(1) scientific protocols for research on the effects of whalewatching;
(2) the scientific basis for management;
(3) research on the effectiveness of management.
(4) criteria for selection of suitable areas for long-term studies on the effects of whalewatching on cetaceans.

In order to make progress in its discussions of this subject, the Committee **recommends** that the Commission:

(1) encourages member governments to conduct relevant scientific studies and send scientists to future meetings to present them;
(2) encourages member governments and scientists to submit relevant scientific work, including scientific protocols, to the next meeting.

15.2.2 Assessment of short-term reactions

The Committee reviewed research on reactions of Hector's (SC/50/WW10) and dusky dolphins (SC/50/WW11) to tourism activities in New Zealand. In both studies dolphins were more tightly bunched in the presence of boats. The fact that shore-based theodolite tracking, used in these and other studies, results in no disturbances from the observer platform was noted. Kato and Findlay reported on land-based research that had been carried out in Japan and South Africa respectively and offered to submit results to future meetings.

Clark reported on observations of humpback whale responses to vessels off Hawaii during research projects designed to examine humpback whale responses to ATOC (Acoustic Thermography of Ocean Climate) and these suggested that response was elicited most strongly by acoustic dynamics (the rate of change of sounds) rather than sound levels. The Committee **encourages** the submission of a report on this to a future meeting of the Scientific Committee.

The Committee welcomed this information and noted that there may be considerable research information not directly aimed at assessing reactions of whales to whalewatching, but pertinent to that discussion. Clark agreed that intersessionally he would try to collate a list of such acoustic research. Interested members are requested to provide him with relevant references.

15.2.3 Comparative studies

SC/50/ProgRep UK described two studies being carried out at Aberdeen University. The first is the study also reported in SC/50/WW8 that involves the use of a theodolite in conjunction with video, while the second is a study on distribution and acoustic behaviour of bottlenose dolphins in an area of intense dolphin watching activity.

15.2.4 Report for Monkey Mia, Western Australia

The report of the bottlenose feeding activity (Annex J, Appendix 2) at Monkey Mia, Shark Bay, Western Australia was reviewed. It was noted that after the 1993 introduction of a new feeding regime, almost all the deaths could be ascribed to natural causes. Long-term ecological and behavioural studies on bottlenose dolphins in Shark Bay are continuing.

The Committee noted the General Principles for Whalewatching that it had agreed in 1996 and which had been endorsed by the Commission (IWC, 1997). It believed that dolphin feeding did not concur with the principle that cetaceans should be 'allowed to control the nature and duration of interactions'. It **agrees** that this matter should be kept on its Agenda.

15.3 Longer term priorities

The Committee **reaffirmed** the four priority areas it had identified for future work at its 1996 meeting (IWC, 1997) and also **agrees** that a further item on assessment of long-term effects be included as a future priority.

Komatsu, Lawrence, Okamoto, Walters and Yagi expressed reservations about IWC competence over the management of whalewatching and dolphin feeding because they believed that issues related to whalewatching as well as small cetaceans were outside the scope of the Convention.

16. WHALE SANCTUARIES

For the last three years (IWC, 1996a; 1997b; 1998b), the Committee has requested advice from the Commission on commonly agreed objectives for the Southern Ocean Sanctuary, in the context of a recommendation from a Commission Working Group in 1995. The Commission has as yet made no comment and the Committee **draws the attention** of the Commission to this and requests its advice. In particular, it notes that such advice is important in the context of developing a longer-term workplan (see Item 6.2) and given that the Commission may require scientific advice when it reviews the Sanctuary provision in 2004 (Schedule Para. 7b).

17. RESEARCH PROPOSALS

17.1 Review research results from 1997/98

Borchers reported that analysis of the 1996/97 SOWER survey data could not be completed before this meeting because the data were not available in time. The work was

underway and would be completed prior to next year's Committee meeting. Consolidated estimates of abundance of Southern Hemisphere humpback and sperm whales based on the data from the IDCR-SOWER cruises contained in DESS were reported in SC/50/CAWS37, and discussed under Agenda Items 9.3.3.1 and 9.6.2 respectively. SC/50/O15, reporting on the biopsy delivery system developed by Larsen, was reviewed under Item 4.2.3 of Annex E.

17.2 Review proposals for 1997/98

Five proposals were reviewed by the intersessional review group and outside reviewers and discussed further during this meeting. The group's report is given in Annex S. Zeh summarised its conclusions as follows.

A proposal for retrospective analysis and method development for integrated analysis for the SOWER 2000 survey of baleen whales and krill (SC/50/RP5) received the highest rating and was **recommended** for funding.

A proposal to develop a stock identification system for cetaceans based on trace element signatures (SC/50/RP1) was given a low score and not recommended for funding.

Two proposals for photo-identification and biopsy sampling of humpback whales in the South Pacific (SC/50/RP2 and SC/50/RP6) and a third proposal for genetic work on blue whales (SC/50/RP3) received intermediate scores and were considered worthy of support if funds were available after accounting for other needs and priorities identified by the Committee.

In discussion it was clarified that the method of stock identification based on trace elements (SC/50/RP1) was considered promising and further development of the method was **encouraged**. The proposal was given a low score because it failed to identify a specific stock identification problem to be addressed or to recognise some obvious complications in applying the method to migratory whales.

Some members believed that lower scores should have been given to SC/50/RP2 and SC/50/RP3, which had been scored low to medium and medium respectively, because of concerns about whether they could acquire adequate numbers of samples to meet their objectives.

It was noted that the photo-identification and biopsy sampling in French Polynesia proposed in SC/50/RP6 would provide data for a breeding area in the South Pacific where existing data are limited and that this might be valuable in assessing Southern Hemisphere humpback whales.

17.3 Research proposals - preambular text

Gambell outlined the terms and conditions (in the form of specimen wordings) which have been included in the contracts given by the IWC for research proposals during recent years. These are used selectively and modified as appropriate for the particular proposals and contracts under consideration.

The language used defines:

(1) the tasks to be performed;
(2) the schedule of work;
(3) the costs, including support for attendance at a meeting of the Scientific Committee to present a report on the work carried out;
(4) arrangements should data or specimens to be analysed prove to be inadequate or not available.
(5) the schedule of payments (this usually comprises an initial payment on signing the contract, a final payment on receipt of a final report, with provision for intermediate payment(s) if appropriate);
(6) identification of any proprietary software which may be used and licensed;
(7) recognition that any equipment purchased (or modified) using contract funds will become IWC property on completion of the project.

The Committee confirmed the *Understanding on Access to Data and Use of Software* considered in 1996 (Borchers and Allison, 1997).

On completion of the work, a final report should be submitted to the Commission (normally to the annual meeting of the Committee). Where a project has been completely or largely funded by the IWC, it has been expected that the paper, or rather those elements directly related to the Committee's priorities as agreed by the Editor in consultation with the proposer, should be submitted for publication in an IWC volume, subject to the normal review process.

Donovan pointed out that the IWC is unusual in that it is both a funding organisation and a scientific publisher, and argued for retention of this arrangement particularly given that these were unsolicited research proposals and in the context of a new journal initiative. There was disagreement over this provision within the Committee, although there was general agreement that proposers should be strongly encouraged to submit relevant papers, and this will be reviewed again next year. Similarly, the issue of intellectual property rights has not been addressed thus far, and should be considered.

18. DATA PROCESSING AND COMPUTING NEEDS FOR 1998/99

The Committee identified the requests for intersessional computing work given in Table 10. In the light of its discussions on Committee priorities (Items 6.2 and 6.3), the Committee **agrees** that the work identified for furthering the AWMP and RMP should be accorded highest priority. It noted that at present, this was estimated to account for eight months of intersessional work for Allison. The Committee recognised that final decisions on priorities would need to be made after the Commission meeting to take into account Commission deliberations. The Committee **agrees**, as last year, that the Chairman, in consultation with Allison and the Chairmen of those sub-committees requesting priority computing (Donovan, Hammond), will develop a final list of priorities as soon as possible after the closure of the Commission meeting. It **agrees** that this group would also review progress during the year to decide if priorities needed to be changed in the light of experience.

19. FUNDING REQUIREMENTS FOR 1998/99

The Committee noted that £59,888 is already available in the Research Fund to finance ongoing projects continuing from the current year. It **strongly recommends** that the additional research-related activities given in Table 11 (p.50) should be funded in the 1998/99 financial year.

This leaves a potential shortfall of £37,354. Given the importance of the items requested, the Committee **strongly requests** that the Commission funds all the designated activities.

The Committee **agrees** that in the event that the Commission is unable to support all the activities proposed, the Chairman should be authorised to suggest deletion of SC/50/RP5, i.e. £32,641.

Table 10

Computing needs for 1998/99. A: work to be done by Allison; C: contract out; S: work to be done by other members of the Secretariat; Small ≤ 1 week.

Task		By	Estimated time
AWMP			
(1)	Revise the program to implement the multi-stock trials for fishery type 1 as detailed in Annex F, Appendix 3.	A	1 month
(2)	Implement the stochastic dynamics model (including the three methods given in Annex F, Appendix (3) and apply the stochastic backwards method to obtain input parameters for fishery type 2. This may require iteration through the AWMP correspondence group. As a first step, modify the control program to input rather than pre-specify P_0 and apply the deterministic backwards method to obtain input parameters for fishery type 2 that can be used until the task is completed.	A	2 months
(3)	Modify the common control program to implement and run trials to investigate the effects of three different methods of incorporating stochasticity into fishery type 3 trials.	A	Small
(4)	Finalise the plotting program (in collaboration with Zeh).	A	Small
(5)	Investigate software distribution problems.		Small
RMP			
(6)	Complete internal documentation of, and a users guide for, the NCC program implementing the *CLA*, in consultation with the authors Annex D, Item 3.2.	A	1 month
(7)	Test NCC program above and conduct tuning according to the procedures given in Annex D, Appendix 2, Adjuncts 1 and 2.	A	1 month
(8)	Amend the control program and complete the conditioning of the North Pacific minke whale trials (Annex D, Appendix 6).	A	3 months
(9)	Add incidental catches off Japan and Korea to the catch data files for North Pacific minke trials.	A/S	1 week ?
(10)	Extract data from sightings database for calculation of additional variance.	S	Small
(11)	Complete documentation of the single stock control program (carried over).	A	2 weeks
(12)	Incorporate 1996/97 SOWER cruise data into the sightings database.	S	1 week
(13)	Coding of 1997/98 SOWER cruise and blue whale cruise data.	S	3-4 weeks
(14)	Validation of 1997/98 SOWER cruise data and incorporation into sightings database.	S	6 months
(15)	Coding and validation of data from 1998/99 SOWER and blue whale cruises.	S	6 months
(16)	Code pre and post IDCR data 1978/9-1991/92.	S	3 months/year of data (at least for most recent data).
Comprehensive assessment of whale stocks			
(17)	Code any revised Soviet catch data if they become available.	S	Depends on extent of data.
(18)	Complete validation of Southern Hemisphere Discovery marking data from 1930s.	A/S	2 months
(19)	Continue coding and validation of Southern Hemisphere catch records for the period 1900-1939, in particular the data from South Georgia.	S	Small
(20)	Investigate availability of original individual catch data for the *Olympic Challenger* and remove data known to be false from database. Retain/add to data where catches can be confirmed.	A/S	1 month
(21)	Remove false Soviet data from database and collate new data.	A/S	1 month
(22)	Enquire about availability of the original marking data from the Soviet marking scheme.	A	Small
(23)	Directory of humpback identification photographs.	S	1 month
Environmental concerns			
(24)	Produce data inventory and summaries for CCAMLR workshop.	A	1 week
(25)	Southern Ocean GLOBEC Working Group.	A	2 weeks
Small cetaceans			
(26)	Collection of statistics of small cetacean catches and compilation of the table for the Scientific Committee report.	A/S	1 month
Carried over			
(27)	Collate statistics of incidental catches of great whales and incorporate into database.	A/S	?
Routine work			
(28)	Routine work such as compilation of catch statistics for FAO and extraction of data as requested by individuals from the Scientific Committee and general public.	A(/S)	?

20. COMMUNICATIONS

The Committee reviewed the trial procedure for sending circular communications by e-mail introduced last year. It **agrees** that this has been very successful; in future, the subject line will include an informative title, not simply a circular number.

In a small minority of cases there had been problems in receiving attachments and the Secretariat will work with the scientists involved to solve the problem. The Committee also **agrees** that it is unnecessary for the Secretariat to forward hard copies of all circulars that have been sent by e-mail. It **agrees** that a system to allow members to determine which circulars have been sent, and when, should be developed. The Committee **agrees** that an effective way to achieve this would be to establish a Committee web page that would keep a regularly updated list of such information. Donovan agreed to develop a working paper for the next meeting detailing a number of ideas he had for using a Committee web page to further the work of the Committee.

21. PUBLICATIONS

Donovan introduced SC/50/O10 which reviewed the present publications of the IWC and suggested a way forward that would (a) maintain the scientific quality, (b) increase their scientific profile in the wider scientific community and (c) enable more efficient managing of the workload and budget by reducing inter-annual variation. The major initiative involves the establishment of a new scientific journal that maintains the high standards of refereeing and editorial principles already established in IWC publications.

Table 11

Funding requirements for 1998-99.

Item	Cost	Agenda Item
Revised Management Procedure		
DESS (sightings database) maintenance/development	£22,325	Item 7.3.2
CLA, revision of computer program (supplement)	£2,000	Item 7.1
AWMP		
Fund for developers	£5,000	Item 10.9.2
Environmental matters		
Sightings Workshop	£25,000	Item 12.3.1
SOWER 2000 project (Antarctic project – intersessional and planning meetings – supplement)	£5,000	Item 12.2.1
Retrospective analysis and method development for integrated analysis of the SOWER2000 survey (SC/50/RP5)	£32,641	Item 17.2
Comprehensive Assessment of Whale Stocks		
North Atlantic right whale Workshop	£7,500	Item 9.2.2
Antarctic catalogue	£3,000	Item 9.3.2
Blue whale acoustic data - archive	£2,000	Item 9.1.1
Blue whale acoustic data - analysis	£2,000	Item 9.1.1
SOWER cruise	£81,000	Item 9.9.1.2
Total new activities	£187,466	
Amount available	£150,112	
Balance	-£37,354	

The Committee welcomed this initiative. It **agrees** that the proposal, which has been designed to be at least cost neutral to the Commission, will, for both scientific and pragmatic reasons, be advantageous to the commission and the Committee. It noted that other organisations, including CCAMLR and ICES, have adopted a similar approach. It recognised the major achievement already made in improving the scientific quality and reputation of IWC publications. It commended the thoroughness of the proposal and agreed that a shortened revised version of the paper should be included as Annex T. Annex T would also incorporate aspects of the general discussion in the Committee. The Committee **strongly recommends** adoption of the proposal in Annex T.

It was agreed that initially, in addition to Donovan, the Editorial Board should comprise the present Chairman and Convenors, i.e. Bannister, Hammond, Kato, Martin, Reilly, Walløe, Zeh and Donovan.

22. ELECTION OF OFFICERS

In view of the proposed changes to the Rules of Procedure (i.e. that the Chair and Vice-Chair should normally remain in office for three years), no elections were held.

23. OTHER BUSINESS

There was no other business.

24. ADOPTION OF REPORT

The Committee adopted the report at *ca* 17:50 on 9 May 1998. It agreed that Item 6.3 would be completed by the Convenors, meeting on 10 May.

The Committee expressed its appreciation to Bannister for chairing the meeting, to Donovan for his customary perceptive and painstaking rapporteuring and to the Secretariat for their cheerfulness, support and hard work throughout the entire meeting period.

REFERENCES

Allen, K.R. 1980. Size distribution of male sperm whales in the pelagic catches. *Rep. int. Whal. Commn* (special issue 2):51-6.

Anon. 1986. First meeting of experts on mortality of marine mammals. Kuwait, 22-23 November 1986. Regional Organisation for the Protection of the Marine Environment, Kuwait.

Baker, C.S. and Medrano-González, L. 1998. World-wide distribution and diversity of humpback whale mitochondrial DNA lineages. *In:* C.J. Pfeiffer (ed.) *Molecular and Cell Biology of Marine Mammals.* Krieger Publishing Co, Melbourne, FL.

Baker, C.S., Slade, R.W., Bannister, J.L., Abernethy, R.B., Weinrich, M.T., Lien, J., Urban, J., Corkeron, P., Calambokidis, J., Vasquez, O. and Palumbi, S.R. 1994. Hierarchical structure of mitochondrial DNA gene flow among humpback whales, *Megaptera novaeangliae*, world-wide. *Mol. Ecol.* 3:313-27.

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.

Balcomb, K.C. and Goebel, C.A. 1977. Some information on a *Berardius bairdii* fishery in Japan. *Rep. int. Whal. Commn* 27:485-6.

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.

Best, P.B. 1988. Right whales, *Eubalaena australis*, at Tristan da Cunha. A clue to the 'non-recovery' of depleted stocks? *Biol. Conserv.* 46:23-51.

Best, P.B. 1989. Some comments on the BIWS catch record data base. *Rep. int. Whal. Commn* 39:363-9.

Blaylock, R.A., Hain, J.W., Hansen, L., Palka, D.L. and Waring, G.T. 1995. US Atlantic and Gulf of Mexico marine mammal stock assessments. *NOAA Tech. Mem.* SEFSC-363:211pp.

Borchers, D.L. and Allison, C. 1997. Report of the Scientific Committee, Annex R. IWC Sightings survey database and software for estimating whale abundance by small mangement areas. *Rep. int. Whal. Commn* 47:257.

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. NAMMCO Scientific Committee Working Group Document SC/5/AE/1.

Buckland, S.T. and Turnock, B.J. 1992. A robust line transect method. *Biometrics* 48:901-9.

Burns, J.J., Montague, J. and Cowles, C. (eds.). 1993. *The Bowhead Whale*. Allen Press, Lawrence, Kansas. Special Publication No. 2 (D. Wartzok, Series ed.) for the Society for Marine Mammalogy xxxvi+787pp.

Butterworth, D.S., Thomson, R.B. and Kato, H. 1997. An initial analysis of updated transition phase data for minke whales in Antarctic Area IV. *Rep. int. Whal. Commn* 47:445-50.

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). [In press]

Calambokidis, J., Steiger, G.H., Straley, J.M., Quinn II, T.J., Herman, L.M., Cerchio, S., Salden, D.R., Yamaguchi, M., Sato, F., Urbán R, J., Jacobsen, J., von Ziegesar, O., Balcomb, K.C., Gabriele, C.M., Dahlheim, M.E., Higashi, N., Uchida, S., Ford, J.K.B., Miyamura, Y., Ladrón de Guevara P,P., Mizroch, S., Schlender, A. and Rasmussen, K. 1997. Abundance and population structure of humpback whales in the North Pacific basin. Contract report submitted to NMFS. 72pp.

Childerhouse, S.J. and Dawson, S.M. 1996. Stability of fluke marks used in individual photoidentification of male sperm whales at Kaikoura, New Zealand. *Mar. Mammal Sci.* 12(3):447-51.

Childerhouse, S.J., Dawson, S.M. and Slooten, E. 1995. Abundance and seasonal residence of sperm whales at Kaikoura, New Zealand. *Can. J. Zool.* 73(4):723-31.

Chittleborough, R.G. 1965. Dynamics of two populations of the humpback whale, *Megaptera novaeangliae* (Borowski). *Aust. J. Mar. Freshwater Res.* 16:33-128.

Cooke, J.G., de la Mare, W.K. and Beddington, J.R. 1983. Some aspects of the reliability of the length data for the western North Pacific stock of sperm whales. *Rep. int. Whal. Commn* 33:265-7.

Cosens, S.E. and Innes, S. 1998, Distribution and numbers of bowhead whales (*Balaenoptera mysticetus*) in northwestern Hudson Bay in August 1995. *Arctic.* [In press]

Cosens, S.E., Qarnukaq, T., Parker, B. Dueek, L.P. and Anardjuak, B. 1997. Distribution and numbers of bowhead whales, *Balaena mysticetus*, in northern Foxe Basin in 1994. *Can. Field Naturalist* 111: 381-88.

Donovan, G.P. 1991. A review of IWC stock boundaries. *Rep. int. Whal. Commn* (special issue 13):39-68.

Ellis, P. 1969. *A Baleia no Brasil Colonial*. Ediçoes Melhoramentos, Editora da Universidade de São Paulo, Sao Paulo, Brasil. 235pp.

Esseen, M. 1996. A survey of the fisheries in the Jubail Marine Wildlife Sanctuary. pp. 479-96. *In:* F. Krupp, A.H. Abuzinada and I.A. Nader (eds.) *A Marine Wildlife Sanctuary for the Arabian Gulf. Environmental Research following the 1991 Gulf War Oil Spill.* Riyadh and Senckenberg Research Institute, Frankfurt am Mein.

Fenstad, A.M., Helgeland, J., Aldrin, M. and Volden, R. 1993. High accuracy computer program for the IWC Catch Limit Algorithm. Paper SC/45/Mg3 presented to the IWC Scientific Committee, April 1993 (unpublished). 38pp.

Gillespie, D. 1997. An acoustic survey for sperm whales in the Southern Ocean sanctuary conducted from the *RSV Aurora Australis*. *Rep. int. Whal. Commn* 47:897-907.

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.

Givens, G.H. and Thomas, D.J. 1997. Sample bowhead aboriginal management procedure trials. *Rep. int. Whal. Commn* 47:875-82.

Givens, G.H., Zeh, J.E. and Raftery, A.E. 1996. Implementing the current management regime for aboriginal subsistence whaling to establish a catch limit for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. *Rep. int. Whal. Commn* 46:493-9.

Gordon, J., Gillespie, D. and Chapell, O. 1998. Potential uses of automated passive acoustic techniques to determine porpoise distribution and abundance in the Baltic Sea. (Unpublished ms.) 3pp.

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.

Hoelzel, A.R. and Dover, G.A. 1989. Molecular techniques for examining genetic variation and stock identity in cetacean species. *Rep. int. Whal. Commn* (special issue 11):81-120.

Hofmann, E. (ed.). 1998. Report of the meeting of the Southern Ocean Planning Group, San Diego, California, 1-3 August 1997. GLOBEC Report no. 7A. International GLOBEC. 21pp.

International Whaling Commission. 1981. Report of the Scientific Committee. *Rep. int. Whal. Commn* 31:51-165.

International Whaling Commission. 1989. Report of the Scientific Committee. *Rep. int. Whal. Commn* 39:33-157.

International Whaling Commission. 1990. Chairman's Report of the Forty-First Annual Meeting. *Rep. int. Whal. Commn* 40:11-37.

International Whaling Commission. 1992a. Report of the Comprehensive Assessment Special Meeting on North Atlantic Fin Whales, Reykjavík, 25 February-1 March 1991. *Rep. int. Whal. Commn* 42:595-644.

International Whaling Commission. 1992b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 42:51-86.

International Whaling Commission. 1992c. Report of the Scientific Committee, Annex E. Report of the bowhead whale assessment meeting. *Rep. int. Whal. Commn* 42:137-55.

International Whaling Commission. 1993a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 43:55-228.

International Whaling Commission. 1993b. Report of the Scientific Committee, Annex H. Draft specification for the calculation of catch limits in a Revised Management Procedure (RMP) for baleen whales. *Rep. int. Whal. Commn* 43:146-52.

International Whaling Commission. 1994a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 44:41-201.

International Whaling Commission. 1994b. Report of the Scientific Committee, Annex H. The Revised Management Procedure (RMP) for Baleen Whales. *Rep. int. Whal. Commn* 44:145-52.

International Whaling Commission. 1995a. Chairman's Report of the Forty-Sixth Annual Meeting. *Rep. int. Whal. Commn* 45:15-52.

International Whaling Commission. 1995b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 45:53-103.

International Whaling Commission. 1995c. Report of the Scientific Committee, Annex G. Report of the sub-committee on small cetaceans. *Rep. int. Whal. Commn* 45:165-86.

International Whaling Commission. 1995d. Report of the Scientific Committee, Annex N. Revisions to annotations to the Revised Management Procedure (RMP) for baleen whales. *Rep. int. Whal. Commn* 45:214.

International Whaling Commission. 1996a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 46:49-236.

International Whaling Commission. 1996b. Report of the Scientific Committee, Annex D. Report of the sub-committee on management procedures. *Rep. int. Whal. Commn* 46:107-16.

International Whaling Commission. 1996c. Report of the Scientific Committee, Annex G. Report of the sub-committee on North Pacific Bryde's Whales. *Rep. int. Whal. Commn* 46:147-59.

International Whaling Commission. 1996d. Report of the Scientific Committee, Annex K. Guidelines for conducting surveys and analysing data within the revised management scheme. *Rep. int. Whal. Commn* 46:211.

International Whaling Commission. 1997a. Chairman's Report of the Forty-Eighth Annual Meeting. *Rep. int. Whal. Commn* 47:17-55.

International Whaling Commission. 1997b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 47:59-257.

International Whaling Commission. 1997c. 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. 1997d. 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. 1997e. Report of the Scientific Committee, Annex K. Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme. *Rep. int. Whal. Commn* 47:227-35.

International Whaling Commission. 1998a. Chairman's Report of the Forty-Ninth Annual Meeting. *Rep. int. Whal. Commn* 48:15-52.

International Whaling Commission. 1998b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48:53-127.

International Whaling Commission. 1998c. Report of the Scientific Committee. Annex D. Report of the Working Group on the RMP. *Rep. int. Whal. Commn* 48:128-43.

International Whaling Commission. 1998d. Report of the Scientific Committee. Annex H. Report of the Sub-Committee on the Other Great Whales. *Rep. int. Whal. Commn* 48:183-202.

International Whaling Commission. 1998e. Report of the Scientific Committee. Annex I. Report of the Workshop 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 M. Report of the Sub-Committee on Small Cetaceans. *Rep. int. Whal. Commn* 48:258-80.

International Whaling Commission. 1998g. Report of the Scientific Committee. Annex O. Research Items Arising out of Sub-Committee Discussions Related to Analyses of Sightings Data, Particularly as Regards DESS. *Rep. int. Whal. Commn* 48:283-5.

International Whaling Commission. 1998h. Report of the Scientific Committee. Annex S. Modified Guidelines for Progress Reports. *Rep. int. Whal. Commn* 48:292-5.

International Whaling Commission. 1998i. Report of the Scientific Committee. Annex L. Report of the Working Group on Scientific Committee Objectives and Procedures. *Rep. int. Whal. Commn* 48:254-57.

International Whaling Commission. 1998j. Report of the Scientific Committee. Annex J. Report of the Sub-Committee on Aboriginal Subsistence Whaling. *Rep. int. Whal. Commn* 48:237-48.

International Whaling Commission. 1998k. Report of the Scientific Committee. Annex F. Report of the Standing Working Group on Environmental Concerns. *Rep. int. Whal. Commn* 48:160-69.

Kasamatsu, F. and Joyce, G.G. 1995. Current status of Odontocetes in the Antarctic. *Antarct. Sci.* 7(4):365-79.

Kasuya, T. 1995. Baird's beaked whales. pp. 521-9. *In:* S. Odate (ed.) *Base Data on Japanese Rare Aquatic Organisms (I).* Hihon Suisan-Sigen Hogo-kyokai, Tokyo. 751pp. [In Japanese].

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 Sakuramoto, K. 1991. Age at sexual maturity of southern minke whales: a review and some additional analyses. *Rep. int. Whal. Commn* 41:331-7.

LeDuc, R.G. and Curry, B.E. 1996. Mitochondrial DNA sequence analysis indicates need for revision of the genus *Tursiops*. Paper SC/48/SM27 presented to IWC Scientific Committee, June 1996, Aberdeen (unpublished). 12pp.

Ljungblad, D.K., Clark, C.W. and Shimada, H. 1998. A comparison of sounds attributed to pygmy blue whales (*Balaenoptera musculus brevicauda*) recorded south of the Madagascar Plateau and those attributed to 'true' blue whales (*Balaenoptera musculus*) recorded of Antarctica. *Rep. int. Whal. Commn* 48:439-42.

Michel, J., Gundlach, E.R. and Hayes, M.O. 1986. Oil spill contingency planning in the Arabian Gulf. pp. 249-62. *In:* Halwagy *et al.* (eds.) Marine Environment and Pollution. Proceedings of the Arabian Gulf Conference on Environment and Pollution, Kuwait.

Moore, M.J., Berrow, S.D., Jensen, B.J., Carr, P., Sears, R., Rowntree, V., Payne, R. and Hamilton, P.K. 1998. Right whale and other cetacean sightings around South Georgia (1979-1997). Paper SC/M98/RW26 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

O'Hara, T.M., House, C., House, J.A., Suydam, R.S. and George, J.C. 1998. Viral serologic survey of bowhead whales in Alaska. *J. Wildl. Dis.* 34(1): 39-46.

Palka, D. and Polacheck, T. 1997. Comparison of several analytical methods that estimate $g(0)$ and account for covariates in density estimates using double-team line transect data. Paper SC/49/O 18 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 24pp.

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.

Perrin, W.F., Donovan, G.P. and Barlow, J. (eds.). 1994. *Reports of the International Whaling Commission, Special Issue 15. Cetaceans and Gillnets.* International Whaling Commission, Cambridge, UK. 629pp.

Poole, D. and Raftery, A.E. 1999. Assessment of the Bering-Chukchi-Beraufort Seas stock of bowhead whales using Bayesian and full pooling Bayesian synthesis methods. *J. Cetacean Res. Manage.* 1(1). [In press]

Preen, A. 1991. Report of the die-off of marine mammals associated with the Gulf War oil spill. Prepared for the National Commission for Wildlife Conservation and Development (unpublished). 8pp.

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.

Punt, A.E. and Butterworth, D.S. 1999. An assessment of the Bering-Chukchi-Beaufort seas stock of bowhead whales (*Balaenoptera mysticetus*) for 1998 using a Bayesian approach. *J. Cetacean Res. Manage.* 1(1). [In press]

Richards, R. 1993. *Into the South Seas: The Southern Whale Fishery Comes of Age on the Brazil Banks 1765 to 1812.* The Paramatta Press, Wellington. 128pp.

Rosenbaum, H., Brownell Jr, R.L., Brown, M., Schaeff, C., Portway, V., White, B., Malik, S., Pastene, L., Best, P.B., Clapham, P.J., Hamilton, P.K., Moore, M., Payne, R., Rowntree, V. and Desalle, R. 1998. A genetic review of inter-relationships between right whales in different ocean areas. Paper SC/M98/RW23 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

Schweder, T. and Hjort, N.L. 1997. Indirect and direct likelihoods and their synthesis - with an appendix on minke whale dynamics. Paper SC/49/AS9 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 24pp.

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.

Shimadzu, Y. and Kasamatsu, F. 1983. Operating pattern of Antarctic minke whaling by the Japanese expedition in 1981/82. *Rep. int. Whal. Commn* 33:389-91.

Sigurjonsson, J., Vikingsson, G., Gunnlaugson, T. and Halldorsson, S.D. 1996. North Atlantic sightings survey 1995 (NASS-95): shipboard surveys in Icelandic and adjacent waters June-July 1995. Preliminary Cruise Report. NAMMCO Scientific Committee, Torshavn, 5-9 February 1996. 9pp.

Simmonds, M.P. 1997. The meaning of cetacean strandings. *Bull. Inst. R. Sci. Nat. Belg. Biol.* 67-suppl. :29-34.

Tobayama, T., Yanagisawa, F. and Kasuya, T. 1992. Incidental take of minke whales in Japanese trap nets. *Rep. int. Whal. Commn* 42:433-6.

Tonnessen, J.N. and Johnsen, A.O. 1982. *The History of Modern Whaling.* C. Hurst & Co., London. i-xx+798pp.

Tormosov, D.D. 1998. Some data on the right whale, *E. glacialis*, by materials of 1960-1970. Paper SC/M98/RW40 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

Yablokov, A.V. 1994. Validity of whaling data. *Nature London* 367(6459):108.

Yoshida, H., Kishiro, T. and Kato, H. 1998. A list of frozen tissue samples of minke whales from the past Japanese whaling operations in the Antarctic, possessed by the National Research Institute of Far Seas Fisheries. Paper SC/50/RMP6 presented to the IWC Scientific Committee, April 1998 (unpublished).

Zeh, J.E., Clark, C.W., George, J.C., Withrow, D., Carroll, G.M. and Koski, W.R. 1993. Current population size and dynamics. pp. 409-89. *In:* J.J. Burns, J.J. Montague and C.J. Cowles (eds.) *The Bowhead Whale.* Allen Press, Lawrence, Kansas. Special Publication No. 2 of the Society for Marine Mammalogy. 787pp.

Zemsky, V.A., Berzin, A.A., Mikhalev, Y.A. and Tormosov, D.D. 1995a. Report of the sub-committee on Southern Hemisphere baleen whales. Appendix 3. Soviet Antarctic pelagic whaling after WWII: Review of actual catch data. *Rep. int. Whal. Commn* 45:131-5.

Zemsky, V.A., Berzin, A.A., Mikhaliev, Y.A. and Tormosov, D.D. 1995b. *Soviet Antarctic Whaling Data (1947-1972).* 1st Edn. Center for Russian Environment Policy, Moscow. 321pp.

Annex A
List of Participants

AUSTRALIA
J.L. Bannister
D. Thiele

AUSTRIA
M. Stachowitsch

DENMARK
E.W. Born
L. Witting

DOMINICA
N. Lawrence

FRANCE
D. Robineau

GERMANY
P. Deimer
K-.H. Kock

IRELAND
E. Rogan

ITALY
G. Nortarbartolo
F. Fabbri
P. Galoppini

JAPAN
Y. Fujise
M. Goto
T. Hakamada
H. Hatanaka
H. Kato
W. Kawachi (I)
S. Kawahara
M. Komatsu
T. Miyashita
H. Moronuki
T. Nakamura (I)
S. Nishiwaki
S. Ohsumi
A. Okada (S)
J. Okamoto
H. Okamura
Y. Shimadzu
E. Tanaka
S. Tanaka
H. Tanakura
A. Tomita (I)
N. Yagi
K. Yamamura

REPUBLIC OF KOREA
Z. Kim

MEXICO
L. Rojas Bracho
H. Pérez-Cortés

NETHERLANDS
P. Reijnders

NEW ZEALAND
C.S. Baker
S. Childerhouse
M. Donoghue
E. Slooten

NORWAY
N. Øien
T. Schweder
H.J. Skaug
L. Walløe

RUSSIAN FEDERATION
R. Borodin

ST. LUCIA
H. Walters

ST. VINCENT AND THE GRENADINES
F. Hester

SPAIN
S. Lens

SWEDEN
P. Berggren

SWITZERLAND
D. Senn

UK
J.T. Addison
P. Evans
J. Gordon
P.S. Hammond
A.R. Martin

USA
T. Albert
J. Breiwick
R. Brownell
C. Carlson
P. Clapham
C. Clark
D. DeMaster
M. Donahue
N. Friday
C. George
G. Givens
T. O'Hara
D. Palka
W. Perrin
D. Poole
A. Raftery
A. Read
S. Reilly
A. Rooney
T. Smith
S. Swartz
P. Wade
J. Zeh

INVITED PARTICIPANTS
R.M. Baldwin
P. Best
A. von Bismark
D. Borchers
S. Buckland
D. Butterworth
C. Chen
E. Clark
P. Ensor
K. Findlay
K. Finley
T. Gunnlaugsson
A. Hiby
E. Hofmann
S. Innes
T. Kasuya
R. Leaper
K. Magnusson
V. Melnikov
Y. Mykhalyev
V. Papastavrou
L. Pastene
C. Pinedo
T. Polacheck
A. Punt
R. Reeves
M. Simmonds
T. Sweeney (I)
K. Van Waerebeek
Q. Zhu

INTERNATIONAL ORGANISATIONS
P. Reijnders (ASCOBANS)
K.-H. Kock (CCAMLR)
J. Cooke (IUCN)

IWC
C. Allison
G.P. Donovan
R. Gambell

(I) = Interpreter
(S) = Support staff

Annex B
Agenda

1. Chairman's welcome and opening remarks

2. Adoption of Agenda

3. Appointment of rapporteurs
   - 3.1 Meeting procedures and time schedule
   - 3.2 Establishment of sub-committees
   - 3.3 Computing arrangements

4. Review of available data, documents and reports
   - 4.1 Documents submitted
   - 4.2 National progress reports on research
   - 4.3 Data collection, storage and manipulation
     - 4.3.1 Catches and other statistical material
     - 4.3.2 Progress of data coding projects
     - 4.3.3 Progress on program verification projects
     - 4.3.4 Whale marking, including artificial and natural marks

5. Cooperation with other organisations
   - 5.1 CMS
     - 5.1.1 ASCOBANS
     - 5.1.2 ACCOBAMS
   - 5.2 ICES
   - 5.3 IATTC
   - 5.4 CCAMLR
   - 5.5 NAMMCO
   - 5.6 UNEP
   - 5.7 Southern Ocean GLOBEC
   - 5.8 FAO/COFI

6. Committee objectives and priorities
   - 6.1 Amendments to the Rules of Procedure
   - 6.2 Longer term priorities and directions
   - 6.3 1998/99 work plan and initial agenda for the 1999 meeting

7. Comprehensive Assessment – Revised Management Procedure (CA/RMP) – General issues
   - 7.1 CLA program and tuning – report of the intersessional WG
   - 7.2 Additional variance
   - 7.3 Abundance estimation
     - 7.3.1 Report of the intersessional group on statistical estimators
     - 7.3.2 IWC-DESS
   - 7.4 RMP – Documentation for future possible Schedule
   - 7.5 Stock identity

8. CA/RMP – Preparations for implementation
   - 8.1 Questions relating to Implementation Trials
   - 8.2 North Pacific minke whales
     - 8.2.1 Progress on Implementation Trials
     - 8.2.2 Uncertainty over catches
     - 8.2.3 Sightings survey planning – report of intersessional Working Group (Smith)
   - 8.3 North Atlantic minke whales
     - 8.3.1 Northeastern stock – report of intersessional group; survey permits
     - 8.3.2 Central stock – reconsideration of earlier estimates; concerns over data availability
   - 8.4 Western North Pacific Bryde's whales
     - 8.4.1 Trial specifications
       - 8.4.1.1 Report of the intersessional Working Group
       - 8.4.1.2 Development of trials
     - 8.4.2 Sightings survey planning – report of the intersessional Working Group

9. Comprehensive Assessment of whale stocks
   - 9.1 Southern Hemisphere blue whales
     - 9.1.1 Assssments
     - 9.1.2 Reports of the SOWER cruises
     - 9.1.3 Other
   - 9.2 Right whales
     - 9.2.1 Report of the Cape Town workshop
     - 9.2.2 Action arising
   - 9.3 Southern Hemisphere humpback whales
     - 9.3.1 Progress in catch and marking data coding
     - 9.3.2 Establishment of centralised Southern Hemisphere directory and Antarctic catalogue
     - 9.3.3 Progress towards assessment
     - 9.3.4 Future special meeting
   - 9.4 North Atlantic humpback whales
   - 9.5 North Pacific humpback whales
   - 9.6 Sperm whales
     - 9.6.1 Report of the intersessional group
     - 9.6.2 Action arising
   - 9.7 Southern Hemisphere minke whales
   - 9.8 Other species and/or stocks
   - 9.9 Other issues
     - 9.9.1 Future SOWER cruises
       - 9.9.1.1 Report of intersessional group
       - 9.9.1.2 Planning for 1998/99 season
     - 9.9.2 Acoustics – report of intersessional correspondence group
     - 9.9.3 Mathematically-based techniques for recognition analyses

9.9.4 Biopsy sampling – collection of behavioural data – report of intersessional group

10. Aboriginal Subsistence Whaling Management Procedure (AWMP)
    10.1 Action arising from 1997 meeting and Commission's considerations
    10.2 Future work

11. Aboriginal subsistence whaling stock assessments
    11.1 Bowhead whales
        11.1.1 Bering-Chukchi-Beaufort Seas stock
            11.1.1.1 Assessment
            11.1.1.2 Management advice
        11.1.2 Other stocks
    11.2 North Pacific gray whales
        11.2.1 Eastern stock
            11.2.1.1 Current status, including stock monitoring – report of the intersessional group
            11.2.1.2 Management advice
        11.2.2 Western stock
    11.3 West Greenland fin whales
    11.4 West Greenland minke whales
    11.5 East Greenland minke whales
    11.6 Humpback whales off St Vincent and The Grenadines

12. Environmental concerns
    12.1 Pollutants
        12.1.1 Future activities/proposed meeting
    12.2 Climate change
        12.2.1 Planning activities
            12.2.1.1 IWC/GLOBEC joint survey (SOWER 2000)
    12.3 Other activities
        12.3.1 Future workshop – report of the intersessional group
        12.3.2 SOWER cruise activities
    12.4 Arctic issues

13. Small cetaceans
    13.1 Action arising from the 1998 meeting
    13.2 Small cetaceans in the Indian Ocean and Red Sea, with special reference to the Middle East
    13.3 Future topics

14. Scientific permits
    14.1 Advice on the effect on stock(s) of scientific permit catches
    14.2 Review of results from existing permits
        14.2.1 Japan – Southern Hemisphere
        14.2.2 Japan – North Pacific
    14.3 Review of new or revised proposals

15. Whalewatching
    15.1 Action arising from 1997 meeting, including Commission's response
    15.2 Priority items
        15.2.1 Review of guidelines
        15.2.2 Assessment of short term reactions
        15.2.3 Comparative studies
        15.2.4 Report from Monkey Mia, Western Australia
        15.2.5 Other matters
    15.3 Action arising

16. Whale sanctuaries

17. Research proposals
    17.1 Review research results from 1997/98
    17.2 Review proposals for 1997/98

18. Data processing and computing needs for 1998/99

19. Funding requirements for 1998/99

20. Communications

21. Publications

22. Election of officers

23. Other business

24. Adoption of report

Annex C
List of Scientific Committee Documents

REVISED MANAGEMENT PROCEDURE
SC/50/RMP

1 SKAUG, H.J. and HJELLVIK, V. Abundance of northeastern Atlantic minke whales. A reanalysis of the NILS-95 data.
2 SKAUG, H.J. Duplicate identification in double platform line transect surveys.
3 SKAUG, H.J. Further investigations of the results in SC/48/NA1.
4 MIYASHITA, T. Feasibility sighting survey for the western North Pacific minke whale in 1998.
5 MIYASHITA, T. and SHIMADA, H. Japanese sighting surveys for the western North Pacific Bryde's whale in 1998.
6 YOSHIDA, H., KISHIRO, T. and KATO, H. A list of frozen tissue samples of minke whales from the past Japanese whaling operations in the Antarctic, possessed by the National Research Institute of Far Seas Fisheries.
7 GOTO, M. and PASTENE, L.A. Population structure in the North Pacific minke whale as revealed by RFLP and sequencing analyses of the mtDNA control region.
8 ABE, H., GOTO, M. and PASTENE, L.A. Further microsatellite analysis in the western North Pacific minke whales, *Balaenoptera acutorostrata*.
9 PASTENE, L.A., YOSHIDA, H., GOTO, M., KATO, H. and PASBØLL, P.J. Population structure in the Bryde's whale (*Balaenoptera edeni*) based on analysis of mitochondrial DNA control region sequences.
10 BORCHERS, D.L., ØIEN, N., GUNLAUGSSON, Th., and BURT, M.L. Minke whale abundance in the NVS stratum of the CM management Area from NASS95.
11 HATANAKA, H. Stock structure hypotheses of Bryde's whale in the western North pacific for RMP implementation simulation.
12 FUJISE, Y., ZENITANI, R., and KATO, H. An examination of the W-stock hypothesis for North pacific minke whales with special reference to some biological parameters using data collected from JARPN surveys from 1994 to 1997.
13 PERRIN, W.F. and DOLAR, Ma. L.L. Depth of Bryde's whale habitat in the Philippines.
14 HIBY, L. Reanalysis of cue counting data for minke whales from the NASS87 aerial surveys.
15 LENTO, G.M, CIPRIANO, F., PATENAUDE, N., PALUMBI, S.R. and BAKER, C.S. Taking stock of minke whales in the North Pacific: origins of products for sale in Japan and Korea.
16 OKAMURA, H., MIYASHITA, T. and SHIMADA, H. The preliminary GLM analysis of past Bryde's whale sighting data in the North Pacific.
17 ØIEN, N. and GUNNLAUGSSON, T. Abundance of minke whales in the CM management area from NASS87 data.
18 KISHIRO, T. Further analysis of the mark-recapture data of the western North Pacific bryde's whales by a unit of five degree square latitude-longitude.
19 COOKE, J. and LEAPER, R. A model to account for the rounding of recorded angles and distances in shipborne sightings surveys.
20 COOKE, J.G. and LEAPER, R. Results of simulations studies of a hazard probability approach to estimation of whale density and effective strip width.
21 COOKE, J.G. and LEAPER, R. A general modelling framework for the estimation of whale abundance from line transect surveys.
22 COOKE, J.G. and LEAPER, R. Analysis of covariates for NILS 95 minke whale sighting data using the hazard probability method.

COMPREHENSIVE ASSESSMENT OF WHALE STOCKS
SC/50/CAWS

1 KATO, H. and KOMIYA, N.K. Surfacing behavior of pygmy blue whales from analyses on video sequences through 1996/97 JAPAN/IWC and 1997/98 IWC/SOWER blue whale cruises.
2 KATO, H. and MIYASHITA, T. Current status of the North Pacific sperm whales and its preliminary abundance estimates.
3 SHIMADA, H. and KATO, H. Proposal of research plan of the 1998/99 IWC/SOWER/Antarctic cruise with incorporating blue whale survey components.
4 PASTENE, L.A. and GOTO, M. Further RFLP analysis of mitochondrial DNA in Antarctic minke whales from Area V and VI.
5 [NO PAPER]
6 PASTENE, LA. and OHSUMI, S. A brief review of the information on distribution and stocks identity of Bryde's whales (*Balaenoptera edeni*) in the eastern South Pacific.
7 GOTO, M., ZENITANI, R., FUJISE, Y. and PASTENE, L.A. Examination of mitochondrial DNA heterogeneity in minke whales from Area IV considering temporal, longitudinal and latitudinal factors.
8 ISHIKAWA, H., MATSUOKA, K, TOHYAMA, D, YZU, S, SHIMOKAWA, T., OHSHIMA, K., MIZUSHIMA, Y., NIBE, T., KIDO, T., ASADA, M., NAKAMURA, M., ICHINOMIYA, D. and KINOSHITA, T. Cruise report of the Japanese whale research programme under special permit in the

Antarctic (JARPA) Area IV and eastern part of Area III in 1997/98.
9 MATSUOKA, K., HAKAMADA, T., NISHIWAKI, S. and KASAMATSU, F. Abundance and distribution of sperm and beaked whales in the Antarctic Areas IV and V – preliminary report.
10 KASUYA, T. Evidence of statistical manipulations in Japanese coastal sperm whale fishery.
11 CLAPHAM, P.J., SMITH, T.D., REEVES, R.R. and SWARTZ, S.L. Status and stock origin of humpback whales in the Windward Islands.
12 OHSUMI, S. History of Japanese regulation measures for the sperm whaling in the North Pacific.
13 BEST, P. A review of the distribution and population separation of Bryde's whale off Southern Africa.
14 BEST, P. Blue whales off Namibia - a possible wintering ground for the Antarctic population.
15 BEST, P. and ARNOLD, P. Field characters for distinguishing between the two forms of southern minke whale.
16 THIELE, D., BROWN, M., BUTTERWORTH, D.S. and BRANDZO, A. Abundance estimate for Area IV humpbacks from an oceanographic and biological survey off the coast of east Antarctica.
17 [NO PAPER]
18 TYNAN, C.T. Critical habitat and abundance estimation of right whales in the southeast Bering Sea.
19 TAYLOR, B.L., MESNICK, S.L. and DIZON, A.E. Progress report and suggested future research on using genetic data to define sperm whale stock structure in the North Pacific.
20 BARLOW, J. and TAYLOR, B.L. Preliminary abundance of sperm whales in the northeastern temperate Pacific estimated from a combined visual and acoustic survey.
21 BALDWIN, R. Humpback whales (*Megaptera novaeangliae*) of the Sultanate of Oman.
22 BALDWIN, R. A note on sightings of sperm whales off the coasts of the Sultanate of Oman and the United Arab Emirates, October 1994 —October 1997.
23 PALACIOS, D.M. Blue whale (*Balaenoptera musculus*) occurrence off the Galápagos islands, 1978-1995.
24 WHITEHEAD, H. Density-dependent habitat selection and the modelling of sperm whale exploitation.
25 FINDLAY, K.P. A review of abundance of humpback whales in the Southern Hemisphere from modern whaling catches (1904 to 1963) and recent surveys.
26 SMITH, T.D., HAMMOND, P.S., FRIDAY, N. and CLAPHAM, P.J. Update on the status if information on the North Atlantic Humpback Whale.
27 BROWNELL, R.L., Jr, YABLOKOV, A.V. and ZEMSKY, V.A. USSR pelagic catches of North Pacific sperm whales, 1949-1979: conservation implications.
28 WARD, N., STEVICK, P. and CARLSON, C. Current status of individual identification photographs of humpback whales (*Megaptera novaeangliae*) from the eastern Caribbean.
29 LJUNGBLAD, D.K. and CLARK, C.W. Unique calls of the pygmy blue whale (*B. musculus brevicauda*) recorded off the west coast of Chile IN December 1997 and January 1998 during the SOWER 1997/1998 program.
30 PINEDO, M.C. Review data of colonial whaling in Brazil (16^{th} to 19^{th} centuries) and from 1910-74.
31 MIZROCH, S.A. and HARKNESS, S.A.D. Update on The North Pacific Humpback Whale Fluke Photograph Collection - April 1998.
32 POLACHECK, T. Selectivity assumptions and recruitment trends: a few additional VPA analyses of Southern Hemisphere minke whales in Areas IV and V.
33 CLARKE, E.D., ASHBRIDGE, J., BURT, M.L., HEDLEY, S.L. and BORCHERS, D.L. GAM-based abundance estimation from JARPA survey data: progress and simulation model design.
34 ASHBRIDGE, J., BORCHERS, D.L. and BURT, M.L. Estimates of Antarctic minke density from the first six IWC/IDCR independent observer surveys.
35 ROSENBAUM, H.C., RAZAFINDRAKOTO, Y., FLOREZ-GONZALEZ, L., CAPELLA, J., GARRIGUE, C., GREAVES, J., JENNER, C., JENNER, M-N., ROBLES-SAAVEDRA, M.R., DESALLE, R. and BAKER, C.S. Variation and geographic structure of humpback whale mitochondrial DNA from the wintering ground of Areas II, IV and VI in the Southern Hemisphere.
36 SECCHI, E.R., DALLA ROSA, L., KINAS, P.G., ZERBINI, A.N., JANA, D.V., BETHLEM, C., SANTOS, M.C.O. and WALTER, T. Density and photo-identification of humpback whales, *Megaptera novaeangliae*, around the Antarctic Peninsula with special reference to the Gerlache Strait and South Shetland Islands: summer 1997/98.
37 BROWN, M.R. and BUTTERWORTH, D.S. Estimates of abundance of Southern Hemisphere humpback whales and sperm whales from the IWC/IDCR-SOWER sightings survey cruises from 1978/1979 to 1995/96.
38 JAQUET, N., DAWSON, S. and SLOOTEN, E. Diving behavior of male sperm whales: foraging implications.
39 JAQUET, N., DAWSON, S. and SLOOTEN, E. Abundance, occupancy and seasonal distribution of male sperm whales off Kaikoura, New Zealand.
40 MIKHALEV, YU., A. Sperm whales of the Arabian Sea

ABORIGINAL WHALING MANAGEMENT PROCEDURES

SC/50/AWMP

1 PUNT, A.E. A full description of the standard Baleen II model and some variants thereof.
2 PUNT, A.E. A note on the comparison of alternative methods for conditioning the *Initial Exploration Trials* for fishery type 2.
3 PUNT, A.E. Preliminary evaluation of an SLA for the multi-stock trials for fishery type 1.
4 GIVENS, G.H., PUNT. A.E. and BERNSTEIN, T.A.O. Equivalence tuning of SLAs.
5 GIVENS, G.H. Further investigations of AWMP *Strike Limit Algorithms* and their optimisation.
6 WITTING, L. On the unification and optimisation of subsistence and commercial management regimes
7 WITTING, L. Catch limit algorithms for multi species subsistence management regimes.

ABORIGINAL SUBSISTENCE STOCK ASSESSMENTS

SC/50/AS

1 PUNT, A.E. and BUTTERWORTH, D.S. An assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales (*Balaena mysticetus*) for 1998 using a Bayesian approach.
2 SCHWEDER, T. and IANELLI, J.N. Bowhead assessment by likelihood synthesis, methods and difficulties.

3 MELNIKOV, V.V, ZELENSKY, M.A and AINANA, L.I. Observations on distribution and migration of bowhead whales (*Balaena mysticetus*) in the Bering and Chukchi Seas.
4 ZHU, Q. Observations on the muscles of the eye of the bowhead whale (*Balaena mysticetus*).
5 ZHU, Q. Strandings and sightings of the western Pacific stock of the gray whale *Eschrichtius robustus* in Chinese coastal waters.
6 POOLE, D. and RAFTERY, A.E. Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales using Bayesian and Full Pooling Bayesian synthesis methods.
7 BREIWICK, J.M. A Bayesian assessment of the Bering-Chukchi-Beaufort Seas bowhead whale stock.
8 WADE, P.R. Sensitivity of the assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whale (*Balaena mysticetus*) to alternative assumptions.
9 GEORGE, J.C., O'HARA, T.M., BROWER, H. Jr, SUYDAM, R. and ALBERT, T.F. Results of the 1997 subsistence harvest of bowhead whales by Alaskan Eskimos with observations on the influence of environmental conditions on the success of hunting bowhead whales off Barrow, Alaska.
10 GEORGE, J.C., BADA, J., ZEH, J., SCOTT, L., BROWN, S.E. and O'HARA, T. Preliminary age estimates of bowhead whales via aspartic acid racemization.
11 LEDUC, R.G., ROSENBERG, A.E., BURDIN, A.M., BLOKHIN, S.A. and BROWNELL, R.L., Jr. A. Preliminary genetic analysis (mtDNA & microsatelites) of two populations of bowhead whales.
12 CLARK, C.W., CALUPCA, T., CHARIF, R., CORZILIUS, B. and FRISTRUP, K. Autonomous seafloor acoustic recording systems for whale research: application to the census of bowhead whales during the spring migration off Point Barrow, Alaska.
13 BLOKHIN, S.A. To the gray whale (*Eschrichtius robustus*) distribution and abundance nearshore of the South-Eastern Chukotka peninsula.
14 ROONEY, ALP. And DERR, J.N. Evaluating the likelihood of a presumed bottleneck in the Bering-Chukchi-Beaufort Seas stock of bowhead whales.
15 FINLEY, K.J. Observations of bowhead whales at Isabella Bay, Baffin Island, 1983-1997.

ENVIRONMENTAL CONCERNS

SC/50/E

1 KASAMATSU, F. and KIMURA, N. Effect on environment change on distribution of minke whales in Area II with special reference to the sea ice and sea surface temperature.
2 KASAMATSU, F., MATSUOKA, K., and HAKAMADA, T. Spatial structure of whale community in the Antarctic feeding grounds with special reference to the interspecific relationships - preliminary report.
3 SHIMADA, H., WATANABE, T., MIZUNO, K. and KATO, H. Oceanographic data records by CTD and XBT collected under the IWC/SOWER/Blue whale cruise through 1995/96 to 1997/98.
4 TYNAN, C.T. and DEMASTER, D.P. Ozone depletion in the Arctic.
5 O'HARA, T., BRATTON, G., KRAHN, P., WOSHNER, V., and COOPER, L. Heavy metal radionuclide and organochlorine contaminant levels in eskimo harvested bowhead whales of Arctic Alaska with a review of contaminant levels and effects in Arctic ecosystems.
6 SIMMONDS, M.P., JOHNSTON, P.A. and DOLMAN, S. Organochlorines and mercury in a sample of cetaceans from the N.E. Atlantic.
7 SIMMONDS, M.P. and VON BISMARCK, A. Recent important developments in the marine environment.
8 DOLMAN, S. and SIMMONDS, M.P. The threat posed by noise to cetaceans: preliminary considerations with particular reference to anti-predator devices.
9 PERRY, C. A review of the impact of anthropogenic noise on cetaceans.

SMALL CETACEANS

SC/50/SM

1 ROBINEAU, D. The cetaceans of the Arabo-Persian Gulf: a review.
2 CAMERON, G. Cetacean mortality in California gillnet fisheries: Preliminary estimates for 1997.
3 VAN WAEREBEEK, K., BALDWIN, R., GALLAGHER, M. and PAPASTAVROU, V. On spinner dolphins *Stenella longirostris* from waters off the Sultanate of Oman.
4 MELNIKOV, V.V, ZELENSKY, M.A. and AINANA, L.I. Distribution and migrations of the Belukha (*Delphinapterus leucas*) in the Chukchi Sea and northern Bering Sea.
5 HENSHAW, M.D., CHIVERS, S.J. and ROBERTSON, K.M. Composition of the incidental kill of cetaceans in the California drift gillnet fishery in 1997.
6 BALDWIN, R., VAN WAEREBEEK, K. and GALLAGHER, M. A review of small cetaceans from waters off the Arabian Peninsula.
7 BERGGREN, P., WADE, P.R., CARLSTRÖM, J. and READ, A.J. Potential limits to anthropogenic mortality for harbour porpoises in the Baltic region.
8 PROCHNOW, G. and KOCK, K.-H. Towards the protection of the harbour porpoise (*Phocoena phocoena*) in the waters off Sylt and Amrum (German Wadden Sea): a baseline study.
9 GORDON, J.C.D., MATTHEWS, J.N., PANIGADA, S., GANNIER, A., BORSANI, J.F. and NOTARBARTOLO DI SCIARA, G. Distribution and relative abundance of striped dolphins in the Ligurian Sea cetacean sanctuary: results from an acoustic collaboration.
10 ANDRADE, A.L.V, PINEDO, M.C. and PEREIRA, J. Jr. Franciscanas from Southern Brazil, Uruguay and North Argentina coasts: are one or more ecological stocks?
11 BRUHN, R., SIEBERT, U. and WÜNSCHMANN, A. Toxicological and pathological investigations of harbour porpoises (*Phocoena phocoena*) from the German north and Baltic Seas and the waters around Greenland.
12 JENSEN, J. Progress report to the IWC on The Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), October 1997-May 1998.

WHALEWATCHING

SC/50/WW

1 ARNOLD, P.W. and BIRTLES, R.A. Towards sustainable management of the developing dwarf minke whale tourism industry in northern Queensland.
2 PIRZL, R. Australian management of cetacean observation activities – a commonwealth perspective.

3 PROVOST, S. The formation of an independent association for the Australian dolphin- and whale-based tourism industry.
4 [NO PAPER]
5 CORKERON, P.J. Whalewatching – management and research in Australia.
6 CONSTANTINE, R. The whale and dolphin tourism industry in New Zealand: a review of management and research.
7 FISHER, S. Whale Watching in Iceland.
8 DENARDO, C. Whalewatch management in Tysfjord, northern Norway.
9 CARLSON, C. An update of whalewatching guidelines and regulations around the world.
10 BARR, K. and SLOOTEN, E. Effects of tourism on dusky dolphins.
11 BEJDER, L. and DAWSON, S. Responses by Hector's dolphins to boats and swimmers in Porpoise Bay, New Zealand.

OTHER

SC/50/O

1 Government of Japan. The 1998/99 Research Plan for the Japanese Whale Research Program under Special Permit in the Antarctic (JARPA).
2 Government of Japan. The 1999 Research Plan for the Japanese Whale Research Program under Special Permit in the Northwestern Part of the North Pacific (JARPN).
3 INSTITUTE OF CETACEAN RESEARCH. Research activities of the Institute of Cetacean Research. October 1997 to April 1998.
4 MIGNUCCI-GIANNONI, A.A., PINTO-RODRÍGUEZ, B., MONTOYA-OSPINA, R.A., JIMÉNEZ-MARRERO, N.M., RODRÍGUEZ-LÓPEZ, M.A., WILLIAMS, E.H., Jr. and ODELL, D.K. Cetacean strandings in Puerto Rico and the Virgin Islands.
5 DE OLIVEIRA SANTOS, M.C. and SICILIANO, S. Cetacean records and distribution along São Paulo state coast, southeastern Brazil.
6 DE LA MARE, W., SOUTHWELL, C., UNDERWOOD, M. and QUATARARO, F. An automated data logging system for collection of line transect/independent observer data on aerial and shipboard sighting surveys.
7 GRACE, R.V. and FRIZELL, J. Oceanic debris observations near the eastern edge of the Indian Ocean whale sanctuary, from *SV Rainbow Warrior*, November 1997 to January 1998.
8 LENTO, G.L., DALEBOUT, M.J. and BAKER, C.S. Species and individual identification of whale and dolphin products for sale in Japan by mtDNA sequences and nuclear microsatellite profiles.
9 SMITH, T. Scientific Committee priorities.
10 DONOVAN, G.P. Suggested changes to IWC publications.
11 KOCK, K-H. Towards a closer cooperation between CCAMLR and the IWC.
12 GOVERNMENT OF JAPAN. A comment on the pertinence of JARPA research for management.
13 [NO PAPER]
14 FOX, C.G. Acoustic methods: progress report.
15 LARSEN, F. Development of a biopsy system primarily for use on large cetaceans.
16 LEAPER, R. and KARPOUZLI, E. Interactions between sperm whales and deep water trawlers based on sightings from fisheries observers in the NW Atlantic.
17 NATIONAL TAIWAN OCEAN UNIVERSITY. Progress report on cetacean research in Taiwan, July 1997 to March, 1998.
18 MIKHALEV, YU., A. Recovered whale tags on factory ship *Slava*.

SUBMITTED REPORTS

SC/50/Rep

1 1997-98 IWC-Southern Ocean Whale and Ecosystem Research (IWC-SOWER) Antarctic Cruise, Area II.
2 1997/1998 IWC-Southern Ocean Whale and Ecosystem Research (IWC-SOWER) Blue Whale Cruise, Chile.
3 Report of the Intersessional Correspondence Group on North Pacific Sighting Survey Steering Group (NPSSSG).
4 Report of the Workshop on the Comprehensive Assessment of Right Whales: A Worldwide Comparison.

PROGRESS REPORTS

SC/50/ProgRep

Australia
Brazil
Denmark
France
Germany
Ireland
Japan
Korea
Mexico
The Netherlands
New Zealand
Norway
Spain
Sweden
United Kingdom
USA

RESEARCH PROPOSAL

SC/50/RP

1 OUTRIDGE, P. and GREGOIRE, C. Development of a stock identification system for cetaceans based on trace element signatures in teeth or baleen.
2 GARRIGUE, C., GREAVES, J. and BAKER, C.S. Abundance and stock identity of humpback whales (*Megaptera novaeangliae*) in New Caledonia, South Pacific.
3 MAY, B.P. and CONWAY, C. Delineation of breeding stocks of the blue whale (*Balenoptera musculus*).
4 [NO PAPER]
5 BORCHERS, D.L., REILLY, S.B. and HAMMOND, P.S. Retrospective analysis and method development for integrated analysis of the SOWER 2000 survey.
6 DARLING, J. and GERBER, L. Baseline photo-identification and genetic sampling of humpback whales off Moorea, French Polynesia.

Annex D
Report of the Sub-Committee on the Revised Management Procedure

Members: Hammond (Chair), Addison, Allison, Baker, Berggren, Borchers, Borodin, Born, Breiwick, Brownell, Buckland, Butterworth, Chen, Childerhouse, Clarke, Cooke, Donahue, Donovan, Ensor, Fujise, Givens, Goto, Gunnlaugsson, Hakamada, Hatanaka, Hester, Hiby, Innes, Kato, Kawachi, Kawahara, Kim, Kock, Komatsu, Leaper, Lens, Magnusson, Miyashita, Moronuki, Nakamura, Nishiwaki, Øien, Ohsumi, Okamoto, Okamura, Palka, Papastavrou, Pastene, Perrin, Pinedo, Polacheck, Punt, Schweder, Shimadzu, Skaug, Slooten, Smith, Stachowitsch, Tanaka, E., Tanaka, S., Tanakura, Thiele, Tomita, Wade, Walløe, Witting, Yagi, Yamamura, Zeh.

1. ELECTION OF CHAIRMAN AND APPOINTMENT OF RAPPORTEURS

Hammond was elected Chairman. Cooke, Palka, Punt and Smith acted as rapporteurs. Polacheck chaired Item 8.3.

2. ADOPTION OF AGENDA

The adopted agenda is given in Appendix 1.

3. *CLA* PROGRAM

3.1 Tuning

Last year the Committee requested the Secretariat to convert the MANAGE computer program, which calculates catch limits for the RMP, to use double precision arithmetic. The Committee also asked the Secretariat to use this modified program to determine a revised value for the tuning parameter that assures that the median final depletion for the D1 trial is 0.72K (accurately to 0.001K) (IWC, 1998a). Allison reported that the program had been successfully converted, but that it was too slow to allow her to achieve the level of precision specified by the Committee in the time available. The MANAGE program had been originally designed for quickly determining approximate catch limits in simulation trials and had then been adapted for implementation purposes. The numerical integration methods used cannot achieve the required precision because precision does not improve rapidly enough with decreasing integration step size.

The precision specified by the Committee is necessary, in the case of a population as large as one million animals, to guarantee the requirement in the RMP that calculated catch limits are accurate to one whale. It is recognised that this level of precision exceeds the precision of the biological input data. Rather, it ensures that exactly the same catch limit will be obtained regardless of the numerical integration methods used in any computer program that correctly implements the *Catch Limit Algorithm*.

A procedure for determining the tuning parameter was developed that the sub-committee believed was sufficient to ensure a unique value for the tuning parameter. The steps are as follows.

(a) Obtain a callable sub-program implementing the *CLA* that has been shown to calculate, for a given tuning parameter, catch limits accurate to within one whale in all the test scenarios described in Appendix 2, Adjunct 1 for tuning parameter values of 0.40 and 0.41.
(b) For the purpose of running the trials specified below (d), set the precision of the *CLA* sub-program to achieve a tuning accuracy in relative terms of 10^{-6} for each catch limit calculated (i.e. the cumulative probability of each catch limit calculated should be within 10^{-6} of the specified value of the tuning parameter)[1].
(c) Modify the control programmes (MANTST and MANRES) for the D1 trial to enable up to 50,000[2] replicates to be conducted, and to extend the random number seed file to 50,000 replicates.
(d) By iteration if necessary, determine a value of the tuning parameter which gives a median final depletion on the 50,000 replicates that lies within 10^{-5}K of 0.72K, and with 99% confidence limits on the median, calculated with the standard formula for confidence limits on a median, that lie within the range 0.719K to 0.721K, as previously agreed by the Committee (IWC, 1993b, p.225a).
(e) Round the value of the tuning parameter obtained by (d) to the nearest 0.0001. This would become the official new tuning parameter to replace the value of 0.4102 in the current RMP specification.
(f) All subsequent real implementations of the *CLA* should calculate the catch limit accurate to within one whale, conditional on the fixed value of the tuning parameter arising from step (e).

3.2 Revision of program

At last year's meeting (IWC, 1998, item 7.2.2), the Committee recommended that the Secretariat investigate methods to calculate catch limits under the *CLA* more efficiently. It noted that it would be desirable if the same

[1] It is necessary to specify this alternative level of precision because the population in the D1 trial is very small, with catch limits typically about 10; it is not intended to reflect absolute numbers of whales. A precision set to one whale accuracy is not sufficient for these trials.
[2] Note: Preliminary results from 40,000 trials indicate that 50,000 trials will almost certainly be sufficient to obtain 99% confidence limits that lie inside the range 0.719 to 0.721. Should this turn out not to be the case, steps (c) and (d) should be repeated using a larger number of trials.

computer program could be used for calculating catch limits and for simulation studies. The Committee also recommended that this work be completed before the 1998 meeting and that the Secretariat should consider contracting out this task. An intersessional Working Group was set up to facilitate this with membership Allison, Butterworth, Cooke, Givens, Hammond (Chair), Punt, Smith, Walløe.

During the intersessional period the Working Group finalised a specification for computer program structure, documentation, and performance, including specification of a set of test conditions. This is given as Appendix 2, and formed the basis of an invitation to bid for a contract to revise the program that implements the *CLA*. The invitation to bid was distributed to the members of the Working Group. One bid was received that substantially exceeded the amount allocated by the Secretariat. Recognising this and after some discussion, the sub-committee believed that these requirements could be met using a program previously presented by the Norwegian Computing Center (NCC) (Fenstad *et al.*, 1993). Noting that this program was shown during the last meeting to give the same answer as MANAGE when converted to double precision in at least one case, the sub-committee agreed that, suitably documented, it should meet the above needs.

The sub-committee **recommends** that the authors of the program be approached about completing the work that would be required to meet the most important requirements of Appendix 2, with the expectation that by using the previous coding and allocating some tasks to the Secretariat the costs might be more in line with the amount allocated last year.

The most important requirements of Appendix 2 for NCC to complete are:

(a) extract the subroutine that implements the *Catch Limit Algorithm* from the more general program described in Fenstad *et al.* (1993) ;
(b) **either** *[complete internal documentation of the code]* **or** *[complete sufficient internal documentation to allow Allison, in consultation with the authors, to finalise internal documentation]*;
(c) revise and expand Fenstad *et al.* (1993) to provide a complete description of the numerical analysis methods used, and how those methods are implemented.

The remaining aspects of Appendix 2 should be addressed by the Secretariat. This especially includes completing a User's Guide (including guidance on the use of control parameters for numerical precision), linking the subroutine into MANAGE, and evaluating the accuracy of the catch limits from the revised version of MANAGE. The latter would be done in two steps. First, exact comparisons to calculations using the existing double precision version of MANAGE with fine integration steps would be made for a small set of cases. Second, catch limits would be compared to those from double precision MANAGE with coarser integration steps for the several combinations of data input sets described in Appendix 2.

The task of adjusting this program for use in the tuning procedure, described under Item 3.1, would then be taken up by the Secretariat. In modifying the control programs under (c) of Item 3.1, the sub-committee agreed that a minor inconsistency should be rectified so that births derive from the current year's abundance. To demonstrate the expected result that this will have no appreciable affect on the results previously obtained, it was agreed that one or two trials should be repeated and compared.

4. ADDITIONAL VARIANCE

Some years ago the Committee specified that, to improve our basis for drawing inferences from trends from surveys, IDCR sighting data should be extracted on several spatial scales over the time series of the surveys. This task has yet to be completed. The sub-committee agreed that it was still important to complete the work. Borchers suggested that the data extraction may require up to two weeks using the DESS computer system. The sub-committee **recommends** that this task receive high priority during the intersessional period and that, if the Secretariat workload precludes accomplishing this, funds should be requested to see it to completion.

Smith believed that the general issue of additional variance should be further considered. Smith *et al.* (1997) concluded that additional or unmeasured variability was involved in many two-way and multi-way interactions in that study. The authors noted that there are many forms of unmeasured variability, and that the Committee has primarily considered the case where it increases when a population is more depleted. They suggest that the effects of other forms of unmeasured variability have not been explored sufficiently, and may be substantially different. Although, as some numbers suggested, this could be picked up in specific implementation trials, Smith argued that alternate formulations could usefully be considered in general. Schweder suggested that when unmeasured variability is modelled, care should be taken to specify the basis for the forms considered.

5. ABUNDANCE ESTIMATION - GENERAL ISSUES

5.1 Report of intersessional Working Group on statistical estimators

At last year's meeting an intersessional Working Group was re-established to test the performance of abundance estimation procedures over an appropriate range of sighting survey factors. The Working Group initiated a simulation experiment at that meeting in which two abundance estimation methods were applied to 25 replicates of 32 sets of data that simulated shipboard line transect two-platform surveys where there were different types of sighting heterogeneities and $g(0) < 1$. The results were reported to that meeting (IWC, 1998, item 7.1). During the intersessional period, two additional estimation methods (perpendicular distance implementation of the hazard probability model by Skaug and a radial distance implementation of the hazard probability model by Cooke) were applied to the simulation data sets. These results were presented to the sub-committee this year under Items 5.3 and 8.3.1.2. In addition, during the intersessional period more sets of simulated data sets with different conditions were created and more replicates of all the data sets were and continue to be created so that there will eventually be 100 replicates of each set of data.

The intersessional Working Group also began discussions about what topics should be addressed in the near future. It recognised that the remit was broad and so should focus on topics that are the most relevant to abundance estimates that are currently or will in the near future be submitted to the Committee. Priority topics identified were:

(1) condition simulated data sets on North Pacific sighting surveys for minke and/or Bryde's whales;
(2) test procedures that identify duplicates and correct for duplicate identification errors;

(3) test procedures that estimate abundance from multi-year surveys;
(4) increase the number of simulated data sets that have the characteristics already created, to allow better estimates of precision of the abundance estimation method that is being tested;
(5) create simulated data sets that have other characteristics, such as animal movement or errors in measurement and duplicate identification.

The sub-committee deferred discussion of these topics to Item 9.

The sub-committee re-established the intersessional Working Group under Palka (with membership listed in Annex Z) to continue its work testing the performance of abundance estimation procedures over an appropriate range of sighting survey factors.

5.2 IWC-DESS

Borchers reported that the work contracted to the University of St Andrews, described in last year's report (IWC, 1998d, annex O, appendix 1), had been completed and the relevant data files transferred to the Secretariat. Some problems were encountered during the transfer; Borchers reported that these were being addressed and would soon be resolved.

The sub-committee established a Working Group under Donovan to consider the future maintenance, support and development of the IWC-DESS. Its report is given as Appendix 3.

The report proposes that the best way for the Secretariat to ensure the appropriate maintenance, support and development of the DESS was to fund a part-time post at the RUWPA in St Andrews. This would have a number of advantages concerning the working environment, flexibility and continuity. The cost to the Secretariat was estimated at approximately £19,000 plus VAT per annum. Routine requests for data from accredited members of the Committee and international organisations would still be handled by the Secretariat. The intention under the proposal was that items 1-7 under existing relevant tasks in Appendix 3 would be completed as soon as possible and that items 1-3 under possible tasks in the near future in Appendix 3 would be considered in due course. Butterworth noted that some of these tasks would take a considerable amount of time.

The sub-committee **recommends** that the proposal described in Appendix 3 be adopted as a matter of priority.

5.3 Other

A number of papers dealing with new developments in abundance estimation methods were presented to the sub-committee.

SC/50/RMP2 described a new method to identify duplicate sightings for independent observer surveys where posterior probabilities were assigned to each candidate duplicate pair. All candidate pairs with posterior probabilities larger than a threshold value were judged as duplicate pairs. Two types of duplicate identification errors were defined and used in a method to correct the abundance estimate.

Concerns were raised that the posterior probabilities were subjectively chosen and that this could cause biases. It was suggested that certain animal behaviour and other factors may make some duplicates more obvious and be assigned a high probability; thus only certain types of duplicates would be included. Skaug pointed out that this could be true for most duplicate identification algorithms but with these procedures, because Type I and Type II errors were estimated and used to correct the abundance estimate, the abundance estimate would not contain such biases.

Part of SC/50/RMP22 reported the results of applying a duplicate identification rule to these data. The rule is explained in Cooke (1997). The rule is not subjective, applies to whale surfacing and not whale tracks, as in SC/50/RMP2, but also allows diagnostics to be calculated. It was suggested that, perhaps after modifications, this approach could supplement the methods proposed in SC/50/RMP2 to obtain better posterior probabilities.

Last year the Committee had noted that further analyses taking account of the heterogeneity among surveys and the spatial and temporal pattern of the surveys were required before the western North Pacific Bryde's whale abundance estimate would be appropriate for implementation of the RMP. SC/50/RMP16 described a preliminary GLM analysis that investigated the effects of potential heterogeneities due to year, month and type of vessel on sighting rates and density indices from several sighting surveys. The paper indicated that the effects of the differences between vessel types and the variation from year to year were statistically significant. However the influence of vessel types on the abundance estimate could be excluded if the effective search width was estimated separately for vessels with and without barrels.

The sub-committee welcomed this analysis and several comments were made. Concerns were expressed that the power of the analysis could be small because of the large SEs of the estimates of ship type effects, the low effort associated with at least one type of ship and the large influence that including the effective search width had on some estimates of ship type effects. It was suggested that a power analysis could provide information on the reliability of the results presented. Whether observer heterogeneity should be included in this analysis was also questioned.

SC/50/RMP19 described a model that enables the proportion of sighting records that are rounded to convenient radial distances and angles to be estimated as a function of the implicit pre-rounding estimate of distance and/or angle. When applied to radial distance and angle data for minke whales in the Northeast Atlantic, the model fitted the observed distribution of distances well, but the observed distribution of angles somewhat less well. Although the error due to rounding was found to make only a small contribution to the total mean square error of distance estimates, the rounding did have a strong influence on the plot of the goodness of fit between observed and predicted distributions.

The sub-committee welcomed this paper because it addressed a potential problem that could occur in all line transect sighting surveys. It was noted that for the type of detection function models used in this paper, the hazard probability with covariates, the Chi-squared test for the goodness of fit to radial distances and angles is only an approximation because the actual degrees of freedom are unknown. There is an unknown non-linear relationship between the degrees of freedom and the number of parameters used in this type of detection models. In this goodness of fit test and in those presented for other tests using the hazard probability models, a linear relationship was assumed. More work is needed to determine the actual degrees of freedom and the effects of the linear assumption on the results of the goodness of fit test.

SC/50/RMP20 described a study where the Cooke implementation of the hazard probability approach (Cooke, 1997) with covariates was applied to simulated data that emulated harbour porpoise type shipboard line transect surveys that use independent teams. Two variants of the method were tested: one which assigned duplicate sightings as those that were nearly simultaneously detected; and one where assigned duplicate sightings included not only simultaneous sightings but those that were delayed in time. For the simulated data sets where the two platforms were searching the same area of water, the agreement between true and estimated densities was generally good when the delayed duplicates were used, but there was a negative bias averaging about 12% in the density estimates when only the simultaneous duplicates were used.

The sub-committee noted that this type of analysis, where the statistical properties of an estimation method were tested using simulated data, had been recommended when testing the performance of abundance estimation procedures over an appropriate range of sighting factors.

The parts of SC/50/RMP19 and SC/50/RMP20 relevant to the application of methods to the northeast Atlantic minke whale abundance estimates, are discussed under Item 8.3.2.1.

Clarke presented the first part of SC/50/CAWS33 describing progress on the development of an unbiased abundance estimator based on generalised additive models (GAMs) with spatial covariates. Traditional abundance estimates from JARPA survey data are negatively biased because the use of closing mode with predetermined start-points for each day causes high density areas to be under-surveyed. Burt and Borchers (1997a; 1997b) proposed an estimator that compensates for the reduced effort using a raising factor based on the ratio of intended effort to actual effort but it had been suggested that this estimator may be positively biased. Model-based abundance estimation is in principle robust to the JARPA survey design. Following Hedley *et al.* (1997), the spatial distribution of density was modelled using 'waiting areas' (i.e. the effective area surveyed between sightings). Abundance estimates produced by this method are broadly similar to those obtained by Burt and Borchers (1997a) and in analyses of IDCR survey data. The work to date provides a good basis for future development of this methodology, using the simulation study described in the second part of the paper.

A concern raised last year about this estimation method was how to obtain unbiased variance estimates. Borchers reported that it was not planned to use the likelihood estimates of variance because these neglect spatial correlation. Instead, they planned to investigate using a parametric bootstrap method which attempts to account for spatial correlation.

The authors of SC/50/CAWS33 asked the sub-committee to comment on the proposed simulation study to be conducted before next year's meeting. The simulation study is designed to test and develop the GAM-based estimation methods. The sub-committee agreed that the re-established intersessional Working Group under Palka (see Item 5.1) should review the simulation design and provide comments.

Hiby expressed a number of concerns about the hazard probability model currently used to estimate abundance of Northeast Atlantic minke whales. The first concern related to the vulnerability of the hazard probability (and cue counting) methods to distance estimation error or possible changes in surfacing behaviour in response to the vessel. His second concern related to the possibility that small sampling bias is not accounted for by the AIC selection criterion when using models that contain many covariates and their interactions.

With respect to the first concern, Hiby noted that the effective search area in the cue-counting method depended on the square of the estimated distance. Distance estimation errors could be highly influential and cause large biases. He believed that this also applied to the effective search width estimated by the hazard probability model, particularly as distances are estimated by eye. Schweder believed that the abundance estimate would be susceptible to distance estimation error in the same way as conventional line transect methods.

The sub-committee discussed whether reaction of whales to survey vessels could include a change in surfacing behaviour, how minke whales might react, and the question of data to address these questions. It is not known whether minke whales may react by either increasing dive times or increasing surfacing rates but the effects on hazard probability abundance estimates are very different. Cooke reviewed the results from a simulation study described in Cooke (1992). When half of the whales increased their dive time the resulting abundance estimate was only slightly negatively biased. However, when half of the whales surfaced prematurely at 0.2 n.miles from the ship, the resulting abundance estimate was positively biased by about 67%. It was suggested that simulation data similar to that produced in Cooke (1992) could be used to test the currently used hazard probability estimation methods to determine the potential effect of changes in surfacing behaviour. It was also suggested that a first step could be to collect surfacing behaviour data to determine if there is a change in surfacing rates in response to survey ships.

Several members commented that the Buckland-Turnock method of abundance estimation, in which the two teams survey at different distances ahead of the ship, would not be affected by changes in surfacing behaviour because it was designed to take responsive movement into account.

With respect to the second concern, Cooke indicated that he planned to investigate whether his method has been influenced by small sample bias. He noted that the number of duplicates in a cell is the influencing factor. The maximum likelihood and AIC could probably still be used to estimate and determine the covariates in the model; however, total abundance could be estimated using a summation of bias-corrected block abundance estimates.

There was no time available to discuss these issues further.

6. DOCUMENTATION OF RMP FOR INCORPORATION INTO SCHEDULE

At last year's meeting, an intersessional Working Group was established under Donovan to finalise documentation of the RMP for incorporation into the Schedule. This work had not been completed during the year. During the meeting, a finalised documentation was drafted and referred to plenary under Plenary Item 7.4.

7. STOCK IDENTITY

Pastene, Goto, Hatanaka and Kato suggested that it may be useful for the Committee to reconsider its definitions of the term stock. The importance of stock definition, or population subdivision for the purposes of management and conservation of whale resources by the IWC is obvious. For

exploited species, an understanding of stock boundaries is critical for estimating abundance, setting catch limits and interpreting life-history parameters. For protected species, stock boundaries are important for assessing population trends, establishing territorial jurisdiction and identifying critical habitats (Baker *et al.*, 1994).

Under the New Management Procedure (NMP), the IWC managed the different whale species using specific 'management units' (see Donovan, 1991). An example of these 'management units' is the six management Areas in the Southern Hemisphere used by the IWC to manage the baleen whales species (except the Bryde's whale).

Under this scheme, the 'management stock' was defined as the group of whales occurring within a specific geographical boundary which is actively or potentially exploited by IWC member countries. These are the individual stocks whose status is assessed by the Committee (Hoelzel and Dover, 1989).

To date, most studies on stock identity of large whale species have attempted to test the hypothesis that IWC management units (management stocks) correspond to biologically defined entities (biological stocks). For that purpose, different techniques such as genetics, morphology, Discovery marks, ecological markers, sighting pattern and catch distribution have been used. In recent Committee discussions on the stock identity issue, however, the difficulty in interpreting genetic data has been evident.

There has been substantial development in techniques useful for determining stock structure in recent years, especially genetics based methods. The sub-committee agreed that, given this development, it would be useful to undertake a review with the goal of establishing more useful definitions of the term stock.

An *ad hoc* Working Group was established under DeMaster to develop terms of reference for such a review and to outline the tasks that it may be useful to address overall, including identifying specific steps that can be taken intersessionally in preparation for a more comprehensive discussion during the next meeting. The report of the Working Group is given as Appendix 4 and was considered directly by the plenary under Plenary Item 7.5.

In response to last year's recommendation by the Committee, SC/50/RMP6 presented a list of tissue samples of southern minke whales preserved at the National Research Institute of Far Seas Fisheries, which were collected under past commercial whaling. The sub-committee welcomed submission of the list but no time was available to review it.

8. PREPARATIONS FOR IMPLEMENTATION

8.1 Questions relating to implementation trials

Implementation Simulation Trials 'involve identifying the range of plausible hypotheses relevant to recommending an *Implementation* or *Implementation Review* for the RMP and formulating simulation models which conform with these hypotheses, (IWC, 1995, p.214). Appendix 5 provides a structured approach to the development of *Implementation Simulation Trials* in cases in which there is uncertainty about stock structure. Butterworth emphasised the need for addressing each of the issues in Appendix 5 sequentially because, for example, assumptions regarding choices of sub-areas depend on hypotheses about the number of stocks and how they migrate. The sub-committee thanked Butterworth for completing this task which it had requested at last year's meeting.

8.2 North Pacific minke whales

At its 1996 meeting, the Committee developed a set of *Implementation Simulation Trials* for North Pacific minke whales and recommended that the Secretariat develop a computer program to implement these trials and then conduct them (IWC, 1997a, p.70). The trials involve 13 sub-areas in the North Pacific and consider two hypotheses regarding the number of breeding stocks of minke whales in the North Pacific: (i) that there are three stocks, the J stock ('home' area - Sea of Japan and perhaps also the Yellow Sea and East China Sea), the O stock ('home' area - the Okhotsk Sea, the east coast of Japan) and the W stock (West Pacific); and (ii) that there are only the two stocks, J and O.

During its 1997 meeting, the Committee reviewed recent information on stock identity and catches and made some revisions to the trials.

8.2.1 Progress during intersessional period

Allison reported that she had developed most of the program to implement the trials. However, she had been unable to complete this task and conduct the trials because some of the specifications were incomplete. A Working Group under Alison was established to finalise the specifications for the trials, taking into account discussions under the remainder of Item 8.2. Its report is given in Appendix 6 and discussed under Item 8.2.4.

8.2.2 Uncertainty over catches

In 1994, the Revised Management Procedure for baleen whales (IWC, 1994, annex H, p.150) stated that 'known 'indirect' catches, e.g. whales killed through entanglement in fishing gear, should also be included in the catch history' in the RMP. *Implementation Simulation Trials* should include estimates of all non-natural removals. Some of the currently specified trials are used to examine the implications of alternative assumptions about catches. At last year's meeting, the Committee had agreed to modify the trials to include incidental catches of minke whales by Korea and Japan (IWC, 1998a).

In response to a request at last year's meeting, Kim presented new information about incidental catches of minke whales off Korea (Appendix 7). In response to a question, he indicated that the increase in incidental catches during 1996 was related to unusual environmental conditions that also led to substantially increased fish catches. Information about fishing effort and catches for the years before 1996 is not available due to the lack of a systematic recording system. Kim suggested that examination of further information including prices in the market could be used to provide estimates of earlier catches. He indicated that incidental catches off Korea had increased following the cessation of whaling in 1986 and suggested that this may be because of an increase in the abundance of minke whales in the inshore waters off Korea.

At last year's meeting, it had been agreed to include variants of the four base-case trials in which an incidental catch of 150 whales per annum is taken from sub-area 6. This means that the incidental catch does not respond to changes in abundance. The sub-committee agreed to retain these trials but also to include incidental catches off Korea (sub-area 6) in all the other trials. These incidental catches are assumed to be zero before 1989, to increase from 0 in 1988 to 78 in 1995, and to be 129 in 1996. The catches for the years from 1997 onwards are defined as 78 multiplied by the ratio of 1+ abundance to the 1+ abundance in 1997. The rationale for these specifications are the comments by Kim that minke whales returned inshore only gradually after the

end of commercial whaling in 1986, that 1996 was environmentally abnormal resulting in an atypically high incidental catch that year, and the expectation that future incidental catches would be depend on the size of the population.

At last year's meeting, a Working Group was established to consider all the information on incidental catches in Japanese fisheries (estimated and observed) and to specify a time series of total incidental catches. Brownell reported that no agreement had been reached. He also noted that the incidental catches reported in the Japanese Progress Reports are notably lower than the estimates in Tobayama *et al.* (1992). While it is likely that the reported incidental catches are under-estimates, it is unclear whether the extrapolations made by Tobayama *et al.* (1992) are appropriate. Intersessionally, Brownell and Yagi had discussed the issues of what correction factors to apply to the reported estimates of incidental catch and how to collect better data in the future. Yagi reported that a project had been initiated to examine the first of these issues but it had not yet been completed. It was agreed that the completion of this work was necessary before the Commission could actually apply the RMP to this stock. In the meantime, it was also agreed that plausible scenarios on incidental catch should be used for the purpose of *Implementation Simulation Trials.*

The sub-committee agreed that two scenarios should be considered in trials: (a) that incidental catches are taken to be those in the Japanese Progress Reports, and (b) that incidental catches should be based on the values reported in Tobayama *et al.* (1992). Specifications incorporating these bycatches are given in Section D of Appendix 6. Further discussion is reported under Item 8.3.4.

Although it was generally agreed by the Commission last year that, as far as possible, the *CLA* should be used 'to determine the allowable removals and then take account of all known human-induced mortalities', other views were also expressed. The sub-committee therefore agreed that trials should be conducted in which (a) the incidental catches are taken over and above commercial catches as set by the RMP, and (b) in which the removals from each sub-area are the maxima of the incidental catches and the catches set by the RMP. This last case corresponds to the assumption that the RMP catch limits cover all non-natural removals.

8.2.3 Sightings survey planning

Smith described the intersessional work of the North Pacific Sighting Survey Steering Group (NPSSSG), noting that five tasks were identified (Appendix 8). The Steering Group was able to address several of these, and additional material was presented to the sub-committee relative to the remaining tasks. One important task was the development of review comments on an initial draft of the sighting survey proposal (SC/50/RMP4). Although comments were generated within the group, there was insufficient time for members to discuss the points raised. These comments were available for further discussion during this meeting. Several documents were also available to the meeting that addressed the outstanding issues.

Miyashita presented SC/50/RMP4, the revised version of the sighting survey plan addressed by the NPSSSG. He noted that this document included text in italics for convenience in determining how the recommendations of the NPSSG were accommodated. He also outlined the key features proposed for the conduct of the survey, and noted that the expected number of sightings, if the survey were conducted in the area proposed, would be 80.

In discussion, it was clarified that although this is a feasibility study it was intended that, if the survey is successful, estimates of abundance using the data were intended to be used in both implementation simulation trials and, potentially, in actual implementation of the RMP. It was suggested that because the applicability of the proposed methodology was not known, and because of concerns that some had raised about possible biases due to whale responsive movement (Item 5.3), it would be useful to include in the design the possibility of using an alternate estimation method. One possibility would be to use standard line transect analysis methods assuming $g(0) = 1$. The possibility of using the method used during the SCANS survey (Hammond *et al.*, 1995) due to Buckland and Turnock (1992) was also discussed. It was noted, however, that the latter two methods require different searching patterns, and that the observers would be required to adopt different search patterns so that the methods would not be compatible.

The sub-committee noted that the proposed determination of dive times using visual observations was not recommended as it is difficult to be confident about tracking individual animals and as some surfacings may be missed. The sub-committee **recommends** the use of other approaches such as monitoring diving using VHF telemetry. While it was noted that such monitoring would most desirably be made during the survey, as proposed for the visual observations, it would be acceptable if they were made at appropriate different times and even locations as was the case for abundance estimates in the northeast Atlantic (Schweder *et al.*, 1997). It was also suggested that if visual observations are attempted, they might be compared with VHF data or data from other more direct methods to determine the degree of bias in the visual observations.

The use of binoculars for searching and distance estimation was discussed. The sub-committee **recommends** that the experiments and testing of estimation of angles and distances should be conducted using the same methods used in the actual survey. The possibility of using binoculars for searching if the Buckland and Turnock method were adopted was noted.

Miyashita thanked the NPSSSG for its helpful assistance, and requested that it continue to function as the preparations for this survey and that for Bryde's whales (see Item 8.4.2). The sub-committee agreed and re-established the Steering Group under Smith with membership as listed in Annex Z.

The sub-committee considered the requirements for participation of a member of the Scientific Committee in this survey, as decided by the Committee last year. The sub-committee agreed that Scientific Committee representation on the planned surveys should take the form of participation of a scientist with active experience of surveys of the type proposed (hazard probability approach) and other methods that may be incorporated (such as the Buckland and Turnock method). The sub-committee noted that Miyashita (who has participated in Norwegian surveys using the hazard probability approach) would participate in the survey.

The sub-committee reiterated from last year its **strong recommendation** that the survey includes waters within the Russian EEZ in order to provide the necessary coverage. It **recommends** that the Commission requests the relevant authorities of the Russian Federation to grant permission for the vessels to operate in their EEZ. More generally, the sub-committee agreed that this recommendation should apply to all relevant countries in similar situations for all such surveys in the future.

8.2.4 Development of trials

The sub-committee considered the new information regarding stock structure for North Pacific minke whales in the context of whether it implied that changes had to be made to the specifications of the *Implementation Simulation Trials*.

SC/50/RMP7 presented the results of RFLP and sequencing analyses of the mtDNA control region for the examination of the population structure of North Pacific minke whales. In the first analysis, a total of 656 samples including 100 whales taken during the 1997 JARPN was examined. The pattern of genetic variation revealed by AMOVA in the 1997 JARPN samples was similar to that reported in a previous study (Goto and Pastene, 1997b). Haplotype frequencies in the samples from sub-areas 8 and 9 were not significantly different from those of the O stock. In the second analysis, a total of 153 samples was examined in a preliminary sequencing analysis. A consensus of 487 base pairs of the mtDNA control region was used. A total of 25 polymorphic sites discriminated 41 unique sequences (haplotypes) in the total sample of 153 individuals from sub-areas 6, 7 and 9. Nucleotide diversity was lower in sub-area 6 (0.0046 ± 0.0029) than in sub-areas 7 (0.0088 ± 0.0050) and 9 (0.0076 ± 0.0043). In general, nucleotide diversity in sub-areas 7 and 9 was similar to that for the eastern North Atlantic minke whale but lower than that for the Antarctic ordinary form minke whale. The results of the homogeneity test by AMOVA (PHI-st) showed a clear discrimination between minke whales from Korea (sub-area 6) and the eastern side of Japan (sub-areas 7 and 9) supporting previous results that used nuclear and mtDNA markers to investigate stock identity for these sub-areas. No significant heterogeneity was found in the comparison between sub-areas 7 and 9, though the probability was close to significant. Further sequencing analysis in sub-areas 7 and 9 was suggested.

SC/50/RMP8 presented the results of a microsatellite analysis to examine stock structure in western North Pacific minke whales based on a larger number of samples and loci than in a previous study (SC/49/NP12). Genotyping of three sub-areas (sub-area 6; $n = 26$-28, sub-area 7; $n = 184$-206, and sub-area 9; $n = 177$-188) at six microsatellite loci revealed significant differences in the expected heterozygosity between sub-area 6 and sub-areas 7 and 9. Heterozygosity was significantly lower in the Korean samples of sub-area 6 than in the samples from sub-areas 7 and 9. Significant differences were also found between allele frequencies from samples from sub-area 6 and those from sub-areas 7-9. No significant differences in allele frequencies were found between the coastal (sub-area 7) and offshore (sub-area 9) sub-areas on the eastern side of Japan. In contrast to the previous study, no significant deviation from the expected Hardy-Weinberg proportions for sub-area 9 was found although significant deviations were still detected for sub-area 7.

SC/50/RMP12 examined the evidence for a W stock for North Pacific minke whales using data for the early period (early May to early June) of migration in sub-area 9 using the data from the 1997 JARPN survey. A high proportion of males (82.1-90.1%), high apparent pregnancy rate (100%), and relatively lower proportion of mature females (6.6-7.5%) were observed in samples in the early season and the summer season. Furthermore, whales taken in the early migration season, had almost the same peak of conception date as the sample in summer in sub-area 9 as well as the eastern side of sub-areas 7 and 8. Regarding other information such as the occurrence of anomalous testes of males, no difference was observed between the samples in the early season and summer. Overall, the results obtained from the 1997 JARPN samples provide no evidence to support the existence of a W stock in sub-area 9.

Baker summarised information in SC/50/RMP15 relating to the stock structure of North Pacific minke whales. From a forensic study conducted from 1993-97, 79 products were identified as northern minke whales using phylogenetic analysis of mtDNA control region sequences (Baker *et al.*, 1996). Variation within a highly variable 350 nucleotide segment of the control region resolved 26 unique sequences (i.e., haplotypes) among the northern minke whale products. It was assumed that the origin of the products from Japan was hunting, under scientific permit, of the O stock (IWC, 1997b, pp.203-26), primarily in sub-areas 7, 8, and 9 of the western North Pacific (to the east of Japan). It was assumed that the origin of products from Korea was coastal bycatch of the J stock (IWC, 1997b, pp.203-26) in the Sea of Japan/East China Sea (SC/50/ProgRep Korea). Contrary to expectations from previous genetic analysis (Goto and Pastene, 1997a), seven of the seventeen haplotypes in the Japanese samples were identical to Korean haplotypes. These shared, identical haplotypes accounted for 44% of the 25 Japanese products. A collection of 15 North Pacific minke whale products purchased in late 1997 and early 1998 showed a similar high proportion of shared, identical haplotypes with the Korean products (SC/50/O8). An analysis of variance modified for haplotype frequencies and molecular information (AMOVA) showed significant differences between the Korean and Japanese samples collected from 1993-97 (SC/50/RMP15). However, the magnitude of the genetic differentiation was 10-fold lower for the haplotype statistic and several-fold lower for the molecular distance statistic, compared to that of SC/50/RMP7 and Goto and Pastene (1997a).

The authors of SC/50/RMP15 and SC/50/O8 believed that this analysis raised two biological concerns relevant to the *Implementation Simulation Trials*. First, the currently accepted division between J and O stocks could be over-estimated due to the small and, perhaps, seasonally and geographically restricted sample used to represent the J stock in previous genetic analyses. Second, the current estimate of mixing between J and O stocks could have been underestimated. These are not mutually exclusive hypotheses.

Yagi recalled that, when similar forensic papers by Baker were presented last year to the Committee, 'some members noted that these reports did not provide information that could be used to evaluate stock structure as the geographic location of the samples referred to was unknown'. This year's documents SC/50/RMP15 and SC/50/O8 had exactly the same problem and he believed that they did not contain new information relevant to specifying *Implementation Simulation Trials*.

In discussion, Baker, Brownell and Wade noted that the analysis of mtDNA control region sequences in SC/50/RMP7 provided valuable new information on the question of stock differences or mixing between the J and O stocks. In particular, it allowed the comparative identification of previously defined RFLP haplotypes 2/5 using the direct sequencing methods of Baker *et al.* (1996) as applied specifically to the Japanese and Korean markets (SC/50/RMP15). The 2/5 types account for 76.7% of the samples representing the J stock (i.e., sub-area 6) and only about 4% of the 'O' stock (i.e., sub-areas 7, 8 and 9), except in sub-area 11 where seasonal mixing results in about 13.7% of types 2/5 (table 4 of SC/50/RMP7). However, the large

majority of whaling since 1994 has been in sub-areas 8 and 9. Only 30 whales were killed in sub-area 11 (Pastene *et al.*, 1997) of the total of nearly 300 from 1994-97. For these reasons, the frequency of type 2/5 products, representing J stock whales, should be low in Japan, perhaps 6%.

Baker noted further that information in SC/50/RMP7 showed that a 'G' in position 298 of the control region identified all 21 of the type 5 sequences and one of the two type 2 sequences (table 8, SC/50/RMP7). Only one of the other 124 sequences from sub-area 7 and 9 was characterised by this 'G', suggesting a potential misclassification error of about 0.8% for non-type 2/5 sequences. Based on this information, a review of figs 1 and 2 of SC/50/RMP15 showed that 7 (28%) of the 25 Japanese North Pacific minke whale products purchased from 1993-97 were type 2/5. Baker noted that unpublished data also showed that 6 (40%) of the 15 North Pacific minke whale products purchased in late 1997 and early 1998 were type 2/5. Overall, type 2/5 products accounted for 32.5% of the 40 North Pacific minke whale products purchased in Japan from 1993-98. Baker believed that this is difficult to reconcile with the expectation of a small percentage of J stock whales in the Japanese markets and supports the need to address uncertainty about stock structure or mixing rates in the *Implementation Simulation Trials*.

Yagi stated that there was no reason to assume that the difference between 32.5% and 6% of the frequency of type 2/5 samples reflects uncertainty about stock structure or mixing rate. Rather the difference could be explained by the different nature of the two datasets: Baker's value of 32.5% was calculated using samples of unknown origin while the value of 6%, which was estimated using data from SC/50/RMP7, came from samples of known origin. Thus, he saw no reason to reconcile this difference.

The sub-committee noted that the location of the samples in SC/50/RMP15 and SC/50/O8 was unknown. Some members believed that because of this, SC/50/RMP15 and SC/50/O8 did not provide information that could be used to evaluate stock structure. Hatanaka noted that some of the animals could have been taken incidentally from the Sea of Japan, and that substantial quantities of frozen meat remained. Other members believed that the information in these papers was useful and might necessitate changes to the assumptions regarding stock structure and the values in the mixing matrices.

The sub-committee noted that the number of samples from sub-area 6 that had been genetically analysed in SC/50/RMP7 and previous papers was small (30) and had been collected from a limited area over a very short period (Sept.–Oct. 1982). It agreed that additional samples from animals stranded in Japan and from the incidental catches off Korea would further an understanding of stock structure in the Sea of Japan. Kim stated that he would contribute morphological and genetic samples from bycatches to improve understanding of stock structure in the region.

It was noted that the trials already allow for a small fraction of J stock animals to mix into sub-area 7 and some members suggested that increasing this fraction should be considered in the revised trials. Baker pointed out that if substantial quantities of J stock animals are found in sub-area 7, one of the possible explanations for the results in SC/50/RMP15, this was inconsistent with the results in SC/50/RMP8. However, Punt noted that this fraction was estimated as part of the conditioning process rather than being fixed. He also noted that because the revised trials would include incidental catches off Japan (including catches in the Sea of Japan) this would reduce the difference between the current set of trials and the apparently conflicting information in SC/50/RMP15.

It was agreed that an additional set of trials based on the four base-case trials would be developed that include the fraction of type 2/5 haplotypes in the Japanese market in the conditioning (Section F (g) of Appendix 6) assuming that the product available in the market each year is selected randomly from catches during that year. It was recognised that this last assumption was extreme because of the unknown locality of the market sample. The values for the coefficients in the mixing matrices (e.g. the fraction of J stock animals in sub-area 7) would be chosen to mimic this fraction as well as to be consistent with the other information used for conditioning.

It was agreed that this overall issue would be considered further when additional genetic samples from the incidental catches off Korea and from strandings and incidental catches in Japan are analysed.

Allison presented the revised specification for North Pacific minke whales *Implementation Simulation Trials* (Appendix 6). She drew attention to those aspects that had changed since the specification had last been published (IWC, 1997b, pp.216-225).

(i) The trials are amended to take into account, and to investigate the effect of different levels of, incidental catches off Japan. Two different options are to be tested: J(i) in which the catches are taken to be those reported in Japanese progress reports and which are assumed to continue at a similar level in the future (of 27 per year); and J(ii) in which an annual catch of 93 animals is assumed, as estimated by Tobayama *et al.* (1992). This level of catch is applied both since 1900 and continuing in the future.

These trials include taking an incidental catch from sub-areas for which a catch limit is set by the *CLA*. The commercial catch taken is assumed to be equal to the catch limit less the incidental catch. Robustness trials will also be performed in which the commercial catch taken is equal to the catch limit, with the incidental catch being taken in addition.

(ii) The trials specified last year to test the effect of incidental catches off Korea are extended following information presented by Kim (Appendix 7). The base case assumes an incidental catch of 0 is taken in 1988 rising to 78 in 1995, followed in 1996-97 by the actual values reported by Kim. Future catches are assumed to be at a level proportional to the future population size in this sub-area. Four robustness trials are added to investigate the effect of a different level of incidental catch: a constant catch of 150 whales per annum since 1988 is assumed which continues into the future.

(iii) Trials will be run to test the effect of potentially different proportions of J whales in the catch taken by Japan. The effect of selecting the initial parameters (i.e. conditioning) to meet the requirement that 39.2% of the total catch (both commercial and incidental) off Japan are J stock whales is to be compared with results of trials where this condition is not met.

(iv) The conditioning process is amended to ensure that the entire historic catch can be taken from the pertinent sub-area. This may require the addition of extra parameters into the catch mixing matrices.

The sub-committee thanked Allison and the Working Group for their work. A number of points of clarification were raised and minor modifications were made. Polacheck queried whether there was an alternative to adding free

parameters in the conditioning process when there were problems identified in ensuring that the entire historic catch can be taken from the pertinent sub-area. Allison and Butterworth responded that this would be investigated.

Several members expressed reservations about the plausibility of Option J(ii) in the trials concerning incidental catch in Japan as an independent review of this issue is ongoing. Nevertheless they accepted that this option should be included in the *Implementation Simulation Trials* at this time. Brownell expressed reservations about the plausibility of option J(i).

The sub-committee agreed the revised specification for North Pacific minke whale *Implementation Simulation Trials* as given in Appendix 6 and **recommends** as a high priority that the Secretariat conduct the trials during the intersessional period and report the results to next year's meeting.

Two years ago the sub-committee had established a Steering Group to consider and resolve any inconsistencies that remained when the trials were conditioned and run, and make decisions about the choices specified in Appendix 6. It re-established this Steering Group with membership Allison, Butterworth (Chair), Kawahara, Punt and Taylor. [Other members joined following plenary discussion under Plenary Item 8.2.4].

8.3 North Atlantic minke whales

8.3.1 Northeastern stock

8.3.1.1 PROGRESS DURING INTERSESSIONAL PERIOD

Polacheck reported on work completed by the intersessional Abundance Estimation Steering Group. He noted that at the 48th Annual Meeting it was agreed that additional analyses should be undertaken with respect to the estimates of abundance for eastern North Atlantic minke whales from the NASS 1989/90 and NILS-95 surveys. The identified analyses were (IWC, 1997a, p.76):

(1) additional simulation tests to more fully explore the statistical properties of the Norwegian Computing Center (NCC) estimator and for the purpose of further confirmation that software was adequately verified;
(2) to reconcile any differences between comparable estimates obtained from the NCC and Cooke implementations by identifying the main causes of any such differences;
(3) to further assess the implications, in terms of possible bias in the NCC estimates, of the lack of model fit to the Bernoulli data, with respect to the marginal distributions of radial distances.

In the interval between the 48th and 49th meetings an intersessional Steering Group was established to undertake the above analyses. While significant progress had been made by the Steering Group on the above issues and some additional progress had been made at the 49th annual meeting, definitive answers were not reached. Consequently, the Steering Group (Butterworth, Skaug, Schweder, Laake, Hammond, Palka, Polacheck (Chair), de la Mare, and Zeh) was asked to continue work on these issues intersessionally and to 'define and pursue a course of analysis that in its judgement would allow definitive answers to these questions to be available at the next annual meeting'. In order to facilitate this, Cooke agreed to join Steering Group.

After considering various options, the Steering Group agreed that there were two additional methods and implementations that could be used to analyse the NASS 1989/90 and NILS-95 survey data. One was the method presented by Skaug (1997) and the other was the implementation of the NCC approach that Cooke had been developing (Cooke, 1997). The group further agreed that it was the estimates that needed to be validated and not the estimator. It also noted that there were insufficient time and resources available to comprehensively address the statistical properties and lack of fit issues using the software implementation of Schweder *et al.* (1997), particularly given the short time period between the 49th and 50th Committee meetings. As such, the Steering Group agreed that the best approach was to produce independent estimates using these two other approaches. Skaug and Cooke agreed to undertake the analyses of the survey data using their respective approaches. If these two other approaches yielded estimates that were approximately the same as those in Schweder *et al.* (1997), the Steering Group agreed that this would provide sufficient validation of the estimates and that it would consider that the three issues had been resolved. If the different estimates did not agree, further analyses of the underlying source of the discrepancy might be required. However, the additional analyses that might be required could not be specified in advance.

Polacheck noted that the intention of the Steering Group was to have the results from analyses using these two approaches available with sufficient time for review prior to the 50th Committee meeting. Preliminary results were available from Skaug in February that indicated substantial agreement between the estimates from his approach and those in Schweder *et al.* (1997). Final results were not available until just shortly before the Committee meeting and yielded estimates that were about 30% greater than those in Schweder *et al.* (1997). An incomplete draft of a working paper which was intended for this year's meeting and which detailed some of Cooke's results was also made available to the Steering Group shortly before the meeting. At the same time, a copy of an intended working paper which Cooke had prepared too late for consideration by the Abundance Estimation sub-committee at last year's meeting was also circulated. The latter indicated close agreement between the abundance estimates from Cooke's implementation and the results in SC/47/NA1 for the NASS 1988/89 data, when no covariates were included. The time available in the period between when the Skaug and Cooke results became available and the start of this year's meeting was too short for the Steering Group to be able to review them. However, results from both approaches were to be presented in meeting documents to the 50th Scientific Committee meeting. The Steering Group considered that these result should provide the basis for the Committee to resolve the three outstanding issues.

8.3.1.2 REVIEW OF NEW INFORMATION

Papers that provided new information that could be used to address the three issues listed in Item 8.3.1.1 were SC/50/RMP1, 2, 3, 20, 21 and 22.

The portions of the results in SC/50/RMP1 that pertained to issues 1 and 2 were discussed. This paper presented an application of the perpendicular distance based hazard probability method (Skaug and Schweder, 1998) to the NILS-95 data. The application incorporated the approach described in SC/50/RMP2 for identifying duplicates in independent observer surveys, and for correcting for duplicate identification errors. The resulting estimate of abundance in SC/50/RMP1 was 114,916 without any covariates. When sea-state was included as a covariate, the estimate was 126,863. These estimates of abundance are approximately 30% higher than the corresponding estimates in Schweder *et al.* (1997). Possible reasons for this

difference include the method for determining duplicates and possible bias in the estimator for some parameterisations of the logit hazard rate models for the detection process. The duplicate identification method was different from that in Schweder *et al.* (1997) as it was necessary to classify sightings into duplicate or non-duplicate whales in contrast to surfacings in Schweder *et al.* (1997). This classification was done subjectively, based on a careful examination of the data. This could be a source of bias in the estimates. However, in performing the subjective classification, a conservative approach was adopted when classifying possible duplicates as separate whales in order to prevent a positive bias in the estimates. Simulation results indicate that this perpendicular distance based method yielded positively biased estimates when applied to simulated data sets conditioned on observed radial sighting distance and angle distributions from harbour porpoise surveys. In one instance, the bias was as large as 30% suggesting that the current implementation of the model may not be robust to certain types of detection functions.

SC/50/RMP3 presented additional analyses concerning the apparent lack of model fit to the Bernoulli data with respect to the marginal distributions of radial distances in the NCC results. At last year's meeting, a test was performed that indicated that the lack of fit was statistically significant (IWC, 1998c, appendix 4). SC/50/RMP3 presented the results of applying this same test to estimates derived from 25 simulated data sets using the NCC analysis method and implementation. This was one approach that had been identified at last year's meeting. The test was found to provide a large number of significant results when applied to the estimated results from the simulated data sets. However, a similarly large number of significant results were found when the same test was applied to the simulated data sets when the 'true' underlying parameter values for the hazard probability function was used to calculate the expected proportion of successes to include in the test. These latter results indicate that the test statistic used was over-dispersed relative to a chi-squared distribution and, as such, was inappropriate.

After a discussion on the form and rationale underlying this test statistic, several reasons were identified that could have contributed to this over-dispersion.

(1) Measurement error: the expected probabilities were not calculated at the true positions due to measurement error;
(2) Duplication identification errors: the number of trials was not equal to the true number of trials due to a certain proportion of the outcomes being incorrectly classified;
(3) Link function: the link function used was that of Schweder *et al.* (1997); ideally, a new link function should have been calculated for the parameter values used the simulating data, so this may have caused a lack of fit for both the actual and observed values.

The sub-committee agreed that because of the large over-dispersion in the distribution of the test statistic in this case, the goodness of fit test presented in SC/50/RMP3 did not provide a reliable indication of significant lack of fit. In light of this, a reasonable approach was to use the simulated realisations of the values of the test statistic in table 1 of SC/50/RMP3 to obtain an empirical approximation to the distribution of the test statistic. This empirical approximation could then be used as a basis for testing goodness of fit. When this was done, the lack of fit to the simulated data was no longer significant. This indicates that the previous lack of fit identified (for test see IWC, 1998c, appendix 4) to the NILS 95 bernoulli data is not likely to be significant. However, the limited power of the statistical test in this case was noted.

SC/50/RMP22 presented results of an alternative implementation of the hazard probability method to the NILS95 data. The basic method for strip width estimation is described in Cooke (1997) and was extended to allow for inclusion of covariates as recommended by the Committee. The extensions to the method to allow the fitting of covariates were specified in SC/50/RMP21. The Akaike Information Criterion (AIC) was used to select covariates for inclusion in the model. A preliminary analysis was first performed to choose a suitable form for the hazard probability function. A sequence of environmental covariates were then fitted: sea state (Beaufort), weather (cloud cover), and meteorological visibility were selected in both the level and the radial components of the hazard rate function on the basis of AIC, but glare was not selected. Observer covariates were then fitted as variance components (sources of heterogeneity). Team effects in the level and radial components of the hazard rate, and in the recorded distance bias all gave substantial reductions in the AIC. Although the AIC indicated that estimating a separate dispersion parameter (where the dispersion is the variance/mean ratio of the number of whales encountered) for each survey block was preferred over estimating a common dispersion parameter, it was clear from the results that the block-specific dispersion rates were not well estimated, and that this aspect of the methodology needed to be improved. A comparison of the observed and predicted distribution of radial distances to initial sightings (which accounted for rounding errors in the manner specified in SC/50/RMP19) indicated an acceptable fit to the data. The fit of observed and predicted duplicate proportions by radial distance was also acceptable, but the distribution of angles indicated significant lack of fit, which the authors attributed to a failure of the rounding model of SC/50/RMP19 to adequately correct for rounding beyond 45°.

Extensive discussion on this paper resulted in a number of suggestions and concerns. These included:

(1) There was concern that the model was over-parameterised, particularly with respect to the heterogeneity between vessels, blocks and observers, all of which are inter-related. It was suggested that the dispersion between blocks should be investigated in order to determine if the dispersion parameter should be allowed to vary for every block or instead for groups of blocks (particularly those with low sample sizes). In addition, it was suggested that team heterogeneity should be investigated to determine if it was in fact as high as the results implied. Because of small sample sizes for some teams, the number of duplicates could be very small and thus cause a bias. It was suggested that consideration be given to pooling data across some teams to alleviate this problem.
(2) The measure of dispersion used for estimating the variances does not appear adequate. An alternative measure should be considered that is less sensitive to cells with small sample sizes.
(3) For presentation purposes and comparison of the standard error of the model parameter estimates, the level of a factor that is set as the aliasing baseline should be a level that has the largest or at least an adequate sample size. This may not be the last level of a factor, as is often the default in statistical packages.

(4) It was suggested that the number of duplicates at the block level be presented in tabled results in order to allow a more complete evaluation of the estimates between blocks.

Additional discussion concerning (1) and (2) focussed on comparing estimates from the NCC and Cooke implementations found in Schweder *et al.* (1997) and SC/50/RMP21, respectively. Comparison of abundance estimates resulting from the NILS95 data for models without any covariates indicated that the Cooke estimate was similar but less than that from the NCC implementation (77,500 compared to approximately 82,000 - this NCC estimate was reduced by approximately 4,000 to account for estimated abundance in blocks NVN and JMC which are not included in the Cooke estimate). It should be noted that exact agreement should not be expected because different parameterisations of the logit model for the hazard probability function were used in the two implementations. The sub-committee considered the closeness of the two estimates as an indication of the robustness of the estimator to the specific parameterisation.

Comparison of the abundance estimates for the two implementations for their respective best fit that included covariates indicated a larger difference between the two. The abundance estimates for the complete model was 112,000 for the NCC implementation and 141,500 for the Cooke implementation. It was noted that the Cooke implementation contained substantially larger numbers of covariates and, as such, it was not surprising that the Cooke estimate was larger. The sub-committee considered the *eshw* estimates for the different blocks from the two implementations. However, these were defined and calculated differently in the tabled results. As such, the estimates were not directly comparable. It was noted the the relative magnitude of the abundance estimates by survey block for the full covariate model for the two different implementations exhibited considerable variability. This same level of variability was not seen in the comparison of the NCC estimates with those based on the perpendicular based method in SC/50/RMP1.

In conclusion, the sub-committee noted that the abundance estimates obtained in SC/50/RMP21 without the inclusion of environmental and observer covariates were reasonably close to the estimate without covariates obtained by Schweder *et al.* (1997). Furthermore, the range of estimates obtained with covariates fitted spanned the range of estimates obtained by Schweder *et al.* (1997) with covariates, although there were differences in the underlying functional form of the hazard rate and the way in which covariates were included in the model. The sub-committee concluded that this comparison adequately addressed item (2) of the tasks identified at its 1996 meeting (IWC, 1997a, p.76), namely the reconciliation of any differences between comparable estimates between the two different implementations of the hazard probability method. The sub-committee noted that the results of SC/50/RMP21 were also relevant to item (3) of these tasks in that there was no indication of a lack of fit to the Bernoulli data by radial distance interval in this implementation. As such, the model fit appeared to be acceptable in this regard.

The sub-committee noted the substantial amount of work involved in producing the abundance estimates in SC/50/RMP21. It thanked Cooke for his sustained effort and considered that SC/50/RMP20 and 21 represented important contributions to the science of line transect abundance estimation in addition to their value in helping to resolve the specific issues being addressed under this Agenda Item.

SC/50/RMP20 presented results for two sets of simulation studies of the version of the hazard probability method described by Cooke (1997), as modified to account for covariates in the way specified in SC/50/RMP21. The first set used simulated data generated with a view to emulating the surveys of minke whales in the eastern North Atlantic (SC/A96/AE20). The results showed that strip width estimates based on a simple logit model for the hazard probability seemed to agree well with the 'true' strip width, although most of the data sets were too small for the latter to be known precisely, hence a precise comparison was possible in only four of the data sets. The results from fitting a product logit model were less satisfactory. The second set used simulated data generated with a view to emulating surveys of harbour porpoise (Palka and Polacheck, 1997). The agreement between estimated and 'true' densities was good in all scenarios when delayed duplicates (cases where a pod is sighted by both platforms, but one sees it before the other) were used, but there was a 10-15% bias in estimated density when only simultaneous duplicates were used. It was noted that these latter results may not be directly relevant to the evaluation of the estimator used with the NASS-87/88 and NILS-95 survey data for eastern North Atlantic minke whales.

8.3.1.3 CONCLUSIONS

The sub-committee agreed that the large amount of new information available at this meeting provided a sufficient basis for resolving the three outstanding issues with respect to the Schweder *et al.* (1997) abundance estimates for northeast Atlantic minke whales from the NASS 1989/90 and NILS1995 surveys. The sub-committee agreed with the advice from the intersessional Steering Group that it was the estimates that needed to be validated and not the estimator. The sub-committee also agreed with the approach taken by the Steering Group to compare the estimates from the NCC implementation with estimates produced by the implementation and methods in SC/50/RMP1 and SC/50/RMP22 as a sufficient basis for validating the NCC estimates with respect to the above three issues. The sub-committee noted that the comparable estimates from these alternative approaches were either quite similar or, when the discrepancies were greater, the NCC estimate was always the smaller. In these latter cases, potential reasons had been identified that could be introducing positive biases in the alternative implementations. The sub-committee noted that in terms of implementation within the RMP the primary concern is to avoid positively biased estimates. In this context, the comparative results provide no indication of a positive bias in the NCC estimates.

The sub-committee further recognised that the new information available this year contained results which dealt directly with each of the three outstanding issues. With respect to the first issue, the additional simulation results in SC/50/RMP20 provided additional information on the statistical properties of the general hazard probability approach and indicated general agreement between the estimated *eshw* using this approach and the 'true' value within the simulated data sets. The sub-committee noted that the issue of software verification had been resolved at last year's meeting. With respect to the second issue, the results in SC/50/RMP22 provided comparable estimates from the NCC and Cooke implementations which provided no indication of any positive bias in the NCC estimates. With respect to the third issue, reconsideration of the statistical test performed at last year's meeting suggests that the test, as performed, was inappropriate. The test in SC/50/RMP3

appeared not to indicate a significant lack of fit to the Bernoulli data in the NCC implementation, although the sub-committee noted that the power of this test is limited. SC/50/RMP22 also found no lack of fit in its implementation and SC/50/RMP19 indicates that the apparent lack of fit in the NCC implementation could be the result of not having taken into account rounding error. Taking all of these factors into consideration, the sub-committee agreed that the model fit appeared to be acceptable.

Overall, the sub-committee agreed that the comparative results from the different implementations combined with the other additional new information meant that the task of undertaking additional analyses with respect to the NCC estimates of abundance for eastern North Atlantic minke whales from the NASS-89/90 and NILS-95 survey as defined at the 48th Annual Meeting had now been completed. The sub-committee further agreed that the results from these analyses did not indicate any problem with the estimates in terms of the issues that had been raised at the 48th Annual Meeting and supported the Committee's previous conclusion that the abundance estimates in Schweder *et al.* (1997) are adequate for use in the RMP.

8.3.2 Central Stock

8.3.2.1 RECONSIDERATION OF EARLIER ESTIMATES

CIC Small Area. Last year, the Abundance Estimation sub-committee had noted an apparent discrepancy between the previously accepted abundance estimate for the NASS87 Icelandic aerial survey block (Hiby *et al.*, 1989) and a recent reanalysis of these data (Borchers *et al.*, 1997).

SC/50/RMP14 reported an investigation into the source of this discrepancy. The effective search area estimated by Borchers *et al.* (1997) was about half that estimated by Hiby *et al.* (1989). There was some slight difference in the data used, probably due to different truncation choices, but the major discrepancy resulted from the use of a peaked detection function, without correction for error in distances estimation, by Borchers *et al.* (1997) versus a detection function with a wider shoulder, in combination with correction for error in distance estimation, by Hiby *et al.* (1989). The error in distance estimation was apparent from comparison of distance estimates to duplicate cues seen by the two observers during the duplicate sightings experiment. In particular, one observer tended to round the angles of declination heavily. If the true detection function is flat at short distances, then error in distance estimates will tend to make the predicted distribution peaked at short distances, whereas if the true detection function is already peaked, error in distance estimation has less effect.

In discussion, it was noted that these data alone are insufficient to distinguish between detection functions which are peaked or flat near the origin. There was some inconclusive discussion as to whether a peaked or flat detection function might be expected *a priori*. It was noted that the detection function fitted to the data recorded during the West Greenland NASS87 aerial survey, for which distance estimation error was far smaller, had a shoulder extending well beyond the first distance interval (Hiby *et al.*, 1989). Assumption of a peaked detection function would yield a higher abundance estimate. However, other options suggested in the discussion, such as repeating the analysis without using the distance estimates from the observer who rounded heavily, could yield a lower estimate.

In conclusion, the sub-committee considered that the previously accepted estimate should remain so, pending resolution of the matters raised above. The sub-committee noted that the data from this survey had been provided to the Committee for use during the current meeting. However, no arrangements were in place for continuing access. The sub-committee considered that if the estimate is to be used in the implementation of the RMP then the data would need to be available to the Committee on a continuing basis in accordance with the Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme (IWC, 1997c, pp.227-28). This was considered critical in order that issues such as those raised in the discussion could be examined further if necessary whenever they arise (see Item 8.3.2.2).

CM Small Area. The Committee had previously calculated an abundance estimate from the NASS-87 data for this area from an *ad hoc* proration of the estimates from Norwegian and Icelandic surveys, based on the number of sightings in the area (IWC, 1993a, p.66).

SC/50/RMP17 presented a reanalysis of the NASS-87 data for this area. While the southern parts of the CM area received a reasonable coverage by Icelandic vessels, the northern parts covered by Norwegian vessels received a low coverage. The data from Icelandic and Norwegian vessels were pooled, resulting in a total of 25 primary sightings. A detection function was fitted to the pooled data, giving an effective search half-width of 0.122 n.miles (CV 0.336). Encounter rates and school sizes were estimated separately by original survey stratum. The total estimate of minke of minke whale abundance for the CM *Small Area* in 1987 was 11,969 whales (CV = 0.445).

In discussion, three concerns were raised about the analysis presented in SC/50/RMP17. First, no smearing of the line transect data had been carried out. The fitted detection function had a very narrow shoulder (approx. 0.025 n.miles) and a steep fall-off, which is suggestive of angles rounded to zero. Second, data were pooled across Icelandic and Norwegian vessels. Previous analysis has suggested that the effective strip width for minke whales was appreciably wider for the Norwegian vessels. Although the number of sightings from Icelandic and Norwegian vessels was about the same, the population size estimates obtained from Norwegian data alone accounted for roughly 80% of the total abundance estimate. Hence, downward bias in the estimated effective strip width for the Norwegian vessel may have led to substantial upward bias in the population estimate, which will not have been compensated for by an opposite bias from the Icelandic data. Third, survey block B2 contributed over 50% to the total abundance estimate, yet survey coverage in this block was very low. All but one detection came from a single transect line. There was no search effort in the northwest portion of the block. It was suggested that it would be more appropriate to treat this portion as not having been covered by the survey. It was further suggested that, instead of analysing these relatively small sets of data in isolation, they should be analysed in the context of the full Norwegian and Icelandic data sets from the NASS-87 surveys.

The authors of SC/50/RMP17 indicated that they would undertake to reanalyse the data to address the concerns raised. The sub-committee noted that the data from this survey were also available to the Committee only during the current annual meeting. The sub-committee emphasised that if the abundance estimates from these data are to be used as input to RMP implementation, the data will need to be available to the Committee on a continuing basis (see Item 8.3.2.2).

SC/50/RMP10 analysed minke whale sightings data collected in the NVS stratum of the CM *Small Area* from

Icelandic vessels in the NASS-95 survey. An estimate of 5,869 minke whales (CV = 0.427) was obtained using standard line transect methodology assuming $g(0) = 1$. It is likely that $g(0)$ was in fact less than unity so that this abundance estimate is negatively biased. Evidence for $g(0) < 1$ include: a paucity of detections near the trackline together with reports that observers may not have 'guarded' the trackline; the omission of sightings first detected behind the abeam line in the analysis; evidence from analyses of Norwegian surveys, in which $g(0)$ for north Atlantic minke whales was estimated to be substantially less than one (Schweder *et al.*, 1997). The estimate for the NVS stratum was added to estimates for the NVN and JMC strata of the CM *Small Area* obtained from the NILS-95 survey using different methodology (Schweder *et al.*, 1997) to yield a total abundance estimate of 12,043 minke whales (CV = 0.277) for the whole CM area in 1995.

The sub-committee had a number of questions concerning the conduct of the survey and the field protocols followed, such as whether there had been experiments to test distance estimation and how duplicate sightings had been identified. The authors of SC/50/RMP10 reported that there had been no independent observer counts, and that there had usually been one observer in the barrel, which had a standing height of 12-13m, while the remaining observers were on the bridge, the height of which was 9m. Some observers had used reticule binoculars and some had used distance sticks to estimate distances. Initial distance estimates were sometimes revised following a resighting of the whale and sometimes the recorded distance estimate was a consensus estimate reached by two or more observers. Experiments were conducted to test observers' ability to determine sight distances and angles, but documentation of these experiments was not available. The sub-committee's attention was also drawn to NAMMCO document SC/4/18 (Sigurjónsson *et al.*, 1996) which contained some of the information requested.

Since this survey had been conducted recently, the sub-committee considered that it was important to consider the extent to which it had met the requirements and guidelines for conducting surveys under the RMP. To facilitate this, a checklist (Appendix 9) was developed summarising the extent to which these were met. This checklist and possible implications for future use of estimates from these data in implementing the RMP are discussed under Item 8.3.2.2.

Data access for the Icelandic survey component described in SC/50/RMP10 was similar to that for the other surveys of the Central area reviewed under this item; i.e. the data had been supplied by Iceland for use only until the end of the current meeting. The sub-committee expressed its appreciation to Iceland for making available all of these datasets during the current meeting. However, the sub-committee once again noted that if the estimates were to be used in an implementation of the RMP, then the data would need to be made permanently available to the Committee.

8.3.2.2 DATA AVAILABILITY

Last year the Committee posed four general questions (IWC, 1998a, item 8.2.2) arising out of specific discussion about the availability of sighting survey data for estimates that it might review for suitability under the RMP. These questions arose out of the specific issue of the suitability of abundance estimates from the CM area that were based in part on data collected by a non-member state and for which the Committee did not have access to the primary data. The sub-committee had extensive discussion on these four questions. It noted that these questions arose out of the requirements and guidelines for surveys under the RMP (IWC, 1996, p.211) and that these requirements pertain strictly to data for estimates to be used in an implementation of the RMP. Requirements for data used by the Committee to address other issues do not fall under these same requirements.

The sub-committee considered that availability meant that the data needed to be lodged with the Secretariat and that they were freely available to all accredited members of the Scientific Committee without restriction. Data availability in this context does not extend to public access nor does it allow for further redistribution of the data by members of the Scientific Committee.

In discussing this issue, the sub-committee noted the desirability of having access to data from abundance surveys for stocks of interest to the Commission that were conducted by non-members states. The sub-committee **recommends** that the Commission request non-member states to cooperate in the work of the Committee by providing information on abundance surveys that they conduct on stocks of interest to the Commission and to make the data from such surveys available.

The sub-committee recognised that results from various other analyses (both inside and outside of the context of the RMP) were used to provide management advice to the Commission for which the data were not available to the Committee. Some members of the sub-committee considered that the question of data availability from these other analyses needed to be addressed by the Committee. However, the general question of data availability was considered beyond the scope of this item. The sub-committee agreed that this more general issue should be referred to the full Committee for its consideration,

The sub-committee discussion focused on the four questions posed last year by the Committee.

(1) REQUIREMENTS FOR CONTINUING AVAILABILITY OF DATA FROM ABUNDANCE SURVEYS

The sub-committee noted the critical importance of having continued access to data from abundance surveys. The need for such access is essential in order to be able to verify estimates when questions arise and to update previous analyses in response to methodological improvements and developments. In addition, a key component of the RMP is the requirement to periodically review the definition of *Small Areas* used in any particular implementation and to redefine these areas in light of additional information. Unless the data used to estimate abundance are available, it would not be possible to re-calculate appropriate abundance estimates that corresponded to redefined *Small Areas*.

The sub-committee **recommends** the requirement that data from abundance surveys be available on a continuing basis as an absolute minimum requirement if an abundance estimate from such a survey were to be used in an implementation of the RMP.

The sub-committee further **recommends** that the Committee should not review such estimates under the terms of the RMP unless there were assurances of such access.

(2) ACCESS TO DATA SUPPLIED BY A COUNTRY SUBSEQUENTLY LEAVING THE COMMISSION

The sub-committee noted the discussion above about the necessity to ensure continued availability of data for abundance estimates when such estimates are for use in the RMP. If data access were lost in the event that a member

state subsequently left the Commission then the continued implementation of the RMP could be compromised. As such, the sub-committee **recommends** that the Commission develop appropriate provisions that ensure that any data supplied by a member country for use under the RMP remains available to the Scientific Committee in the event that a member country withdraws from the Commission.

(3) POSSIBILITY OF ALLOWING 'SLIGHTLY MORE LIMITED RESTRICTIONS' WHERE DATA OF GREAT INTEREST TO THE COMMITTEE ARE OWNED BY A NON-MEMBER NATION

Last year the Committee agreed 'that it would be useful to attempt to make an estimate for the entire CM area for 1995.' At this year's meeting abundance estimates for the CM area that incorporated data collected by Iceland were referred to this sub-committee. These data were made available to the Committee during its current meeting, but no arrangements had been made for continuing access. The sub-committee recognised that Iceland was not currently a member of the IWC and as such was under no obligation to supply data or meet other requirements and guidelines when conducting surveys. The sub-committee also recognised that the Committee may have interest in having data available to it from abundance surveys conducted by non-member states with respect to other aspects of its work.

The sub-committee recognised that in both the case of the use of an estimate under the RMP and the use of an estimate to address other issues of interest to the Committee, limitations on the use of such data for analyses beyond that required for the RMP or the issue for which they were supplied might be considered. Such restrictions might include ensuring safeguarding the rights of collectors for the first use of the data for their own purposes. Such restrictions might be included as a part of the conditions under which the data would be provided to the IWC. The sub-committee considered that such restrictions should not necessarily preclude the use of abundance estimates from such data as long as there was adequate access to the data for use in the RMP. The sub-committee stressed that within the RMP context such data would need to be available without restriction to accredited scientists. However, the publication of results of analyses not clearly and directly related to implementation issues, without the agreement and/or collaboration with the data collectors, could be forbidden.

The sub-committee **recommends** that a set of guidelines be developed for the types of availability restrictions that it would consider acceptable if a non-member country, individual scientists or international organisation were to provide data for use in the RMP. In developing such guidelines, consideration should be given both to the needs for ensuring continuing adequate implementation of the RMP and the limitations on data uses that would facilitate and encourage the provision of such data.

(4) COMMITTEE POLICY ON REVIEWING PUBLISHED ESTIMATES IF THE RAW DATA ARE NOT AVAILABLE

The sub-committee **recommends** that the Committee should not review estimates for use in an application of the RMP based on data that it judges do not adequately meet its requirements and guidelines. However, the sub-committee **recommends** that the Committee should consider the specifics of any data set in terms of its requirements and guidelines. It should evaluate the degree to which the data are adequate for use in the RMP and should judge the relative importance in terms of the behaviour of the RMP in those areas where the requirements were not met and guidelines were not followed. In particular, some aspects of the guidelines dealing with prior notification and timing of data provision, etc. may be inappropriate or irrelevant depending upon the situation under which the survey was conducted by a non-member country.

In the case of the 1995 Icelandic data for the CM area, Appendix 9 provides an evaluation of these data in terms of the RMP requirements and guidelines. It was noted that the several members of the Committee had participated in the planning meeting in Tromsø for this survey. In addition, the methodology and procedures were similar to those used in the previous NASS-87 and 89 surveys. Moreover, results of analyses in SC/50/RMP10 suggested that if a standard line transect estimator was used with these data the resulting estimate would be negatively biased. With the exception of the issue of data availability, the sub-committee did not identify any issues in its review of SC/50/RMP10 and the supplementary information provided to the sub-committee in Sigurjónsson *et al.* (1996) that would have precluded the use of the abundance estimate in SC/50/RMP10 for use within the RMP. However, members of the Committee may wish to conduct additional analyses to verify the acceptability of the estimate for use in the RMP if the data become permanently available.

8.4 Western North Pacific Bryde's whales

8.4.1 Specification of Implementation Simulation Trials

The Scientific Committee completed the Comprehensive Assessment of North Pacific Bryde's whales at its 1996 meeting and recommended development of *Implementation Simulation Trials*. At last year's meeting, the Committee considered information about stock identity and historical catches of North Pacific Bryde's whales. It identified seven tasks which, if completed during the intersessional period, would assist in the development of *Implementation Simulation Trials*. An intersessional e-mail correspondence group chaired by Punt was established to facilitate completion of these tasks.

8.4.1.1 PROGRESS DURING INTERSESSIONAL PERIOD

Punt presented the report of the intersessional Correspondence Group on the Specification of *Implementation Simulation Trials* for the Western North Pacific Bryde's Whales (Appendix 10).

8.4.1.2 DEVELOPMENT OF TRIALS

The sub-committee considered the new information regarding stock structure for North Pacific Bryde's whales.

Pastene presented document SC/50/RMP9. The nucleotide sequence of the mitochondrial DNA (mtDNA) control region was determined to examine the pattern of genetic variation within and between ocean basins in the ordinary form Bryde's whale. A total of 221 samples were examined, 150 from the western North Pacific, 24 from the western South Pacific (south Fijian), 24 from the eastern South Pacific (Peruvian) and 23 from the eastern Indian Ocean (south Javan). For comparison, sequences of seven local form animals from the Solomon Islands and Kochi were used.

A consensus 358 base pairs segment of the control region was used. A total of 50 unique sequences (haplotypes) was identified, 48 in the ordinary form and two in the local form. The overall nucleotide diversity in the ordinary form was 1.10%. The western North Pacific sample was divided into two longitudinal sectors, Gr-A (10°N-35°N; 130°E-155°E, $n=79$) and Gr-B (10°N-40°N; 155°E-180°, $n = 71$). Homogeneity tests were conducted using the chi-squared test of independence, the haplotype (Hst) statistic and the sequence (Kst*) statistic. No significant differences in mtDNA composition were found between the two longitudinal sectors in the western North Pacific. In contrast

significant genetic differences were found among the western North Pacific, western South Pacific, eastern South Pacific and eastern Indian Ocean regions supporting the view that independent genetic populations of the ordinary form Bryde's whales occur in these oceanic regions. The study provided no evidence to support the occurrence of more than one population of the ordinary form in the western North Pacific.

The range of sequence divergence among ordinary form individuals was 0.28-3.74%. These values were much lower than the divergence calculated between ordinary form and local form whales (6.71-16.96%). At the population level, genetic distances among ordinary form populations were well correlated with their geographical locations. A negative value for the net inter-population distance was found between the two sectors in the western North Pacific. Among Pacific Ocean populations, the range was 0.11-0.60% while that between the Pacific and Indian Ocean populations was 0.74-1.09%. Genetic distances between ordinary form populations and the animals from Kochi ranged from 7.41% to 9.25% while those between ordinary form populations and the animals from the Solomon Islands ranged from 14.34% to 15.58%.

In discussion, Baker noted that the second most common haplotype for Bryde's whales in the Western North Pacific was the most common haplotype found in the Western South Pacific and raised the possibility of movement from the North to the South Pacific. Polacheck noted that the results of one test for differences between the Gr-A and Gr-B sectors were very close to significant ($P = 0.0520$). Pastene responded that because the other two statistics were far from significant and the net genetic distance was very low (zero) he would disregard the near-significant results for the Hst statistic.

Perrin presented SC/50/RMP13 which summarised available information on distribution relative to water depth of Bryde's whales in the Philippines. The information was requested by the sub-committee last year because of the suggested possibility of using a depth contour (the 1000-m isobath was mentioned) as the offshore limit of distribution of the local form Bryde's whales in the western Pacific. There are only six confirmed records. Five were in inner waters of about 250-1,000m depth; these were presumably of the local form. One sighting (unidentified but presumably of the ordinary form) was made off the eastern coast of Mindanao, in water some 5km deep. There are no records between 1km and 5km. Catch positions within the Philippines EEZ for 96 whales taken during Philippine commercial whaling in 1983-85 are thought to have been falsified; there is some evidence that the whales were captured outside the EEZ to the east and northeast. The limited data indicate that the 1,000m isobath would not be suitable to delimit the offshore distribution of the local form because more information (from sightings cruises) is needed on distribution over intermediate depths (1,000-5,000m) in the region.

Hatanaka queried the interpretation that water depth limits the distribution of animals, and he suggested the alternative interpretation that animals are distributed mainly in the water between islands.

Since the accuracy of the positions of the commercial catch is suspect, the sub-committee agreed that these data could not be used to make inferences about stock structure or distribution.

SC/50/CAWS6 summarised the information on stock identity and distribution for Bryde's whales in the eastern South Pacific. The Bryde's whale has been difficult to study in this region due to its similarity with the sei whale. Whaling stations continued to confuse both species until 1973 in Peru and 1981 in Chile. Bryde's whales are found in this region from the Equator to 37°S. Morphometric and genetic studies have separated Bryde's whales from Peru from animals from the western South and North Pacific and from animals from the Indian Ocean. No firm evidence exists to support additional stock structure in the eastern South Pacific. Most of the whaling operations and assessment of Bryde's whales in Peru were carried out in square H34 (0°-10°S; 80°W-90°W). Bryde's whales seem to occur in most months of the year in this square but especially during the austral summer. On the other hand, Bryde's whales in Chile seem to occur mainly in the central area (35°S-37°S) in spring-summer associated with a seasonal upwelling event. Relationships between Peruvian and Chilean Bryde's whales are unknown.

Best introduced a review of the distribution and population separation of Bryde's whales off southern Africa (SC/50/CAWS13), as requested last year. Available catch, sightings and biological data suggest that there are three stocks in the region. An inshore population (the South African Inshore Stock) occurs over the continental shelf of South Africa south of about 30°S, and appears to be non-migratory, although it may move up the west coast in winter. A pelagic population (the Southeast Atlantic Ocean Stock) occurs on the west coast of southern Africa, ranging from equatorial regions to about 34°S, and appears to migrate north in autumn and south in spring. A third (pelagic) population (the Southwest Indian Ocean Stock) occurs south of Madagascar northwards. Whales from the Southeast Atlantic Ocean Stock are larger than those from the other two stocks, and differ in scarring, baleen shape, diet, fecundity and seasonality of reproduction from those in the South African Inshore Stock. Circumstantial evidence suggests that the individual from Durban regarded as 'abnormal' may have been from the Southwest Indian Ocean Stock.

SC/50/RMP18 summarised the mark-recapture data for Western North Pacific Bryde's whales by 5° square using all available information (51 animals). The mark-recapture data indicate that: (a) the animals found in the whaling grounds in summer come from a wide latitudinal band from 5°S to 30°N where they are found in winter, and (b) intermingling of animals is observed from 5°S to 40°N and 130°E to 180°. The movements of 16 animals from or to the 5° squares including islands showed that all were connected to the offshore squares without islands. It was believed that this implies that the mark-recapture data do not support the existence the local form around the islands.

It was noted that the interpretation of the information in SC/50/RMP18 needed to account for the historical distribution of effort. For example, the lack of recaptures in the southern longitudinal bands was not surprising owing to the lack of historical effort in this area. Polacheck commented that there did not appear to be much longitudinal movement of animals marked north of 20ºN. He noted that only one animal had been recaptured more than 20º longitude away from where it was marked, although this may also be a consequence of the distribution of effort.

On the basis of inferences from where the local form has been shown to occur, historical commercial catches, sightings from research surveys and observations based on whalewatching as described in Appendix 11. Hatanaka argued that any Bryde's whales around the Hawaiian Islands, Midway Island, the Kiribati Group, the Caroline Islands, and the Northern Marianas should be considered to

be of the ordinary form. Perrin disagreed, noting that no surveys had been conducted near the Hawaiian Leeward Islands and that just because ordinary form Bryde's whales are found near an island does not imply that the local form cannot also occur there. Brownell commented that the situation for Midway Island and the Hawaiian Islands may be quite different from that for the islands in Indo-Pacific including the other island groups noted by Hatanaka.

Hatanaka presented SC/50/RMP11 which proposed three hypotheses regarding stock structure for western North Pacific Bryde's whales based on the results of 1996 Comprehensive Assessment, the outcomes of the intersessional e-mail correspondence group and other available information. These are: (1) only the ordinary form is found in stock division b (SC/50/RMP11, fig. 2), (2) animals of the local form are found around oceanic islands within this division, and (3) Southern Hemisphere Bryde's whales move into division b occasionally. SC/50/RMP11 suggested that the first of these hypotheses was supported by several sources of information, while no information negating it exists. The author believed that there is no information to support the second and third hypotheses. SC/50/RMP11 proposed three options for *Implementation Simulation Trials* based on these hypotheses (and their relative plausibility). These are: (1) a single stock scenario (the base case trial), (2) a 'two forms' scenario related to the second hypothesis, and (3) an intermediate scenario in which those island blocks from which mark-recapture and genetic samples were taken are allocated to the ordinary form.

In response to SC/50/RMP11, Perrin introduced Appendix 12 which raises several concerns with the assumption that the local form is not found around oceanic islands and that Southern Hemisphere Bryde's whales never migrate into the North Pacific. Kato noted that previous whaling operations around the Bonin Islands mainly occurred some 150-200 n.miles east of the islands. He further noted that although information from whalewatching can never be equivalent to a systematic survey, the whalewatching association of the Bonin Islands (OWA) has conducted seasonal surveys, which were organised more systematically than most whalewatching operations, in cooperation with the National Research Institute of Far Seas Fisheries. Whalewatching effort now extends to summer and autumn for sperm whales in addition to that in spring for humpback whales. However, no Bryde's whales had ever been seen around the coast of the Bonin Islands during surveys or whalewatching operations.

Appendix 13 summarises the existing information on sightings and sightings effort in the Western North Pacific and gives revised abundance estimates.

There was insufficient time to finalise discussion of the plausibility of the three hypotheses presented in SC/50/RMP11 or, therefore, to finalise agreement on how to model the structure of inshore and offshore Bryde's whales in and around major island groups.

The sub-committee then discussed plausible stock structure hypotheses for offshore Bryde's whales from a starting point of the stock area proposed by the Comprehensive Assessment and modified to exclude the area south of 10°N (Appendix 10, Adjunct 1).

Smith and Polacheck expressed a number of concerns based on the available information on catch distribution, and genetic and marking data. First, they queried why there was a gap in the catch distribution between 150° and 160°E. Second, they noted that there were large areas of ocean to the east of the proposed stock area in which there were no data. Third, having examined changes in catches over time in the area of pelagic whaling, they pointed out that downward trends in catches had occurred at a small spatial scale (5° × 5° block) over short (up to 5 year) periods of time. This raised concerns about local depletion and the possible desirability of incorporating within-stock spatial structure in the trials.

Hatanaka responded to these three issues. First, he pointed out that the gap in catch distribution between 150° and 160°E was a result of catch regulations; the western boundary to pelagic whaling set by the Government of Japan at that time was 159°E and the eastern extent of coastal whaling was restricted by distance from the land station. Second, he noted that although there were no genetic or marking data in the area to the east of 170°E, there were large catches and analyses of biological data had indicated no difference between whales taken by coastal and pelagic whaling. Third, he believed that it was clear from all the available data that there was no within stock spatial structure latitudinally or longitudinally. Ohsumi added that the observed trends in catches identified by Smith and Polacheck were a result of operational factors such as changes in the range of pelagic whaling grounds and catch quotas.

After considerable discussion of the available data and the areas to which they pertained (summarised in Appendix 14), the sub-committee agreed that an appropriate boundary to the western stock of North Pacific Bryde's whales for the purposes of the RMP was as described in Appendix 14. This specifically excluded the area to the south of the Hawaiian Islands and east of 180° from which there were no data. The sub-committee further agreed that there should be two sub-areas in this stock area divided by 180° which would allow the testing of two alternative stock hypotheses:

(1) there is only one stock of offshore Bryde's whales in the western stock area;
(2) there are two offshore stocks present in the sub-area to the east (sub-area 2 in Appendix 14), the western stock and an eastern stock.

The sub-committee noted that it was planned for future sightings surveys to cover the entire western stock area as defined over a four year period.

Key questions concerning stock structure that remained include: how to model the interchange between inshore and offshore Bryde's whales in the areas around islands; whether or not operational factors can explain the observed trends in catches at small spatial scales, and if not whether within-stock spatial structure needed to be considered.

Concerning catch data, a key issue is resolution of the disagreement last year about how to treat Soviet catches in the trials (IWC, 1998b). This would need to be resolved after sub-areas had been fully defined.

To address these and other questions relating to the specification of the simulation trials, the intersessional Working Group from last year was re-established under Punt to work by e-mail and to report to next year's meeting. Hatanaka further proposed that to ensure good progress a workshop should be held before next year's meeting. This had been considered last year but no workshop had been held. The sub-committee agreed that the detailed work of specifying trials was best conducted at a separate meeting but recognised that the priority given to any such meeting would need to be decided by the Committee during plenary discussions.

8.4.2 Sightings survey planning

Smith described the work of the North Pacific Sighting Survey Steering Group (NPSSSG), noting that nine tasks were identified (Appendix 8). The Steering Group was able

to address several of these, and additional material was presented to the sub-committee relative to the remaining tasks. One important task was the development of review comments on an initial draft of the sighting survey proposal (SC/50/RMP4). Although comments were generated within the group, there was insufficient time for members to discuss the points raised. These comments were available for further discussion during this meeting. Several documents were also available to the meeting that addressed the outstanding issues.

Miyashita presented SC/50/RMP5, the revised version of the four year sighting survey plan addressed by the NPSSSG. He noted that this document included text in italics for convenience in determining how the several recommendations of the NPSSG were accommodated. He also outlined the key features proposed for the conduct of the survey, noting that there will be three vessels used and that the expected number of sightings was 30 per vessel. One of the vessels will have the capability of an independent observer platform, which will be used as a feasibility study to determine if $g(0)$ is close to one or not.

In discussion, it was clarified that the data being collected are intended for use in both implementation simulation trials and implementation of the RMP for North Pacific Bryde's whales. It was suggested that the initial estimate of school size, at the time of sighting, be recorded as well as the actual estimate after closing in order to obtain data to correct school size estimates during passing mode. Although previous experience with this approach for Southern Hemisphere minke whales was noted to have been unsatisfactory, an attempt under these situations was suggested by some as being worthwhile. Covering an entire latitudinal band in one year was noted to be a good approach.

The sub-committee considered the requirements for participation of a member of the Scientific Committee in this survey, as decided by the Committee last year.

The sub-committee agreed that Scientific Committee representation on the planned survey should take the form of participation of a scientist with active experience of surveys of the type. The sub-committee noted that Shimada would participate in the survey.

The sub-committee **strongly recommends** that the surveys include waters within the EEZs of the Federated states of Micronesia, the Republic of the Marshall Islands and the USA in order to provide the necessary coverage. It **recommends** that the Commission requests the relevant authorities of the Federated States of Micronesia, the Republic of the Marshall Islands and the USA to grant permission for the vessels to operate in their EEZs.

9. LONGER TERM PRIORITIES AND DIRECTIONS

The sub-committee discussed priorities and directions under the following items: (a) issues relating to the RMP, (b) specifying, conditioning and conducting implementations and implementation reviews, and (c) reviewing and overseeing surveys plans and abundance estimates that are used in implementation trials and could be used in the implementation of the RMP.

(a) Priorities related to the RMP include:
  (1) revise *CLA* program (see Item 3.2);
  (2) tune the *CLA* to the accuracy needed (see Item 3.1).

(b) Long-term priorities related to specifying implementation trials include:
  (1) finalise specification and conduct implementation trials for North Pacific minke whales;
  (2) specify and conduct implementation trials for North Pacific Bryde's whales;
  (3) review and, as appropriate, re-specify the currently agreed implementation for northeast Atlantic minke whales (see below).

(c) There are long and short-term priorities related to reviewing and overseeing survey plans and abundance estimates.

  Long-term high priority topics include:
  (1) review plans for surveys and, as appropriate, suggest ways to obtain better data so that complicated analytical methods are not needed;
  (2) review abundance estimates from surveys intended for use in the RMP, specifically estimates from surveys for North Pacific minke and Bryde's whales and northeast Atlantic minke whales;
  (3) create and maintain a sufficient number of replicates of simulated data sets that have a variety of characteristics, particularly those that are similar to sighting surveys that have recently or will be conducted in the near future, e.g. in addition to those already simulated, include characteristics such as animal movement, errors in measurement, and duplication identification (see below);
  (4) analyse the above simulated data sets using estimation methods that might be used in the above mentioned surveys;
  (5) test existing abundance estimators for situations where ship avoidance is manifested by animals changing their surfacing patterns in response to survey vessels (e.g. Cooke, 1992).

  Short-term high priority topics include:
  (1) review of Clarke and Borcher's simulation study to test the properties of the GAM-based estimators of abundance, in general and as applied to JARPA data (SC/50/CAWS33) - this started during the meeting and will continue intersessionally;
  (2) test abundance estimation procedures that estimate abundance and trends from multi-year surveys (applicable to IDCR, Northeast Atlantic minke whales and North Pacific Bryde's and minke whale surveys);
  (3) test procedures that identify duplicates and correct for duplication identification errors (applicable to Northeast Atlantic minke whales and North Pacific minke whale surveys).

For North Atlantic minke whales, catches have been taken by Norway under objection and substantial new information is available on abundance estimates. In addition, the methods used for specifying implementation trials have improved significantly since 1992. The sub-committee noted, therefore, that it may be appropriate to consider an *Implementation Review* for minke whales in this region in the near future.

The project to create and maintain simulated data sets is important not only to the work of this sub-committee but also to all other sub-committees. The sub-committee agreed, therefore, that this project should continue for at least the next few years. There are two options available to accomplish this. The first is to award a contract to support a part-time position in CSIRO; the second is to spread out the work to a number of investigators but maintain the central data base of simulation files on a ftp site. These are not mutually exclusive. However, it was noted that a substantial sum would be required to accomplish this, significantly more than the few thousand pounds requested last year.

10. ADOPTION OF REPORT

The report was adopted as amended at 10:30 on 6 May 1998. The sub-committee expressed appreciation of the chairmanship of Hammond and Polacheck.

REFERENCES

Baker, C.S., Slade, R.W., Bannister, J.L., Abernethy, R.B., Weinrich, M.T., Lien, J., Urban, J., Corkeron, P., Calambokidis, J., Vasquez, O. and Palumbi, S.R. 1994. Hierarchical structure of mitochondrial DNA gene flow among humpback whales, *Megaptera novaeangliae*, world-wide. *Mol. Ecol.* 3:313-27.

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.

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. NAMMCO Scientific Committee Working Group Document SC/5/AE/1.

Buckland, S.T. and Turnock, B.J. 1992. A robust line transect method. *Biometrics* 48:901-9.

Burt, M.L. and Borchers, D.L. 1997a. Minke whale abundance estimation from the 1995-96 IWC survey in Area VI. Paper SC/49/SH8 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 14pp.

Burt, M.L. and Borchers, D.L. 1997b. Minke whale abundance estimated from the 1991/92 and 1992/93 JARPA sighting surveys. Paper SC/M97/23 presented to the IWC Intersessional Working Group to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic, May 1997 (unpublished). 16pp.

Cooke, J.G. 1992. Investigation of surfacing-based methods for the estimation of $g(0)$ and effective strip widths for shipborne surveys of minke whales. Paper SC/44/NAB17 presented to the IWC Scientific Committee, June 1992 (unpublished). 14pp.

Cooke, J. 1997. Further analyses for the estimation of $g(0)$ and effective strip width for minke whale surveys. *Rep. int. Whal. Commn* 47:513-28.

Donovan, G.P. 1991. A review of IWC stock boundaries. *Rep. int. Whal. Commn* (special issue 13):39-68.

Fenstad, A.M., Helgeland, J., Aldrin, M. and Volden, R. 1993. High accuracy computer program for the IWC Catch Limit Algorithm. Paper SC/45/Mg3 presented to the IWC Scientific Committee, April 1993 (unpublished). 38pp.

Goto, M. and Pastene, L.A. 1997a. Population structure of the western North Pacific minke whale based on an RFLP analysis of the mitochondrial DNA region. *Rep. int. Whal. Commn* 47:531-8.

Goto, M. and Pastene, L.A. 1997b. RFLP analysis of the mitochondrial DNA control region in minke whales sampled during the 1996 JARPN. Paper SC/49/NP10 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 10pp.

Hammond, P.S., Benke, H., Berggren, P., Borchers, Buckland, S.T., Collet, A., Heide-Jørgensen, M.P., Heimlich-Boran, S., Hiby, A.R., Leopold, M.F. and Øien, N. (eds.). 1995. Distribution and abundance of the harbour porpoise and other small cetaceans in the North Sea and adjacent waters. Life 92-2/UK/027. Final Report to the European Commission. [v]+240pp.

Hedley, S., Borchers, D.L. and Buckland, S.T. 1997. Spatial modelling from line transect data using waiting times. Paper SC/49/O 15 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished).

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.

Hoelzel, A.R. and Dover, G.A. 1989. Molecular techniques for examining genetic variation and stock identity in cetacean species. *Rep. int. Whal. Commn* (special issue 11):81-120.

International Whaling Commission. 1993a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 43:55-228.

International Whaling Commission. 1993b. Special Meeting of the Scientific Committee on the Revised Management Procedure. *Rep. int. Whal. Commn* 43:221-8.

International Whaling Commission. 1994. Report of the Scientific Committee. *Rep. int. Whal. Commn* 44:41-201.

International Whaling Commission. 1995. Report of the Scientific Committee, Annex N. Revisions to annotations to the Revised Management Procedure (RMP) for baleen whales. *Rep. int. Whal. Commn* 45:214.

International Whaling Commission. 1996. Report of the Scientific Committee, Annex K. Guidelines for conducting surveys and analysing data within the revised management scheme. *Rep. int. Whal. Commn* 46:211.

International Whaling Commission. 1997a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 47:59-257.

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 K. Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme. *Rep. int. Whal. Commn* 47:227-35.

International Whaling Commission. 1998a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48: 53-127.

International Whaling Commission. 1998b. Report of the Scientific Committee. Annex D. Report of the Working Group on the RMP. *Rep. int. Whal. Commn* 48: 128-143.

International Whaling Commission. 1998c. Report of the Scientific Committee. Annex E. Report of the Sub-Committee on Abundance Estimation. *Rep. int. Whal. Commn* 48: 144-159.

International Whaling Commission. 1998d. Report of the Scientific Committee. Annex O. Research Items Arising out of Sub-Committee Discussions Related to Analyses of Sightings Data, Particularly as Regards DESS. *Rep. int. Whal. Commn* 48: 283-85.

Palka, D. and Polacheck, T. 1997. Comparison of several analytical methods that estimate $g(0)$ and account for covariates in density estimates using double-team line transect data. Paper SC/49/O 18 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 24pp.

Pastene, L., Goto, M. and Kishino, H. 1998. An estimate of mixing proportion of 'J' and 'O' stocks minke whales in Sub-area II based on mitochondrial DNA haplotype data. *Rep. int. Whal. Commn* 48: 471-474.

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.

Sigurjonsson, J., Vikingsson, G., Gunnlaugson, T. and Halldorsson, S.D. 1996. North Atlantic sightings survey 1995 (NASS-95): shipboard surveys in Icelandic and adjacent waters June-July 1995. Preliminary Cruise Report. NAMMCO Scientific Committee, Torshavn, 5-9 February 1996. 9pp.

Skaug, H.J. 1997. Further simulation studies of the NAILS-96 software for estimating abundance of Northeast Atlantic minke whales. Paper SC/49/NA3 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 2pp.

Skaug, H.J. and Schweder, T. 1998. Hazard models for line transect surveys with independent observers. [Submitted to *Biometrics*].

Smith, T.D., Schweder, T., Allison, C., Palka, D., Punt, A. and Butterworth, D. 1997. Risk performance of the IWC's catch limit algorithm under combinations of robustness trial factors. Paper SC/49/Mg3 presented to the IWC Scientific Committee September 1997, Bournemouth (unpublished). 30pp.

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 1

AGENDA

1. Election of Chairman and appointment of rapporteurs
2. Adoption of agenda
3. *CLA* program
   - 3.1 Tuning
   - 3.2 Revision of program
4. Additional variance
5. Abundance estimation - general issues
   - 5.1 report of intersessional group on statistical estimators
   - 5.2 IWC-DESS
   - 5.3 Other
6. Documentation of RMP for incorporation into Schedule
7. Stock identity
8. Preparations for implementation
   - 8.1 Questions relating to implementation trials
   - 8.2 North Pacific minke whales
     - 8.2.1 Progress during intersessional period
     - 8.2.2 Uncertainty over catches
     - 8.2.3 Sightings survey planning
     - 8.2.4 Development of trials
   - 8.3 North Atlantic minke whales
     - 8.3.1 Northeastern stock
       - 8.3.1.1 Progress during intersessional period
       - 8.3.1.2 Review new information
       - 8.3.1.3 Conclusions
     - 8.3.2 Central stock
       - 8.3.2.1 Reconsideration of earlier estimates
       - 8.3.2.2 Data availability
   - 8.4 Western North Pacific Bryde's whales
     - 8.4.1 Specification of implementation simulation trials
       - 8.4.1.1 Progress during intersessional period
       - 8.4.1.2 Development of trials
     - 8.4.2 Sightings survey planning
9. Longer term priorities and directions
10. Adoption of report

Appendix 2

PROGRESS ON REVISION OF THE *CLA* PROGRAM

P.S. Hammond

At last year's meeting (IWC, 1998, item 7.2.2), the Committee recommended that the Secretariat investigate methods to calculate catch limits under the *CLA* more efficiently. It noted that it would be desirable if the same computer program could be used for calculating catch limits and for simulation studies. The Committee also recommended that this work be completed before the 1998 meeting and that the Secretariat should consider contracting out this task. An intersessional Working Group was set up to facilitate this with membership Allison, Butterworth, Cooke, Givens, Hammond (Chair), Punt, Smith, Walløe.

During the intersessional period the Working Group finalised a specification for computer program structure, documentation, and performance, including specification of a set of test conditions. This is given as Adjunct 1 and formed the basis of an invitation to bid for a contract to revise the program that implements the *CLA*. The invitation to bid was distributed to the members of the Working Group. One bid to do the work was received from the Norwegian Computing Center but at a price that was about ten times greater than the sum allocated by the Secretariat. It was agreed that this matter required further discussion at this meeting.

During intersessional discussions, Cooke described another program (MANAGE2) that he had written, based on MANAGE. He indicated that it gives the same catch limit for the E area as reported in Helgeland *et al.* (1997) using the Norwegian program, RMP, to two decimal places, and that it runs at roughly the same speed as that program.

Tuning

Although not included in the terms of reference of the Working Group, during the intersessional period, Allison identified problems with obtaining a revised tuning parameter at the level of precision specified by the Scientific Committee using the existing program, MANAGE, changed to double precision (IWC, 1998, item 7.2.2). This was confirmed by Cooke, who noted that the MANAGE programme was designed for low-precision work and the precision does not substantially improve as the step sizes are

reduced. Cooke proposed a procedure for accomplishing this task (Adjunct 2) to be followed once a revised program to implement the *CLA* had been completed.

Adjunct 1. Specification for Computer Programs Required

A sub-routine and a calling program that implements the IWC's Catch Limit Algorithm is required. The callable Fortran subroutine must implement the *CLA* for a single stock as defined in IWC (1994a, pp.145-152). This should be written in Fortran 77 in a transparent manner consistent with modern programming principles.

A short main program should read in data (catch, abundance, variance/covariance matrix) and values of control parameters (tuning, phase out, required precision in units of whales), pass these inputs to the subroutine defined above, and return catch limits for the next five years and both calculated absolute (units of whales) and relative upper and lower error bounds of the limits resulting from the precision of the numerical integration.

All subprograms used must be open access and must not use library routines for which the code is unavailable. The subroutine must be readily used with both real data for individual calculations and in simulation trials for repeated calculations. The programs must be compilable and implemental on microcomputers. The precision of the calculation (and hence the time required to execute) must be controllable with a single control parameter setting.

Complete internal documentation is required within the computer code itself. A complete technical description of both the calling program and the subroutine, using modern computer program documentation procedures, with at least the level of detail of IWC (1994b, pp.153-167) is also required.

An overview description of the numerical analysis techniques used in the programs and a User's Guide, to include description of program use and guidance on control parameter values, are required.

The programs and documentation will become the property of the IWC.

The *CLA* sub-routine must be able to compute a catch limit accurate to one whale for a fixed tuning parameter for ranges of input data as follows, although less precise (and hence quicker) calculations must also be possible. The submitted program and documentation will be tested by comparing the calculated catch limits for selected combinations of data to the results obtained using other implementations of the *Catch Limit Algorithm*.

A. Abundance estimates: 1,000 to 1,000,000.
B. Coefficients of Variation of abundance estimates: 0.05 to 1.0.
C. Number of abundance estimates: 1 to 60.
D. Spacing of multiple abundance estimates: consecutive years and up to 10 years apart.
E. Length of catch history: 1 to 300 years.
F. Annual catches (number per year): 1 to 10,000.
G. Distribution of catches: uniform over time up to 90% in first or last half of catch history.
H. Covariance between abundance estimates: 0 to 0.5.

Specific deliverables

1. Fortran 77 subroutine implementing the *Catch Limit Algorithm*, internally documented.
2. Main program that calls sub-routine, internally documented.
3. Technical documentation of both the sub-routine and the calling program.
4. Description of numerical analysis methods used.
5. Users Guide.

Adjunct 2. Draft Specifications for Procedure to be used for Tuning

(a) Calculate (roughly) a number of trials aimed at achieving a 99% confidence interval in the D1 trial that lies within 0.719 to 0.721K, say 50,000 (err on the safe side – see (c) below).
(b) Conditional on this specific number of trials and on Allison's 'standard' random number seeds, calculate the tuning, to the nearest 10^{-5}K, that achieves a median final depletion of exactly 0.72K for this given set of trials.
(c) Calculate the 99% confidence interval for the median final depletion (there is a standard textbook formula for this) and confirm that it lies entirely within the range 0.719 to 0.721. If not, go back to (a) and increase the number of trials (by erring on the high side in the initial choice of the number of trials, it is expected that no iteration will be necessary).
(d) Round the result of (b) to the nearest 0.0001. This would become to the official new value of the tuning parameter to replace the value of 0.4102 in the current RMP specification.
(e) All subsequent real implementations of the *CLA* should calculate the catch limit to within one whale, conditional on the tuning parameter value arising from step (d).

REFERENCES

Helgeland, J., Huseby, R.B. and Smith, T. 1997. Validation of computer programs for the IWC catch limit algorithm. Paper SC/49/Mg1 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 7pp.
International Whaling Commission. 1994a. Report of the Scientific Committee, Annex H. The Revised Management Procedure (RMP) for Baleen Whales. *Rep. int. Whal. Commn* 44:145-52.
International Whaling Commission. 1994b. Report of the Scientific Committee, Annex I. A programme to implement the catch limit algorithm. *Rep. int. Whal. Commn* 44:153-67.
International Whaling Commission. 1998. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48: 53-127.

Appendix 3

REPORT OF THE RMP *AD HOC* GROUP TO CONSIDER FUTURE MAINTENANCE, SUPPORT AND DEVELOPMENT OF DESS

Members: Allison, Borchers, Buckland, Butterworth, Donovan (Convenor)

Background

The initial development of the IWC Database and Estimation Software System (DESS) by the Research Unit for Wildlife Population Assessment at the University of St Andrews (RUWPA) is now virtually complete. DESS is a complex piece of software and specialised programming skills are required to maintain and develop it further. The present IWC staff do not possess these skills and it would be difficult even after training to quickly acquire the same level of understanding as held by the developers (see Continuity below).

A related issue is the level of statistical competence required to perform even routine statistical analyses such as abundance estimation from SOWER surveys, using DESS. In addition to automating the process of extracting and plotting data by any geographic block, sighting type, species, etc., DESS automates standard distance analyses to a large degree. However, nobody in the Secretariat with a sufficient level of expertise to carry out even standard analyses has time available. One obvious option therefore would be for an appropriate additional member of staff to be employed at the Secretariat. However the *ad hoc* group noted that there are disadvantages in employing an additional staff member with the necessary skills.

For example, even if the new staff member took responsibility for routine data analyses as well as support and development of DESS, this work is unlikely to be sufficient for a full-time post. In addition, given that the Secretariat is not primarily a scientific body, that the work will to some extent become largely routine, and that there is little scope for promotion, past experience suggests that such a scientist would not remain in the post for long.

Proposal

The *ad hoc* group felt that an arrangement by which the IWC retains access to the programming and statistical expertise within RUWPA would be preferable to acquiring the expertise within the Secretariat. This being the case, the *ad hoc* group suggests that future maintenance and support for DESS and routine statistical analyses of DESS data could best be effected by the IWC funding part of a post within RUWPA.

The advantages of this arrangement include the following:

1. Working environment

The postholder would already hold much of the necessary expertise and would be working in a group with very relevant experience and expertise, which is active in developing software and methods for assessing wildlife populations.

2. Flexibility

There will probably not be enough regular additional computing and analysis work to justify a regular full-time post.

An arrangement by which the IWC funded around half a post at RUWPA annually, with the option of funding additional work by agreement with RUWPA if and when necessary, could provide both continuity and more flexibility than would normally be possible were the IWC to employ someone directly. RUWPA would make up the balance of the annual post costs from other sources, and the postholder would work on other projects for the remainder of the year. This might also put the IWC in a better position to respond to unanticipated computing and analysis tasks which arose at short notice.

3. Continuity

While substantial documentation has been created for DESS, much of the inner workings of the software cannot realistically be documented. It would be daunting for someone new to maintain and develop DESS. The arrangement suggested above has the advantage of retaining the experience and expertise already developed at RUWPA. In addition, Buckland's and Borchers' familiarity with IWC datasets and analysis methods will ensure consistency of future analyses with IWC methods and conventions.

Some existing tasks which the postholder would be in a good position to perform or assist with are listed below, together with some tasks which are likely to arise in the near future.

The full cost (including salary and office overheads but not travel between St Andrews and Cambridge) of the IWC funding half a post in RUWPA would be approximately £19,000 plus VAT per annum.

Existing relevant tasks* taken from table 5 of IWC (1998), and IWC (1997, p.152):

(1) calculation of Antarctic minke whale estimates south of a common northern boundary, by 10º, 20º, 30º and 60º longitude sectors and estimation of additional variance;
(2) verify North Pacific Bryde's whale abundance data;
(3) analysis of IDCR/SOWER IO data;
(4) development of objective duplicate identification methods for IDCR Antarctic minke survey data;
(5) estimation of trends in abundance using the IDCR Antarctic minke survey data;
(6) development of methods for combining survey data collected over different years;

* Items that were earmarked at a previous IWC Scientific Committee meeting to be performed by Butterworth and Brown have been omitted.

(7) incorporation of 'before/after' IDCR survey data and 'Dedicated survey' data into DESS.

Possible tasks in the near future:

(1) DESS maintenance, support and development, including addition of new datasets;

(2) Incorporation into DESS and analysis of 1997/98 (and any future) SOWER sighting survey dàta;

(3) SOWER2000 Survey. Some or all of: sightings data form preparation; data validation programs; data entry into DESS (including modifications to DESS); assistance in analyses of sightings survey data.

REFERENCES

International Whaling Commission. 1997. 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. 1998. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48: 53-127.

Appendix 4

A RECOMMENDATION BY THE RMP WORKING GROUP ON STOCK DEFINITION TO ESTABLISH A WORKING GROUP OF THE SCIENTIFIC COMMITTEE ON STOCK DEFINITION

Members: DeMaster (Chair), Baker, Born, Brownell, Chen, Clapham, Cooke, Hester, Donahue, Donovan, Friday, Fujise, Goto, Hatanaka, Innes, Kasuya, Kato, Kawahara, Kim, Miyashita, Moronuki, Øien, Okamoto, Okamura, Pastene, Perrin, Pinedo, Rojas Bracho, Shimadzu, Slooten, Smith, Tanaka, E., Van Waerebeek, Wade, Walløe, Witting.

To date, most studies on stock identity of large whale species have attempted to test the hypothesis that existing IWC management units correspond to biologically distinct populations or to try to allow such units to be geographically, or sometimes temporally, defined. For this purpose, a suite of techniques have been used (e.g., sequence divergence, haplotypic frequency, morphological characters, presence/absence of parasites, pollutant loads, distribution, etc.). However, our ability to determine what constitutes a 'distinct' population, and indeed the need to do so in the traditional way, has recently been questioned. Rather, an approach that continues to emphasise management at the subspecific level, but which also allows for low levels (i.e., demographically negligible) of exchange between separate management units, has been proposed (see Taylor, 1997).

Several members of the Scientific Committee have commented that to move forward with such an approach, recently developed genetic techniques, as well as more traditional techniques, could be used to define what is meant by the term 'stock' in the context of managing large whales. It is therefore the recommendation of the RMP Working Group on Stock Definition (WGSD) that the Scientific Committee establish a Working Group for the purpose of developing one or more operational definitions of stock, which are better suited to the types of data currently available to evaluate stock structure and which are based on the management context in which they are to be used. Terms of reference for this group are reported below. In addition, the process by which the IWC's current definition of stock would be modified is outlined.

1. Background

At the recent Workshop on Right Whales (SC/50/Rep4), the following generic description of what a stock is, was reported: a stock is the 'unit that is be conserved. Such a unit is generally termed a 'management stock' and in ideal circumstances would normally be based on a true biological population, although it may be based on smaller groupings (Donovan, 1991).' An example of a smaller grouping would be a stock definition based on distinct feeding aggregations. At this same workshop, it was noted that recently developed genetic techniques for the purpose of stock identification have increased substantially over the last decade (e.g., see Dizon *et al.*, 1996).

However, the difficulty in interpreting genetic and other data regarding stock structure has also been noted during discussions of the Scientific Committee. In particular, the lack of a detected genetic difference cannot be assumed to prove the existence of a single stock. Three examples are summarised here for the purpose of describing the types of problems that are to be addressed by the WGSD.

During the meeting of the Working Group on North Pacific Minke Whale Trials the issue of the stock identify in the western North Pacific minke whale was discussed (IWC, 1997). For minke whales in this area several techniques, including genetics, were used to evaluate stock structure. While these techniques were successful in differentiating between putative stocks of minke whales distributed around the Korean Peninsula (J stock) and the eastern side of Japan (O stock), they did not resolve the issue regarding minke whale stock structure between animals in coastal waters along the eastern side of Japan and those from offshore waters east of Japan. As noted during the Working Group meeting, 'finding no significant differences does not in itself allow the hypothesis of two stocks to be abandoned.' In this case, the problem becomes one of how much additional data and analyses are needed prior to concluding those whales from coastal and offshore areas belong to a single stock. Working Group participants recognised the merit of having a prior agreement as to the level of genetic diversity sufficient to conclude that two putative stocks should be managed as separate stocks.

A second example of difficulties in the interpretation of data regarding the management of large whales concerns Southern Hemisphere minke whales. In this case, a considerable degree of heterogeneity in mtDNA between whales from Areas IV and V has been reported (IWC, 1998a). However, it was also reported that the expected degree of genetic differentiation between two putative stocks (referred to as the effect size) of Antarctic minke whales was very small, given the current sampling regime. Therefore, studies designed to evaluate stock identity for this species in

this area require large sample sizes to obtain statistically reliable results. During recent discussion of the Scientific Committee it was suggested that 'genetic data can be best analysed in this particular case if analysts know the level of differentiation (i.e., effect size) they are looking for' (IWC, 1998b).

A third example concerns problems due to basing stock definitions solely upon genetic data and is illustrated by the North Atlantic population of the humpback whale. Population structure for North Atlantic humpback whales has been divided into several relatively discrete feeding stocks, fidelity to which is determined matrilineally. This fidelity appears to persist over an evolutionary time scale for feeding stocks off Iceland and Norway, where mtDNA work has shown that animals from these two areas are genetically distinct from each other and from the four other feeding grounds in the western North Atlantic (i.e., West Greenland, Newfoundland/Labrador, Gulf of St Lawrence and the Gulf of Maine). However, animals from different feeding grounds in the western North Atlantic cannot be distinguished with mtDNA. As a result, from a purely genetic standpoint, these animals would not be managed as separate management units. In contrast, the rate of exchange of animals between areas is known from photo-identification data to be very low. Therefore, there is no assurance that a feeding subpopulation which was extirpated would be readily repopulated by immigration from other nearby regions. If one of the goals of management is to maintain the extant range over which large whales occur, the use of all available information on stock structure is necessary to avoid or at least lower the likelihood of mismanagement.

2. Terms of reference

It is recommended that a Working Group on Stock Definition be established by the Scientific Committee and charged with the following duties:

(1a) Review the published literature regarding the current usage of the stock concept in managing renewable resources, with special emphasis on long-lived, highly mobile species;

(1b) Prepare a report summarizing the results of the review, particularly in the context of the RMP and any future AWMP;

(2a) Review case studies of management advice for large whales, with special emphasis on the extent to which the definition of a stock used in the assessment contributed to or detracted from the success of the assessment, with particular reference to the level and nature of the available data;

(2b) Prepare a report summarising the results of the review;

(3) Assess the results of studies using suitable spatially explicit population simulation models for the purpose of evaluating the relationships among population size, various rates of movement between putative stocks, methods of analysis, effect size and experimental design, taking into account the approaches presently used in developing Implementation Simulation Trials in the RMP and possible approaches used in developing future AWMP's;

(4) Endeavour to refine existing stock definitions on the basis of the above mentioned reports and activities; and

(5) Assess the desirability and means of considering multiple lines of evidence, including evidence from studies on movement patterns, morphology, and ecology, as well as genetics, in developing definitions of stocks.

It is recommended that the latter two tasks (and possibly task 3) be undertaken at an intersessional meeting sponsored by the Scientific Committee.

3. Proposed assignments for an Intersessional Meeting of the WGSD and the next Scientific Committee Meeting (1999)

An intersessional meeting of the WGSD should be scheduled upon the completion of the tasks identified in the previous paragraph. If this is to be accomplished prior to the 1999 meeting of the Scientific Committee, assignments will have to be agreed at this year's (1998) meeting of the Scientific Committee. Finally, to avoid unnecessary delays and to ensure the efficient development of appropriate stock definitions for the purpose of managing stocks of large whales, it is recommended that a Steering Group be identified and charged with the responsibility for making assignments as necessary to complete the activities described above and for the development of a final agenda for the intersessional meeting. That Group will also determine if sufficient progress has been made to warrant an intersessional meeting prior to the 1999 meeting of the Scientific Committee.

The financial implications of holding intersessional meetings were recognized by members of the RMP working group. Due to the importance of stock definition in the assessment and management of large whales, the RMP working group recommends that this activity be considered a high priority for the Scientific Committee over the next few years.

REFERENCES

Dizon, A.E., Lux, C.A., LeDuc, R.G., Urban-R, J., Henshaw, M., Baker, C.S., Cipriano, F. and Brownell, R.L. Jr. 1996. Molecular phylogeny of the Bryde's/sei whale complex; separate species status for the pygmy Bryde's form? Paper SC/48/O 27 presented to the IWC Scientific Committee, June 1996, Aberdeen (unpublished). 15pp.

Donovan, G.P. 1991. A review of IWC stock boundaries. *Rep. int. Whal. Commn* (special issue 13):39-68.

International Whaling Commission. 1997. 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. 1998a. 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: 170-182.

International Whaling Commission. 1998b. Report of the Scientific Committee. Annex U.1. Report of the Working Group on JARPA stocks. 2. A proposed modification for the JARPN sighting and sampling protocol. *Rep. int. Whal. Commn* 48: 297.

Taylor, B.L. 1997. Using JARPA data to investigate use of historical Japanese Antarctic minke whale samples to examine the temporal changes in stock distribution. Paper SC/49/SH28 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 5pp.

Appendix 5

QUESTIONS THAT NEED TO BE ADDRESSED WHEN SPECIFYING *IMPLEMENTATION SIMULATION TRIALS*

D.S. Butterworth

Introduction

What is the primary purpose of Implementation Simulation Trials?

Implementation of the RMP in a particular situation involves a choice between a number of variants, such as '*catch capping*' and '*catch cascading*'. The results of the trials provide a basis upon which to make this choice.

Since the RMP has already been heavily simulation-tested, why are the additional trials needed?

The tests of the RMP were primarily tests of the *Catch Limit Algorithm* (*CLA*), which is identical to the RMP in the extreme situation where it is clear that only one breeding stock is involved. Although some tests of multi-stock situations were carried out on a generic basis, totally comprehensive testing of the multi-stock situation in this way is not practical. Therefore, the primary purpose of the *Implementation Simulation Trials* is to capture the range of uncertainties regarding stock structure and mixing which may pertain to a particular case.

While the RMP variant to be proposed needs to be robust across a plausible range of such and other uncertainties, there is no need to require robustness against circumstances that are known not to apply in a particular case. Hence the process of developing *Implementation Simulation Trials* involves 'conditioning' these trials on existing data; essentially this process amounts to restricting trials to ones which are not inconsistent with what is known from the data already available for the resource in question.

What do Implementation Simulation Trials involve?

A summary has already been developed by the Scientific Committee at its 1994 meeting (IWC, 1995, pp.117-9). This document therefore endeavours not to repeat that material, but rather to amplify it by casting it in the form of a 'check-list'.

A check-list for developing *Implementation Simulation Trials* (*ISTs*)

Framework

(1) Split the *Region* under consideration into '*Sub-Areas*'. Such areas must be sufficiently small that any catches from them cannot distinguish amongst the various breeding stocks which may be represented, i.e. the catch taken from each breeding stock present will be in proportion to the abundance of that breeding stock in that *Sub-Area*.

(2) Clarify whether there is sex- or age-dependence in migration patterns. If so, the models underlying the *ISTs* must incorporate the necessary level of disaggregation by sex and age.

Stock structure hypotheses

(3) Clarify the number of discrete breeding stocks present for each of the hypotheses put forward.

(4) The 'migration pattern' of each such stock through the year must be clarified for each such hypothesis, at least in so far as specifying the fraction of each breeding stock (disaggregated as under (2) if necessary) present in each *Sub-Area* in each time unit when catching or sighting surveys take place. These proportions, for a specific hypothesis, are collected in forms termed 'catch mixing matrices' or 'sighting mixing matrices'. Note that these matrices are not necessarily time-invariant; they can show trends and incorporate random components (all of which must be specified).

Stock dynamics

(5) Models for the dynamics of each breeding stock must be specified. Normally the age- (and possibly sex-) disaggregated BALEEN II model serves as the basis to develop such models.

Information used for conditioning

(6) Conditioning typically involves the computations of distributions of initial (pre-exploitation) size for the various breeding stocks for each of the hypotheses under consideration. This requires the following historic data:

  (a) past catches, allocated by *Sub-Area* by year (season), and by shorter time-steps within seasons where relevant;
  (b) past sighting survey estimates with their CVs (or more generally if pertinent, variance-covariance matrices) and timings, ideally by *Sub-Area*, but a wider spatial scale for such results can be accommodated;
  (c) information from, for example, genetic analyses which provide estimates of the proportions of the number of whales in a *Sub-Area* at a particular time which belong to each breeding stock; and
  (d) other information, such as CPUE series for example, which may be acceptable to the Scientific Committee as sufficiently reliable to contribute towards the estimation of pre-exploitation population size distributions.

(7) The values of certain parameters of the stock dynamics model about which there is uncertainty (e.g. *MSYR*) have to be specified for each trial before the conditioning process can proceed.

The future

(8) The variety of management options to be considered in the *ISTs* must be specified. This includes decisions upon:

(a) what combinations of *Sub-Areas* should be treated as *Small Areas* (and if such combination involves more than one *Sub-Area*, how are future catches allocated to that *Small Area* to be split amongst its constituent *Sub-Areas*); and
(b) how such *Small Areas* might be combined for the purpose of implementing some *catch cascading* or *catch capping* options (the last-mentioned also requires specification of which of the constituent *Small Areas* will be undercaught, and by how much, in years when it is applied).

(9) Options for the timing, coverage extent, and anticipated CVs for future surveys must be specified.
(10) The output statistics to be used to compare the performances of the RMP variants considered over the set of robustness trials applied must be defined.

REFERENCE

International Whaling Commission. 1995. Report of the Scientific Committee, Annex D. Report of the sub-committee on management procedures. *Rep. int. Whal. Commn* 45:104-19.

Appendix 6

SPECIFICATIONS OF THE NORTH PACIFIC MINKE WHALING TRIALS

A. Basic concepts and stock structure

The objective of these trials is to examine the performance of the RMP in scenarios which relate to the actual problem of managing a likely fishery for minke whales in the North Pacific. They 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. Note that these trials do not take account of 'leakage' (transference of animals) between putative stocks because previous results suggest that unintended stock depletion becomes less likely when leakage occurs (IWC, 1993).

The region to be managed (the western North Pacific) is divided into 13 sub-areas (see Fig. 1). Future surveys are unlikely to cover sub-areas 1, 2, 3, 4, 5, 6, 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 where the number of animals dispersing between breeding grounds is sufficiently small to have no impact on the population dynamics. The model considers two hypotheses in this regard: (1) that there are three stocks, the J stock ('home' area - Sea of Japan and perhaps also the Yellow Sea and East China Sea), the O Stock ('home' area - the Okhotsk Sea, the east coast of Japan) and the W Stock (West Pacific); (2) that there are only the J and O stocks. The reason for considering the W stock is that, by unintentionally counting whales from such a stock during surveys, catch limits may be set which lead to over-exploitation of a coastal O stock.

The main differences from the trials specified by IWC (1997a) are:

(a) addition of trials with differing levels of incidental catch off Korea and Japan (section D); and
(b) addition of trials to condition on the proportion of animals of each stock in catches off Japan (section F, item (g)).

B. Basic dynamics

Further details of the underlying age-structured model and its parameters can be found in IWC (1991, pp. 112-112A), although note that the model has now been extended to take sex-structure into account. The 1+ population of a stock is governed by the equations:

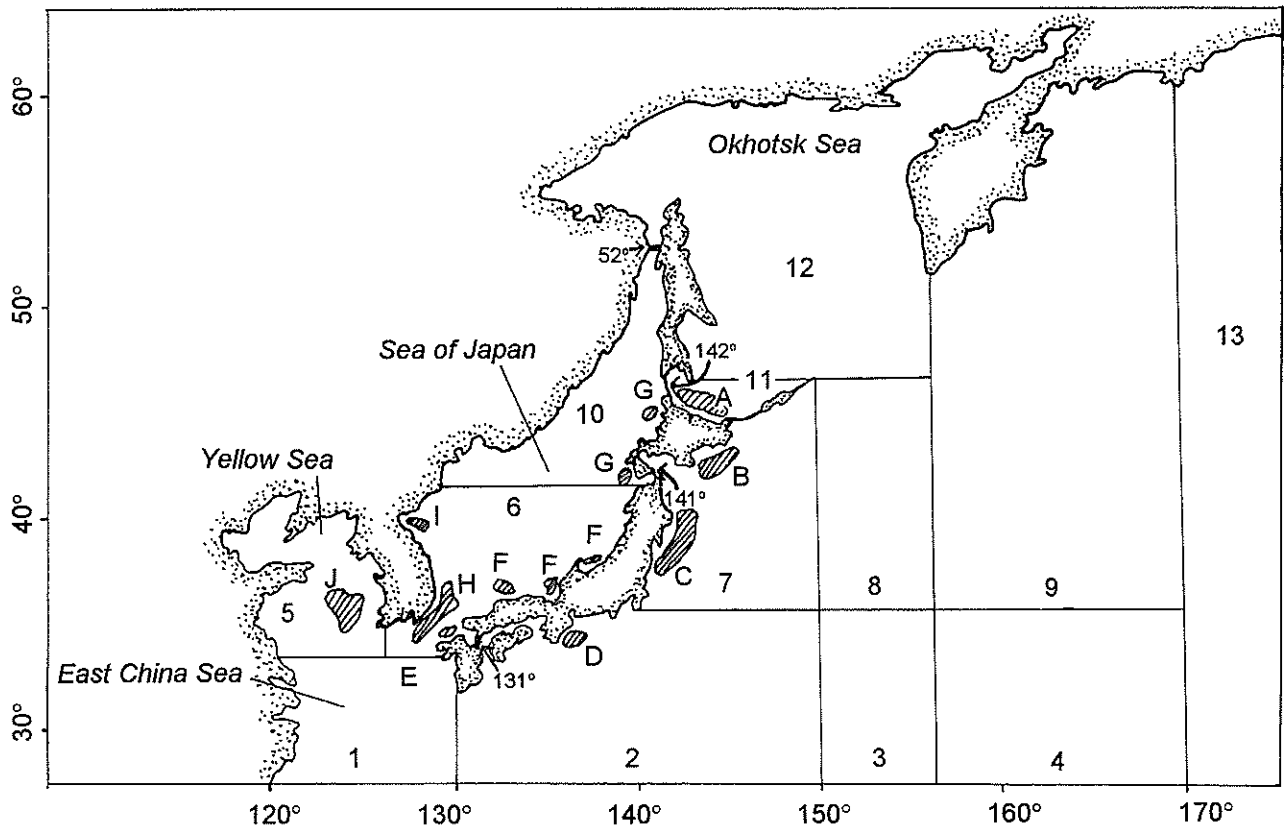


Fig. 1. Whaling grounds and the 13 sub-areas used for the *Implementation Simulation Trials* for the North Pacific minke whales (IWC, 1997c, p.204).

Table 1
Plan for future sighting surveys of minke whales in the western North Pacific.

Season	Sub-Area 7	8	9	11	12
1998				Aug.-Sep.	Aug.-Sep.
1999			Aug.-Sep.		
2000	Aug.-Sep.	Aug.-Sep.			
2001				Aug.-Sep.	Aug.-Sep.
2002			Aug.-Sep.		
2003	Aug.-Sep.	Aug.-Sep.			
2004				Aug.-Sep.	Aug.-Sep.
2005			Aug.-Sep.		
2006	Aug.-Sep.	Aug.-Sep.			
2007	Continuing in this pattern				

$$R^{m/f,s}_{t+1,a+1} = (R^{m/f,s}_{t,a} - C^{m/f,s}_{t,a})S_a + U^{m/f,s}_{t,a}S_a\delta_{a+1} \quad 0 \le a \le x-2$$
$$R^{m/f,s}_{t+1,x} = (R^{m/f,s}_{t,x} - C^{m/f,s}_{t,x})S_x + (R^{m/f,s}_{t,x-1} - C^{m/f,s}_{t,x-1})S_{x-1} \quad (1)$$
$$U^{m/f,s}_{t+1,a+1} = U^{m/f,s}_{t,a}S_a(1-\delta_{a+1}) \quad 0 \le a \le x-2$$

$R^{m/f,s}_{t,a}$ is the number of recruited males/females of age a in stock s at the start of year t,
$U^{m/f,s}_{t,a}$ is the number of unrecruited males/females of age a in stock s at the start of year t,
d_a is the fraction of unrecruited animals of age a-1 which recruit at age a (assumed to be independent of stock and sex),
S_a is the instantaneous survival rate of animals of age a, and is equal to exp(-Ma) where Ma 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),
$C^{m/f,s}_{t,a}$ is the catch of males/females of age a from stock s during year t, 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).

Note that year $t = 0$, for which catch limits might first be set, corresponds to 1998.

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.

$$U^{m/f,s}_{t,0} = 0.5(1 - a_0)B^s N^{f,s}_t\{1 + A^s(1 - (N^{f,s}_t/K^{f,s})^{z^s})\}$$
$$R^{m/f,s}_{t,0} = 0.5a_0B^s N^{f,s}_t \{1 + A^s (1 - (N^{f,s}_t/K^{f,s})^{z^s})\} \quad (2)$$

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,
$N^{f,s}_t$ is the number of mature females in stock s at the start of year t:

$$N^{f,s}_t = \sum_{a=1}^{x} \beta_a (R^{f,s}_{t,a} + U^{f,s}_{t,a}) \quad (3)$$

a_0 is the proportion of animals of age 0 which are recruited, and = 0 in this version,
b_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, written as $t = -\infty$) population:

$$K^{f,s} = \sum_{a=1}^{x} \beta_a (R^{f,s}_{-\infty,a} + U^{f,s}_{-\infty,a}) \quad (4)$$

The values of the parameters A^s and z^s for each stock are calculated from the values of $MSYL^s$ and $MSYR^s$ as detailed in IWC (1991, pp.112-112A). Their calculation 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 ($t \ge 1998$), 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.

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 which depends on sex, age and the time of the year, and may also depend on year, i.e.:

$$C^{m/f,s}_{t,a} = \sum_k \sum_q C^{m/f,s,k,q}_{t,a} \quad (5)$$
$$C^{m/f,s,k,q}_{t,a} = C^{m/f,k,q}_t \{V^{m/f,s,k,q}_{t,a} R^{m/f,s}_{t,a} / \sum_j \sum_{a'=1}^{x} V^{m/f,j,k,q}_{t,a'} R^{m/f,j}_{t,a'}\}$$

$C^{m/f,s,k,q}_{t,a}$ is the catch of males/females of age a from stock s in sub-area k during month q of year t, where $t \ge 1998$, and
$C^{m/f,k,q}_t$ is the catch of males/females from sub-area k during month q of year t.

Each entry in the catch mixing matrix $V^{m/f,s,k,q}_{t,a}$, 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. Table 2 gives the catch mixing matrices considered. The rationale for the values used is given in (IWC, 1997d). 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 γ_1 - γ_{11} are specified (these are estimated separately for each trial in the conditioning process), the catch mixing matrices can be

Table 2

The catch mixing matrices (the sightings mixing matrix is calculated from the catch mixing matrices for August and September). Differences from the base-case matrices (A, B, F and K) are in **bold** type. The rationale for the values used is given in IWC (1997d).
J Stock (Option C) is identical to Option A except there are no J stock whales in sub-Area 5 (i.e. the sub-Area 5 column is replaced with zeros and historic catches from sub-Area 5 are assumed to have been taken from another, unmodelled, stock). J Stock (Option D) is identical to Option B except there are no J stock whales in sub-Area 5 (i.e. the sub-Area 5 column is replaced with zeros and historic catches from sub-Area 5 are assumed to have been taken from another, unmodelled, stock). J Stock (Option E) is identical to Option B except there are no J stock whales in sub-Area 7 (i.e. the sub-Area 7 column is replaced with zeros). W Stock (Option L) is identical to Option K except there are no W stock whales in sub-Area 8 (i.e. the sub-Area 8 column is replaced with zeros).

Month/ Age-class	Sub-Area 1	2	3	4	5	6	7	8	9	10	11	12
J Stock (Option A)												
Age 4												
Apr.	1	0	0	0	1	1	0	0	0	1	γ_1	0
May	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jun.	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jul.	0	0	0	0	1	1	0	0	0	1	γ_2	0
Aug.	0	0	0	0	1	1	0	0	0	1	X^1	0
Sep.	1	0	0	0	1	2	0	0	0	1	0	0
Age 10 - Female												
Apr.	1	0	0	0	1	1	0	0	0	1	$2\gamma_1$	0
May	0	0	0	0	1	1	0	0	0	2	$2\gamma_2$	0
Jun.	0	0	0	0	1	1	0	0	0	2	$2\gamma_2$	0
Jul.	0	0	0	0	1	1	0	0	0	1	$2\gamma_2$	0
Aug.	0	0	0	0	1	1	0	0	0	1	γ_2	0
Sep.	1	0	0	0	1	2	0	0	0	1	0	0
Age 10 - Male												
Apr.	1	0	0	0	1	1	0	0	0	1	γ_1	0
May	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jun.	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jul.	0	0	0	0	1	1	0	0	0	1	γ_2	0
Aug.	0	0	0	0	1	1	0	0	0	1	γ_{11}	0
Sep.	1	0	0	0	1	2	0	0	0	1	0	0
J Stock (Option B) some animals in sub-Area 7 in Aug./Sep. and in sub-Area 12 in May-Aug.												
Age 4												
Apr.	1	0	0	0	1	1	0	0	0	1	γ_1	0
May	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jun.	0	0	0	0	1	1	0	0	0	2	γ_2	0
Jul.	0	0	0	0	1	1	0	0	0	1	γ_2	0
Aug.	0	0	0	0	1	1	$2\gamma_4$	0	0	1	X^1	0
Sep.	1	0	0	0	1	2	$2\gamma_4$	0	0	1	0	0
Age 10 - Female												
Apr.	1	0	0	0	1	1	0	0	0	1	$2\gamma_1$	0
May	0	0	0	0	1	1	0	0	0	2	$2\gamma_2$	γ_3
Jun.	0	0	0	0	1	1	0	0	0	2	$2\gamma_2$	γ_3
Jul.	0	0	0	0	1	1	0	0	0	1	$2\gamma_2$	γ_5
Aug.	0	0	0	0	1	1	γ_4	0	0	1	γ_2	γ_5
Sep.	1	0	0	0	1	2	γ_4	0	0	1	0	0
Age 10 - Male												
Apr.	1	0	0	0	1	1	0	0	0	1	γ_1	0
May	0	0	0	0	1	1	0	0	0	2	γ_2	γ_3
Jun.	0	0	0	0	1	1	0	0	0	2	γ_2	γ_3
Jul.	0	0	0	0	1	1	0	0	0	1	γ_2	γ_5
Aug.	0	0	0	0	1	1	$5\gamma_4$	0	0	1	γ_{11}	γ_5
Sep.	1	0	0	0	1	2	$5\gamma_4$	0	0	1	0	0
O Stock (Option F) for trials with O and W stocks												
Age 4												
Apr.	0	2	0	0	0	0	4	0	0	0	γ_7	0
May	0	1	0	0	0	0	4	0	0	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	0	0	0	γ_7	0
Age 10 - Female												
Apr.	0	2	0	0	0	0	4	0	0	0	$2\gamma_7$	$2\gamma_6$
May	0	1	0	0	0	0	2	0	0	0	$2\gamma_7$	$3\gamma_6$
Jun.	0	0	0	0	0	0	1	0	0	0	$2\gamma_7$	$3\gamma_6$
Jul.	0	0	0	0	0	0	1	0	0	0	$2\gamma_7$	$3\gamma_6$
Aug.	0	0	0	0	0	0	1	0	0	0	γ_7	$2\gamma_6$
Sep.	0	0	0	0	0	0	1	0	0	0	γ_7	γ_6
Age 10 - Male												
Apr.	0	2	0	0	0	0	4	0	0	0	γ_7	γ_6
May	0	1	0	0	0	0	4	0	0	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6

Month/ Age-class	Sub-Area 1	2	3	4	5	6	7	8	9	10	11	12
Age 10 – Female cont.												
Jul.	0	0	0	0	0	0	1	0	0	0	$2\gamma_7$	$3\gamma_6$
Aug.	0	0	0	0	0	0	1	0	0	0	γ_7	$2\gamma_6$
Sep.	0	0	0	0	0	0	1	0	0	0	γ_7	γ_6
Age 10 - Male												
Apr.	0	2	0	0	0	0	4	0	0	0	γ_7	γ_6
May	0	1	0	0	0	0	4	0	0	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	0	0	0	γ_7	γ_6
O Stock (Option G) for trials with an O stock only												
Age 4												
Apr.	0	2	2	2	0	0	4	1	0	0	γ_7	0
May	0	1	1	1	0	0	4	1	0	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	1	0	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	1	0	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	1	0	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	1	0	0	γ_7	0
Age 10 - Female												
Apr.	0	2	2	2	0	0	4	1	4	0	$2\gamma_7$	$2\gamma_6$
May	0	1	1	1	0	0	2	1	2	0	$2\gamma_7$	$3\gamma_6$
Jun.	0	0	0	0	0	0	1	1	1	0	$2\gamma_7$	$3\gamma_6$
Jul.	0	0	0	0	0	0	1	1	1	0	$2\gamma_7$	$3\gamma_6$
Aug.	0	0	0	0	0	0	1	1	1	0	γ_7	$2\gamma_6$
Sep.	0	0	0	0	0	0	1	1	1	0	γ_7	γ_6
Age 10 - Male												
Apr.	0	2	2	2	0	0	4	2	4	0	γ_7	γ_6
May	0	1	1	1	0	0	4	2	2	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	2	2	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	2	2	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	2	2	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	2	2	0	γ_7	γ_6
O Stock (Option H) for trials with O and W stocks (Some O stock animals in sub-Area 10, compared to Option F)												
Age 4												
Apr.	0	2	0	0	0	0	4	0	0	**0**	γ_7	0
May	0	1	0	0	0	0	4	0	0	γ_8	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	0	0	γ_8	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	0	0	γ_8	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	0	0	**0**	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	0	0	**0**	γ_7	0
Age 10 - Female												
Apr.	0	2	0	0	0	0	4	0	0	**0**	$2\gamma_7$	$2\gamma_6$
May	0	1	0	0	0	0	2	0	0	$2\gamma_8$	$2\gamma_7$	$3\gamma_6$
Jun.	0	0	0	0	0	0	1	0	0	$2\gamma_8$	$2\gamma_7$	$3\gamma_6$
Jul.	0	0	0	0	0	0	1	0	0	$2\gamma_8$	$2\gamma_7$	$3\gamma_6$
Aug.	0	0	0	0	0	0	1	0	0	**0**	γ_7	$2\gamma_6$
Sep.	0	0	0	0	0	0	1	0	0	**0**	γ_7	γ_6
Age 10 - Male												
Apr.	0	2	0	0	0	0	4	0	0	**0**	γ_7	γ_6
May	0	1	0	0	0	0	4	0	0	γ_8	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	0	0	γ_8	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	0	0	γ_8	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	0	0	**0**	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	0	0	**0**	γ_7	γ_6

cont...

Table 2 continued.

Month/ Age-class	Sub-Area 1	2	3	4	5	6	7	8	9	10	11	12
O Stock (Option I) for trials with an O stock only (Some O stock animals in sub-Area 10, compared to Option G)												
Age 4												
Apr.	0	2	2	2	0	0	4	1	0	**0**	γ_7	0
May	0	1	1	1	0	0	4	1	0	γ_8	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	1	0	γ_8	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	1	0	γ_8	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	1	0	**0**	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	1	0	**0**	γ_7	0
Age 10 - Female												
Apr.	0	2	2	2	0	0	4	1	4	**0**	$2\gamma_7$	$2\gamma_6$
May	0	1	1	1	0	0	2	1	2	$2\gamma_8$	$2\gamma_7$	$3\gamma_6$
Jun.	0	0	0	0	0	0	1	1	1	$2\gamma_8$	$2\gamma_7$	$3\gamma_6$
Jul.	0	0	0	0	0	0	1	1	1	$2\gamma_8$	$2\gamma_7$	$3\gamma_6$
Aug.	0	0	0	0	0	0	1	1	1	**0**	γ_7	$2\gamma_6$
Sep.	0	0	0	0	0	0	1	1	1	**0**	γ_7	γ_6
Age 10 - Male												
Apr.	0	2	2	2	0	0	4	2	4	**0**	γ_7	γ_6
May	0	1	1	1	0	0	4	2	2	γ_8	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	2	2	γ_8	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	2	2	γ_8	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	2	2	**0**	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	2	2	**0**	γ_7	γ_6
O Stock (Option J) for trials with O and W stocks (Some O stock animals in sub-Area 8, compared to Option F)												
Age 4												
Apr.	0	2	0	0	0	0	4	γ_9	0	0	γ_7	0
May	0	1	0	0	0	0	4	γ_9	0	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	γ_9	0	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	γ_9	0	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	γ_9	0	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	γ_9	0	0	γ_7	0
Age 10 Female												
Apr.	0	2	0	0	0	0	4	γ_9	0	0	$2\gamma_7$	$2\gamma_6$
May	0	1	0	0	0	0	2	γ_9	0	0	$2\gamma_7$	$3\gamma_6$
Jun.	0	0	0	0	0	0	1	γ_9	0	0	$2\gamma_7$	$3\gamma_6$
Jul.	0	0	0	0	0	0	1	γ_9	0	0	$2\gamma_7$	$3\gamma_6$
Aug.	0	0	0	0	0	0	1	γ_9	0	0	γ_7	$2\gamma_6$
Sep.	0	0	0	0	0	0	1	γ_9	0	0	γ_7	γ_6
Age 10 - Male												
Apr.	0	2	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6
May	0	1	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6
Jun.	0	0	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6
Jul.	0	0	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6
Aug.	0	0	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6
Sep.	0	0	0	0	0	0	4	$2\gamma_9$	0	0	γ_7	γ_6

Month/ Age-class	Sub-Area 1	2	3	4	5	6	7	8	9	10	11	12
W Stock (Option K) for trials with O and W stocks												
Age 4												
Apr.	0	0	1	1	0	0	0	0	0	0	0	0
May	0	0	1	1	0	0	0	0	0	0	0	0
Jun.	0	0	1	1	0	0	0	0	0	0	0	0
Jul.	0	0	1	1	0	0	0	0	0	0	0	0
Aug.	0	0	1	1	0	0	0	0	0	0	0	0
Sep.	0	0	1	1	0	0	0	0	0	0	0	0
Age 10 - Female												
Apr.	0	0	2	2	0	0	0	1	2	0	0	γ_{10}
May	0	0	1	1	0	0	0	1	1	0	0	$2\gamma_{10}$
Jun.	0	0	0	0	0	0	0	1	1	0	0	$2\gamma_{10}$
Jul.	0	0	0	0	0	0	0	1	1	0	0	$3\gamma_{10}$
Aug.	0	0	0	0	0	0	0	1	1	0	0	$3\gamma_{10}$
Sep.	0	0	0	0	0	0	0	1	1	0	0	$2\gamma_{10}$
Age 10 - Male												
Apr.	0	0	2	2	0	0	0	1	2	0	0	γ_{10}
May	0	0	1	1	0	0	0	1	3	0	0	γ_{10}
Jun.	0	0	0	0	0	0	0	2	4	0	0	$2\gamma_{10}$
Jul.	0	0	0	0	0	0	0	2	4	0	0	$2\gamma_{10}$
Aug.	0	0	0	0	0	0	0	2	4	0	0	γ_{10}
Sep.	0	0	0	0	0	0	0	2	3	0	0	γ_{10}
W Stock (Option M) for trials with O and W stocks (some W stock animals in the Japanese coastal waters)												
Age 4												
Apr.	0	0	**1**	**1**	0	0	**0**	0	0	0	**0**	0
May	0	0	**1**	**1**	0	0	**0**	0	0	0	**0**	0
Jun.	0	0	**0**	**0**	0	0	**1**	0	0	0	**0**	0
Jul.	0	0	**0**	**0**	0	0	**1**	0	0	0	**1**	0
Aug.	0	0	**0**	**0**	0	0	**1**	0	0	0	**1**	0
Sep.	0	0	**0**	**0**	0	0	**1**	0	0	0	**0**	0
Age 10 - Female												
Apr.	0	0	2	2	0	0	0	1	2	0	0	γ_{10}
May	0	0	1	1	0	0	0	1	1	0	0	$2\gamma_{10}$
Jun.	0	0	0	0	0	0	0	1	1	0	0	$2\gamma_{10}$
Jul.	0	0	0	0	0	0	0	1	1	0	0	$3\gamma_{10}$
Aug.	0	0	0	0	0	0	0	1	1	0	0	$3\gamma_{10}$
Sep.	0	0	0	0	0	0	0	1	1	0	0	$2\gamma_{10}$
Age 10 - Male												
Apr.	0	0	2	2	0	0	0	1	2	0	0	γ_{10}
May	0	0	1	1	0	0	0	1	3	0	0	γ_{10}
Jun.	0	0	0	0	0	0	0	2	4	0	0	$2\gamma_{10}$
Jul.	0	0	0	0	0	0	0	2	4	0	0	$2\gamma_{10}$
Aug.	0	0	0	0	0	0	0	2	4	0	0	γ_{10}
Sep.	0	0	0	0	0	0	0	2	3	0	0	γ_{10}

[1] $X = (\gamma_2 + \gamma_{11})/2$.

converted to the percentages of each age-class in each sub-area. The values for the parameters γ_1 - γ_{11} will be determined 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 0.5, 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-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 Table 3.

Table 3

Commercial and scientific catches by sub-Area and sex for each season and year. The sub-Areas are shown in Fig.1.

Area	Yr	Males						Females					
		J-A	M	J	J	A	S-D	J-A	M	J	J	A	S-D
1	1951	0	0	0	1	0	0	0	0	0	0	0	0
1	1957	17	0	0	0	0	0	11	0	0	0	0	0
2	1948	0	0	2	0	0	1	0	0	0	0	0	0
2	1950	0	0	1	2	0	0	0	0	0	1	0	1
2	1951	0	1	0	0	0	0	0	0	0	0	0	0
2	1952	1	0	0	0	0	0	1	0	0	0	0	0
2	1954	1	0	0	0	0	0	1	0	0	0	0	0
2	1957	1	0	0	0	0	0	1	0	0	0	0	0
2	1965	1	0	0	0	0	0	1	0	0	0	0	0
2	1966	2	0	0	0	0	0	1	0	0	0	0	0
2	1981	0	1	0	0	0	0	0	0	0	0	0	0
2	1985	1	0	0	0	0	0	0	0	0	0	0	0
5	1940	13	4	4	3	2	3	11	4	3	3	2	1
5	1941	25	8	7	6	4	4	22	7	6	6	3	4
5	1942	32	10	9	8	5	7	30	10	8	8	4	4
5	1943	25	8	7	6	4	4	22	7	6	6	3	4
5	1944	24	7	6	6	3	4	20	7	6	5	3	3
5	1945	2	1	1	1	1	0	0	0	0	0	0	0
5	1955	0	1	1	0	0	0	3	3	2	0	0	0
5	1956	0	1	1	0	0	0	3	3	2	0	0	0
5	1957	34	11	11	7	4	6	36	14	12	7	4	6
5	1958	46	11	13	6	3	4	55	22	21	7	3	3
5	1959	53	13	13	8	5	6	67	28	25	9	5	4
5	1960	36	18	13	11	5	5	57	38	31	12	4	9
5	1961	22	14	10	4	1	2	50	33	21	5	1	2
5	1962	7	21	16	10	1	1	35	39	27	12	0	0
5	1963	79	14	16	12	12	6	108	25	17	14	12	3
5	1964	83	18	14	18	8	21	98	25	14	18	8	20
5	1965	22	11	12	12	9	5	28	14	14	13	8	4
5	1966	19	22	10	20	19	17	46	41	22	21	19	15
5	1967	74	25	16	9	9	0	102	43	27	11	9	0
5	1968	54	17	16	22	7	7	83	35	28	23	6	6
5	1969	54	20	25	17	17	4	83	39	37	19	16	3
5	1970	88	41	52	35	2	4	116	60	63	37	1	3
5	1971	98	42	55	20	14	0	125	61	66	21	14	0
5	1972	108	41	52	36	11	37	134	59	63	38	10	36
5	1973	110	44	60	34	14	15	136	63	72	36	14	13
5	1974	80	40	18	9	5	7	108	58	30	11	4	6
5	1975	4	61	40	18	5	12	33	80	51	20	5	9
5	1976	143	23	19	5	0	5	170	41	30	6	0	2
5	1977	169	53	15	9	1	78	197	72	27	10	0	77
5	1978	83	44	32	8	0	38	97	49	34	7	0	35
5	1979	115	44	5	2	0	0	144	62	17	4	0	0
5	1980	101	67	60	63	41	12	100	67	59	62	41	12
5	1981	149	4	4	25	21	17	147	4	3	24	20	16
5	1982	113	2	15	29	17	8	89	5	18	44	21	30
5	1983	50	11	0	23	13	6	48	15	1	20	14	5
5	1984	21	43	14	10	0	1	18	36	11	15	0	3
5	1985	14	3	1	4	5	1	15	2	1	3	5	0
5	1986	0	0	0	0	0	0	0	0	0	0	0	0
6	1940	0	7	6	2	1	8	0	6	5	1	0	6
6	1941	1	12	11	3	1	14	0	12	11	2	1	12
6	1942	1	16	15	3	2	18	0	16	14	3	1	16
6	1943	1	13	11	3	1	13	0	12	11	2	1	12
6	1944	1	11	10	2	1	14	0	11	10	2	1	11
6	1945	0	1	1	0	0	2	0	0	0	0	0	0
6	1948	43	13	0	0	0	0	32	6	0	0	0	0
6	1949	15	5	0	0	0	0	17	12	0	0	0	0
6	1950	0	11	3	0	0	1	0	7	2	0	0	0
6	1951	34	25	2	1	0	0	28	9	1	1	0	0
6	1952	110	31	1	0	0	0	27	13	3	0	0	0
6	1953	76	11	3	0	0	0	42	4	2	0	0	0
6	1954	26	6	1	0	0	0	20	7	0	0	0	0
6	1955	13	7	0	0	0	0	9	6	0	0	0	0
6	1956	13	2	1	0	0	0	18	5	0	0	0	0
6	1957	3	16	18	3	2	17	0	16	17	3	1	16
6	1958	1	16	23	2	1	10	0	15	22	2	1	9
6	1959	1	19	23	3	2	11	0	18	23	2	1	9
6	1960	1	14	18	3	2	9	0	14	18	3	1	8
6	1961	1	10	8	1	1	4	0	9	8	0	0	3
6	1962	0	20	19	3	0	3	0	20	18	3	0	2
6	1963	1	7	11	4	4	8	0	6	11	4	4	7
6	1964	3	22	16	7	3	12	2	22	15	7	2	11
6	1965	6	19	18	5	3	23	5	17	17	5	3	21
6	1966	0	23	9	7	7	15	2	23	9	7	7	19
6	1967	4	28	18	3	3	3	8	27	18	3	3	2
6	1968	10	14	20	8	3	12	3	14	19	8	2	10
6	1969	11	20	35	7	6	9	10	19	35	6	6	8
6	1970	7	55	82	14	1	6	3	54	81	14	0	3
6	1971	5	57	86	8	5	1	3	56	86	7	5	0
6	1972	2	36	41	6	3	35	1	35	41	5	3	34
6	1973	1	35	42	10	8	86	3	35	42	9	7	83
6	1974	7	32	45	13	5	47	6	32	44	12	5	44
6	1975	13	87	60	7	2	8	3	87	60	6	2	4
6	1976	3	24	24	1	0	25	1	23	24	1	0	24
6	1977	4	74	18	3	0	117	2	74	17	2	0	114
6	1978	1	57	41	2	0	234	1	56	40	2	0	232
6	1979	5	82	108	37	13	64	23	82	108	36	12	63
6	1980	0	33	9	2	3	75	0	32	9	2	2	73
6	1981	1	69	31	11	6	47	0	68	30	11	6	46
6	1982	8	32	25	8	7	95	1	39	28	14	3	90
6	1983	0	30	37	4	2	65	0	31	37	3	1	60
6	1984	6	60	11	6	5	21	4	69	13	5	5	16
6	1985	0	8	7	2	2	18	0	5	8	1	1	16
6	1986	8	9	4	31	0	0	4	8	1	4	0	0
7	1930	1	3	2	1	0	0	1	2	1	0	0	0
7	1931	1	3	2	1	0	0	1	2	1	0	0	0
7	1932	1	3	2	1	0	0	1	2	1	0	0	0
7	1933	1	3	2	1	0	0	1	2	1	0	0	0
7	1934	3	5	3	1	1	1	2	4	2	0	0	0
7	1935	3	5	3	1	1	1	2	4	2	0	0	0
7	1936	3	5	3	1	1	1	2	4	2	0	0	0
7	1937	7	14	7	2	1	1	7	9	5	1	1	0
7	1938	8	16	8	2	2	2	8	11	6	1	1	1
7	1939	8	16	8	2	2	2	8	11	6	1	1	1
7	1940	10	19	10	2	2	2	9	12	7	1	1	2
7	1941	7	14	7	2	1	1	7	9	5	1	1	0
7	1942	8	16	8	2	2	2	8	11	6	1	1	1
7	1943	12	25	12	3	2	3	12	16	9	2	1	2
7	1944	10	19	10	2	2	2	9	12	7	1	1	2
7	1945	8	16	8	2	2	2	8	11	6	1	1	1
7	1946	8	15	7	2	1	1	8	9	5	1	1	0
7	1947	9	17	9	2	2	2	9	11	6	1	1	2
7	1948	15	26	13	1	0	0	11	16	9	0	0	0
7	1949	13	34	15	1	0	0	10	18	4	0	0	0
7	1950	0	45	16	2	19	22	0	19	5	1	7	12
7	1951	23	38	24	14	0	0	17	16	10	2	0	0
7	1952	31	39	22	1	0	0	35	32	11	2	0	0
7	1953	30	16	29	1	0	0	33	8	15	2	0	0
7	1954	10	10	8	22	1	0	7	15	6	9	0	1
7	1955	32	53	23	1	6	4	25	31	24	0	4	2
7	1956	15	92	33	1	8	18	12	64	39	7	3	5
7	1957	46	48	21	5	4	6	50	39	20	4	3	6
7	1958	32	49	24	6	11	9	43	57	23	4	5	2
7	1959	18	27	13	3	6	5	23	31	13	2	3	1
7	1960	17	26	13	3	6	4	23	30	12	2	3	1
7	1961	22	33	16	4	8	5	30	39	16	3	3	1
7	1962	13	20	10	2	5	3	17	23	9	2	2	1
7	1963	13	21	10	3	5	3	17	24	10	2	2	1
7	1964	22	33	16	4	8	6	30	40	16	3	3	1
7	1965	15	22	19	4	0	0	21	35	36	0	0	0
7	1966	22	34	16	4	8	6	34	46	18	3	4	2
7	1967	14	21	10	3	5	3	23	31	12	2	3	1
7	1968	14	20	12	1	2	4	24	39	13	2	2	1
7	1969	4	12	7	1	3	1	8	17	6	1	2	0
7	1970	19	64	10	7	4	2	27	54	6	5	0	0
7	1971	23	20	34	7	3	0	23	19	22	4	1	0
7	1972	15	13	5	0	1	12	35	38	2	0	0	4
7	1973	32	42	11	1	14	18	34	36	25	2	4	5
7	1974	15	27	7	5	24	13	34	34	1	3	12	5
7	1975	11	27	2	16	38	10	13	33	0	6	13	7
7	1976	32	17	2	6	7	10	51	19	1	5	9	9

cont...

Table 3 continued.

Area	Yr	Males						Females					
		J-A	M	J	J	A	S-D	J-A	M	J	J	A	S-D
7	1977	11	21	2	20	24	29	16	28	0	7	1	5
7	1978	37	46	9	32	51	53	47	46	1	12	4	6
7	1979	34	53	9	31	55	64	26	21	3	10	9	8
7	1980	33	22	25	37	9	35	40	40	7	9	1	5
7	1981	30	38	55	38	25	3	32	29	11	9	3	2
7	1982	37	34	46	25	13	7	38	24	14	12	6	1
7	1983	24	34	24	32	10	10	42	27	18	13	6	4
7	1984	37	22	18	16	17	42	29	7	19	13	10	16
7	1985	30	7	37	35	12	43	17	16	18	10	4	7
7	1986	44	13	20	28	20	33	26	9	12	17	5	15
7	1987	32	46	15	13	10	50	25	17	11	6	2	12
7	1996	0	0	0	0	15	13	0	0	0	1	0	2
7	1997	0	0	2	0	0	0	0	0	0	0	0	0
8	1949	0	0	0	0	0	0	0	0	1	0	0	0
8	1952	0	0	0	0	0	0	0	0	0	0	1	0
8	1953	0	0	0	0	0	0	0	0	0	0	0	1
8	1954	0	0	0	0	0	1	0	0	0	0	0	0
8	1955	0	0	0	0	0	0	0	0	0	1	0	0
8	1956	0	0	0	0	0	0	0	0	0	1	0	0
8	1957	0	0	0	0	0	1	0	1	0	1	0	0
8	1959	0	0	0	0	0	0	0	0	0	0	1	0
8	1960	0	0	0	0	1	0	0	0	0	0	0	0
8	1973	0	0	0	0	0	14	0	0	0	0	0	7
8	1996	0	0	0	11	5	0	0	0	0	0	0	0
8	1997	0	0	0	30	0	0	0	0	0	1	0	0
9	1949	0	0	0	0	1	1	0	0	0	1	0	0
9	1950	0	0	0	1	1	0	0	0	0	0	0	0
9	1951	0	0	0	0	0	0	0	0	2	1	0	0
9	1952	0	0	0	1	0	0	0	0	1	0	0	0
9	1953	0	0	0	0	3	0	0	0	0	1	1	0
9	1954	0	0	0	0	0	0	0	0	0	0	1	0
9	1955	0	0	0	0	0	1	0	0	0	0	0	0
9	1956	0	0	1	0	1	0	0	0	0	1	1	0
9	1957	0	0	0	1	0	0	0	0	0	0	0	0
9	1958	0	0	0	1	0	0	0	0	1	0	1	0
9	1960	0	0	0	1	0	0	0	0	0	0	0	0
9	1969	0	0	0	0	3	0	0	0	0	0	8	0
9	1970	0	0	1	1	4	0	0	0	0	0	0	0
9	1994	0	0	0	6	8	4	0	0	0	2	1	0
9	1995	0	0	14	56	21	0	0	0	0	5	4	0
9	1997	0	20	35	0	0	0	0	7	5	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	0	3	1	0	0	0
10	1954	9	4	15	4	0	0	0	4	0	0	0	0
10	1955	2	1	6	11	0	0	0	5	0	2	0	0
10	1956	3	10	17	17	0	0	0	2	5	6	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	0	12	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	0	2	2	0	0	0
10	1971	0	0	5	2	1	0	0	2	5	2	0	0
10	1972	0	0	2	0	0	0	0	0	1	1	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	6	1	0	3	0	0	2	3	0	6
10	1977	0	0	0	0	0	0	0	0	2	0	0	0
10	1979	0	0	8	0	0	0	0	0	7	0	0	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	0	2	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

Area	Yr	Males						Females					
		J-A	M	J	J	A	S-D	J-A	M	J	J	A	S-D
11	1933	0	0	0	0	0	0	1	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	4	5	37	56	21	7
11	1973	1	17	47	18	13	5	3	2	36	26	22	4
11	1974	0	6	12	25	10	7	2	11	21	19	9	3
11	1975	0	4	20	17	12	5	0	8	28	11	5	2
11	1976	6	10	15	27	17	2	5	15	19	27	19	9
11	1977	1	16	17	5	3	12	4	10	9	2	3	0
11	1978	2	8	3	3	1	0	8	24	7	0	0	0
11	1979	0	2	10	3	0	1	10	22	16	4	0	1
11	1980	1	4	9	7	7	11	3	23	31	1	2	2
11	1981	0	2	6	4	1	14	10	11	14	12	0	9
11	1982	0	2	1	1	0	1	15	15	6	10	0	1
11	1983	1	2	1	0	0	0	13	3	10	2	2	1
11	1984	1	22	16	1	4	2	14	34	27	0	0	0
11	1985	0	17	5	0	1	5	16	20	8	0	2	9
11	1986	1	7	6	1	2	2	13	25	7	1	4	0
11	1987	0	3	3	5	3	2	15	18	10	1	2	3
11	1996	0	0	0	0	19	0	0	0	0	0	11	0
12	1949	0	0	0	2	0	0	0	0	1	0	0	0
12	1950	0	0	1	0	0	0	0	0	0	1	0	0
12	1951	0	0	0	0	0	0	0	1	0	0	1	0
12	1952	0	0	0	0	0	0	0	1	0	0	0	0
12	1953	0	0	0	0	0	0	0	0	0	0	1	0
12	1954	0	0	0	0	0	1	0	0	0	0	0	2
12	1955	0	0	0	2	1	0	0	0	0	2	0	0
12	1956	0	0	0	0	0	1	0	0	1	1	0	0
12	1957	0	0	0	0	0	0	0	0	1	1	0	0
12	1958	0	0	0	0	0	0	0	0	0	0	0	1
12	1960	0	0	0	0	0	0	0	1	0	0	1	0
12	1961	0	0	0	0	0	0	0	0	1	0	0	0
12	1962	0	0	0	0	0	0	0	0	1	0	0	0
12	1973	0	0	0	11	9	10	0	0	4	14	14	6
12	1974	0	0	1	22	3	0	0	0	1	18	16	0
12	1975	0	0	0	8	4	0	0	0	0	11	7	5

Table 4

Q matrix: the fraction of the catch in sub-Area k which is taken by sex and month. Dashes indicate sub-Areas/months for which catch limits are defined to be zero. The remaining entries reflect the historic commercial catches from 1978-87 (or if there was none, then the entire historic commercial and scientific catch).

	Males							Females						
Area	Jan.-Apr.	May	Jun.	Jul.	Aug.	Sep.-Dec.	n	Jan.-Apr.	May	Jun.	Jul.	Aug.	Sep.-Dec.	n
Option A1														
1-6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	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
8	0.0	0.0	0.0	0.229	0.125	0.333	33	0.0	0.021	0.021	0.063	0.042	0.167	15
9	0.0	0.042	0.096	0.410	0.253	0.036	139	0.0	0.006	0.042	0.036	0.078	0.0	27
10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	0.113	0.098	0.041	0.031	0.062	211	-	0.319	0.223	0.051	0.020	0.043	400
12	-	0.0	0.010	0.236	0.089	0.063	76	-	0.016	0.052	0.251	0.209	0.073	115
Option A2														
1-6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	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
8	0.0	0.0	0.0	0.229	0.125	0.333	33	0.0	0.021	0.021	0.063	0.042	0.167	15
9-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	-	0.113	0.098	0.041	0.031	0.062	211	-	0.319	0.223	0.051	0.020	0.043	400
12	-	0.0	0.010	0.236	0.089	0.063	76	-	0.016	0.052	0.251	0.209	0.073	115

The trials will be conducted using two options related to the sub-areas for which future catch limits might be set:

(a) sub-areas 7,8,9 (April), 7,8,9,11,12 (May - September)[1] - factor A1;
(b) sub-areas 7,8 (April), 7,8,11,12 (May - September)[1] - factor A2.

The future ($t \geq 1998$) commercial catches by sex, sub-area, month and year are calculated using the equation:

$$C_t^{m|f,k,q} = C_t^k \, Q^{m|f,k,q} \qquad (6)$$

$Q^{m|f,k,q}$ 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 ($t \geq 1998$). Note that C_t^k is equal to the catch limit set by the RMP less any pre-specified incidental catch.

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 for both the April and May-September periods for sub-area 9 for factor A2). The non-zero entries in the Q matrix (see Table 4) 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 (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* which are combinations of sub-area 11 and other sub-areas, the entire catch is assumed to be taken from sub-area 11 as this should reflect the highest risk. For trials based on *Small Areas* which are combinations of sub-areas including sub-area 7 but not sub-area 11, the entire catch is assumed to be taken from sub-area 7.

Incidental catches of minke whales are known to occur off South Korea and Japan but the level of such catches is uncertain. Therefore two options are considered both for the incidental catch off Korea and for that off Japan. The incidental catches will be apportioned to stock and age class in the same way as for the commercial catches (i.e. using Equation 5).

Incidental catch off Korea

Option K(i) The incidental catch by Korea in sub-area 6 is assumed to be zero until 1988 after which it increases linearly to 78 in 1995. It is 129 in 1996 and 78 in 1997. 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 and 1997 (Table 5(a). The catch is apportioned by sex according to the average monthly historic ratio of commercial catches off Korea within this sub-area from 1982-86 (the only years for which data by month and sex are available). These values are also given in Table 5a. In future years the incidental catch is set at 78 P_t / P_{1997} where P_t is the 1+ population size in year t averaged over all months and apportioned by month according to the mean of the 1996-97 values and to sex using the 1982-86 ratio above.

The rationale for these levels of catch is: (a) comments by Kim that minke whales returned to inshore areas only gradually after the end of commercial whaling in 1986 - hence the linear increase; (b) indications by Kim that 1996 was environmentally abnormal, so that the incidental catch that year was atypically high; and (c) suggestions, in part in the light of (a), that such catches should therefore be expected to increase in future should the population size increase. More details are given in Appendix 7.

Option K(ii) An incidental catch of 150 whales per annum in sub-area 6 since 1988 is assumed; the sex and timing within the year of these catches is selected as for option K(i). The future catches in the sub-area will also be assumed to be 150 whales per annum. This option for trials is included following information from Anon. (1997) and Mills *et al.* (1997) which indicated

[1] Note: the Q matrix is zero for sub-areas 8 and 9 in April so no catches will be allocated. The matrix elements 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 5

(a) Incidental catches by Korea by month (the catches for Jan.-Apr. and Sep.-Dec. will be combined for input to the trials).

Month	Monthly catch in 1996	Monthly catch in 1997	Historic sex ratio M:F (commercial catch 1982-86)
Jan.	7	18	0 : 0
Feb.	2	5	0 : 0
Mar.	2	1	1 : 1
Apr.	8	11	19 : 8
May	11	11	125 : 139
Jun.	7	7	73 : 78
Jul.	8	3	47 : 25
Aug	6	3	12 : 8
Sep.	7	6	97 : 95
Oct.	26	6	76 : 66
Nov.	11	4	0 : 0
Dec.	34	3	0 : 0
Total	129	78	450 : 420

(b) Incidental catches by Japan, Option (Ji).

Year/sub-Area	1	2	6	7	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
Total (1979-1997)	1	59.3	89.8	32.9	2	2	187

[1] Catches are assumed to begin in 1955 when fishery nets were substantially improved. Catches are taken to equal the mean values from 1979-1987 (years of commercial whaling). [2] Catches off Hokkaido are allocated evenly to sub-Areas 7, 10 and 11. [3] Catches in 1988 are allocated to sub-Areas using information from 1987 and 1989. [4] Two individuals in 1989, whose catch position is unknown, were allocated in proportion to the composition of the six of known position.

that incidental catches up to a level of 128 whales per year had been taken incidentally in Korean fisheries. In addition further catches may have occurred in China-Taiwan and North Korea. When this option is used, the RMP will not be given the true incidental catches but rather will be given the smaller incidental catches listed for Option K(i).

Option K(i) will be used as part of the specifications for the base-case trials while sensitivity trials will be carried out to investigate the effect of option K(ii) (trials NPM45-48).

Incidental catch off Japan

Option J(i) The catches between 1979-1997 are taken to be the reported catches as listed in Japanese progress reports - see Table 5b. Future catches are taken to be the mean values over the years 1996 and 1997. The sex and timing within the year of these catches will be 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.

Option J(ii) An incidental catch of 93 animals is assumed to have been taken in each year from 1900 to the present, and is assumed to continue indefinitely. This estimate of the level of incidental catch was reported by Tobayama *et al.* (1992). Catches are allocated among sub-areas in the same ratio as the 1979-97 catches listed in Table 5b, and the sex and timing within years as for option Ji. When this option is used, the RMP will not be given the true incidental catches but rather will be given the smaller Japanese incidental catches listed for Option J(i).

Some of the incidental catch by Japan is taken from sub-areas in which a catch limit will be set. For all trials the total catch (commercial + incidental) from the sub-areas will be taken as equal to the catch limit set by the *RMP* if the *RMP* catch limit exceeds the incidental catch. Note: the original trial specifications included sensitivity tests to examine the case when the catch from the sub-area is equal to the limit set by the *RMP* plus the incidental catch, but following advice from the Commission (IWC Resolution 1998-2) these sensitivity tests have been deleted.

E. Generation of data

The estimates of absolute abundance (and their associated *CV*s) for the years prior to 1998 provided to the *CLA* are identical to the actual estimates and *CV*s for North Pacific minke whales from surveys conducted in August/September (see Table 6(a)). 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 *CV*s for *Small Areas* comparable to those for the surveys in Table 6(a). The estimates of abundance for a *Small Area* (say *Small Area E*) are generated using the formula:

$$\hat{P} = PYw/\mathrm{m} = P^* \mathrm{b}^2 Yw \qquad (7)$$

Y is a lognormal random variable $Y = e^e$ where $e \sim N[0,s^2]$ and $s^2 = \mathrm{Ln}(a^2 + 1)$,

w is Poisson random variable with $E(w) = \mathrm{var}(w) = \mathrm{m} = (P/P^*)/b^2$, Y and w are independent,

P is the average current total (1+) population size in the *Small Area* (E) over August-September:

$$P = P_t^E = \frac{1}{2}\sum_{k\in F}\sum_{q\in Aug/Sept}\sum_{s}\sum_{a=1}^{x}(V_{t,a}^{m,s,k,q}(R_{t,a}^{m,s} + U_{t,a}^{m,s}) + V_{t,a}^{f,s,k,q}(R_{t,a}^{f,s} + U_{t,a}^{f,s}) \qquad (8)$$

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

$\mathrm{CV}^2(ab) = \mathrm{CV}^2(a)\,\mathrm{CV}^2(b)$: $E(\hat{P}) = P$

and $CV^2(\hat{P}) = a^2 + b^2P^*/P$.

For consistency with the first stage screening trials for a single stock, the ratio $\alpha^2 : \beta^2 = 0.12 : 0.025$, so that:

$$CV(\hat{P}) = t(0.12 + 0.025P^*/P)^{1/2} \qquad (9)$$

and the CV of a survey estimate prior to the commencement of exploitation in the area being surveyed would be:

$$\sqrt{(\alpha^2 + \beta^2)} = 0.38\tau \qquad (10)$$

Table 6

Data used to condition the trials.

(a) The abundance data used to condition the trials.

Sub-Area	Timing	Estimate	CV	Estimate also used by *CLA*	Source
6	Aug.-Sep. 1992	893[1]	0.67	No	Miyashita and Shimada (1994)
7	Aug.-Sep. 1990	1,741[1]	0.655	No	Buckland *et al.* (1992); *Rep. int. Whal. Commn* 47: 211
7	Aug.-Sep. 1991	2,202	0.383	Yes	*Rep. int. Whal. Commn* 47: 211
8	Aug.-Sep. 1990	1,057	0.706	Yes	Buckland *et al.* (1992); *Rep. int. Whal. Commn* 47: 211
9	Aug.-Sep. 1990	8,264	0.396	Yes	Buckland *et al.* (1992); *Rep. int. Whal. Commn* 47: 211
9	Jun.-Jul. 1994	4,673	0.441	No	*Rep. int. Whal. Commn* 47: 211
9	Jun.-Jul. 1995	2,145[2]	0.315	No	*Rep. int. Whal. Commn* 47: 211
10	Aug.-Sep. 1992	707[1]	0.57	No	Miyashita and Shimada (1994)
11	Aug.-Sep. 1990	2,120	0.449	Yes	Buckland *et al.* (1992); *Rep. int. Whal. Commn* 47: 211
12	Aug.-Sep. 1990	15,641	0.363	Yes	?
12	Aug.-Sep. 1992	11,948	0.46	Yes	Miyashita and Shimada (1994); *Rep. int. Whal. Commn* 47: 211

[1] Minimum estimate. [2] Estimate based on some extrapolation to unsurveyed areas.

(b) Estimates of the proportion of 'J' whales used to condition the trials

Sub-Area	Month	Sex	Years	Estimate	SE	Data used	Source
7	Aug.-Sep.		1980-87	0.018	0.023	Isozyme	*Rep. int. Whal. Commn* 47:214
11	Apr.		1980-87	0.512	0.045	Isozyme/mtDNA	*Rep. int. Whal. Commn* 47:214-5
11	May		1980-87	0.049	0.023	Isozyme	*Rep. int. Whal. Commn* 47:214
11	Jun.-Jul.		1980-87	0.076	0.016	Isozyme	*Rep. int. Whal. Commn* 47:214
11	Aug.	M	1980-87	0.315	0.116	Isozyme	Pastene *et al.* (1998)
11	Aug.	F	1980-87	0.044	0.069	Isozyme	Pastene *et al.* (1998)
12	Jun.		1973-75	0.089	0.051	Conception/flipper colour	*Rep. int. Whal. Commn* 47:215
12	Jul.		1973-75	0.013[1]	0.008	Conception/flipper colour	*Rep. int. Whal. Commn* 47:215
12	Aug.		1973-75	0.015[1]	0.009	Conception/flipper colour	*Rep. int. Whal. Commn* 47:215

[1] Based on the centre of the confidence interval.

The value of t 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 9), and solving for t. If more than one abundance estimate exists for a particular sub-area, the value assumed for t 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 t applicable to each sub-area will be calculated separately for each replicate once the conditioning has been accomplished.

An estimate of the *CV*, X_i is also generated for each sightings estimate, $\hat{P}_i$:

$$X_i = \sqrt{(\sigma^2 \text{CHISQ}} \qquad (11)$$

where $s^2 = Ln(1 + a^2 + b^2 P^*/\hat{P})$, and CHISQ is a random number from a Chi-square distribution with 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*.

Table 1 lists the pattern for future surveys. The trials will 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 1999 would first be used for setting the catch limit in 2001.

Four trials consider the case where $g(0) = 0.5$. To implement this, the observed P is taken to be half of its actual value (Equation 8).

In trials in which *Small Areas* which are comprised of sub-areas which are surveyed in different years, the abundance estimate is taken to be a combination of the estimates of abundance in the sub-areas over 3 years and taken to refer to the mean year (IWC, 1998).

F. Parameter values

Following the decision by the sub-committee on North Pacific minke whales (IWC, 1992, p.160), the values of the biological and technological parameters have been taken to be equal to those for the North Atlantic minke *Implementation Simulation Trials* (IWC, 1991, pp.108-112c), i.e.:

$r_{50} = 4$; $s_r = 1.2$; where r is recruitment
$m_{50} = 7$; $s_m = 1.2$; where m is maturity
$MSYL = 0.6$

The maturity ogive is modified so that the first age at which a female can be mature is three, i.e. $b_0 = b_1 = b_2 = 0$.

Natural mortality is age-dependent, and identical to that for the North Atlantic minke trials:

$$M_a = \begin{cases} 0.085 & \text{if } a \le 4 \\ 0.0775 + 0.001875a & \text{if } 4 < a < 20 \\ 0.115 & \text{if } a \ge 20 \end{cases}$$

The MSYR scenarios considered 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 which 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 parameters γ_1 - γ_{11} used to define the catch mixing matrices is known as the conditioning process. The process involves first generating the target data, as detailed in steps (a) to (h) below, that will be 'fitted' to the above model. Values for the initial population sizes and the ts are then selected by minimising the negative of the log-likelihood which contains terms related to the target data generated in steps (a)-(h). The number of animals in sub-area k at the start of year t is calculated starting with guessed values of the initial

population size and projecting the operating model forward to 1998 in order to obtain values of abundance etc. for comparison with the generated data. (When performing the projections, mixing is stochastic, and the catches from each sub-area are set to their historic values - Tables 3 and 5.) A different set of data is generated (and hence a different set of parameters selected) for each of the 100 replicates within a trial. (Note that not all of the ts are estimated in all trials - for example, t_9 is used only in mixing matrix J and hence is estimated only for trials NPM33-NPM38.) The results showing the fits to the conditioning data will be forwarded to the Steering Group. If the fits are not sufficiently good, extra free parameters should be added to the mixing matrices to improve them, and to ensure that the initial conditions modelled are such that all of the historic catches can be taken.

The information used in the conditioning is as follows.

(a) The target values for the historical abundance by sub-area generated using the formula:

$$P_t^k = O_t^k \exp[\mu_t^k - (\sigma_t^k)^2/2] \qquad \mu_t^k \sim N[0;(\sigma_t^k)^2] \qquad (12)$$

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 6(a)), and
σ_t^k is the CV of O_t^k.

The values of abundance generated for sub-areas 6 and 10, and one of those for sub-area 7, 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 generated values.

(b) Estimates of the proportion of J whales in sub-areas 7, 11 and 12 are generated from the appropriately truncated normal distributions which correspond to the observed data (see Table 6(b)) which are based on isozyme, mtDNA, conception date and flipper colour information. Although data do exist for sub-areas other than those listed in Table 6(b), the sample sizes are so low that their information content is effectively nil.

(c) The ratio of the size of the exploitable population in sub-areas 5, 6 and 10 combined averaged over April-September 1987 to that in 1973 is 0.18. This specification is based on a GLM analysis of CPUE data for the South Korean fishery. Sensitivity tests (NPM25 - NPM28) consider assuming that this ratio is 0.43.

(d) The fraction of the O stock in sub-area 12 is fixed by specifying the percentage which the O stock comprises of the combined O-W abundance in that sub-area in August-September 1995. The base-case choice for this percentage is 30%. Some sensitivity tests (NPM9 - NPM12) consider alternative choices of 10% and 100%. The model parameter values are selected to satisfy this requirement exactly. The base-case choice is derived from the estimates of abundance from sub-areas 7, 8, 9 and 11 in August to September on the assumption that the ratio of O to W animals in sub-area 12 in August-September is roughly the same as the ratio of the abundance in sub-areas 7 and 11 to that in sub-areas 8 and 9. The rationale for using these data is that at the time of the surveys the bulk of the animals in these sub-areas are males, whilst females predominate in catches in sub-area 12. The base-case choice should be reasonably conservative in terms of possibly overestimating the fraction of O animals because at least some of the animals in sub-area 9 should migrate to the north of this sub-area (which has never been surveyed) instead of to sub-area 12.

(e) For trials NPM29 - NPM32, the mean proportion of the O stock (1+ animals) in sub-area 10 from May-July is assumed to be 0.05 in the pristine situation i.e. the proportion will be 0.1 in years in which the parameter $\gamma_8 > 0$.

(f) For trials NPM17 - NPM20, the point estimates of the fraction of the J stock animals in sub-area 12 in June to August are doubled (Table 6(b)).

(g) Trials will be run to test the effect of potentially different proportions of J whales in the total (scientific, commercial and incidental) catch taken by Japan. The mean proportion of J whales in the total Japanese catch from 1993-98 is taken to be 39.2% in these trials, the parameter values being selected to satisfy this requirement exactly. (The figure of 39.2% is derived from: (a) the observed proportion of 32.5% of RFLP haplotypes 2/5 in North Pacific minke whale products purchased in Japan from 1993-98, which are assumed to be randomly selected from catches during this period; and (b) the different proportions of 2/5 types occurring in the two stocks: 2/5 types occur in 76.7% of J stock samples and about 4% of O (or O/W) stock samples.) The mean proportion of J whales in the catch over these years will be output in trials when this proportion is not included in the conditioning (see section G).

(h) For trials NPM41-44 (cases for which g(0) = 0.5) the values of the actual abundances are halved for comparison with the conditioning targets.

The abundance in sub-area 13 is taken to be 0 for all of the trials because abundance estimates are unavailable for this sub-area, and because allowing for animals in sub-area 13 may lead to over-optimistic results if catches are taken from sub-areas 8 and 9 as well as from coastal Japanese waters and the Okhotsk Sea.

G. Trials

Trials NPM1 - 4 are the base case trials (Table 7a).

Trials NPM1 - 4 will be used to test the effects of the two options for the level of Japanese incidental catch (Ji and Jii) and the effects of setting the fraction of J animals in the total catch by Japan when conditioning (i.e. including or not including condition (g) above). All combinations of these options will be tested (16 trials in all). The results of these 16 trials will be considered by the Steering Group and used to select the base case options to use with the remaining sensitivity trials which are listed in Table 7b.

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 AREAS

Sub-areas 1, 2, 3, 4, 5, 6, 10 and 13 are *Residual Areas*. There are three alternative *Small Area* definitions.

(a) Sub-areas 7, 8, 9, 11 and 12 (i.e. *Small Areas* = sub-areas).
(b) Sub-areas 7+8, 9, 11 and 12.
(c) Sub-areas 7+11+12, 8 and 9.
(d) Sub-areas 7+8+9+11+12.

Table 7

Trials.

(a) The base-case trial NPM1-4.

Trial No.	Number of stocks	MSYR (mixing matrix) Stock J	Stock O	Stock W	O Stock % sub-Area 12	Comments
NPM1	3	1 (A/B)	1 (F)	1 (K)	30	Base-case trial 1
NPM2	3	4 (A/B)	1 (F)	4 (K)	30	Base-case trial 2
NPM3	2	1 (A/B)	1 (G)	-	-	Base-case trial 3
NPM4	2	4 (A/B)	1 (G)	-	-	Base-case trial 4

(b) Remaining sensitivity trials.

Trial No.	Number of stocks	MSYR (mixing matrix) Stock J	Stock O	Stock W	O Stock % sub-Area 12	Comments
NPM5	3	4 (A/B)	4 (F)	4 (K)	30	NPM1 + MSYR=4%
NPM6	3	1 (A/B)	4 (F)	1 (K)	30	NPM1 with $MSYR_O$=4%
NPM7	2	4 (A/B)	4 (G)	-	-	NPM3 + MSYR=4%
NPM8	2	1 (A/B)	4 (G)	-	-	NPM4 with MSYR=4%
NPM9	3	1 (A/B)	1 (F)	1 (K)	10	NPM1 + 10% O stock in sub-Area 12
NPM10	3	4 (A/B)	1 (F)	4 (K)	10	NPM2 + 10% O stock in sub-Area 12
NPM11	3	1 (A/B)	1 (F)	1 (K)	100	NPM1 + no W stock in sub-Area 12
NPM12	3	4 (A/B)	1 (F)	4 (K)	100	NPM2 + no W stock in sub-Area 12
NPM13	3	1 (C/D)	1 (F)	1 (K)	30	NPM1 + ignore sub-Area 5 catches
NPM14	3	4 (C/D)	1 (F)	4 (K)	30	NPM2 + ignore sub-Area 5 catches
NPM15	2	1 (C/D)	1 (G)	-	-	NPM3 + ignore sub-Area 5 catches
NPM16	2	4 (C/D)	1 (G)	-	-	NPM4 + ignore sub-Area 5 catches
NPM17	3	1 (A/B)	1 (F)	1 (K)	30	NPM1 + greater fraction J stock in sub-Area 12
NPM18	3	4 (A/B)	1 (F)	4 (K)	30	NPM2 + greater fraction J stock in sub-Area 12
NPM19	2	1 (A/B)	1 (G)	-	-	NPM3 + greater fraction J stock in sub-Area 12
NPM20	2	4 (A/B)	1 (G)	-	-	NPM4 + greater fraction J stock in sub-Area 12
NPM21	3	1 (A/E)	1 (F)	1 (K)	30	NPM1 + no J stock in sub-Area 7
NPM22	3	4 (A/E)	1 (F)	4 (K)	30	NPM2 + no J stock in sub-Area 7
NPM23	2	1 (A/E)	1 (G)	-	-	NPM3 + no J stock in sub-Area 7
NPM24	2	4 (A/E)	1 (G)	-	-	NPM4 + no J stock in sub-Area 7
NPM25	3	1 (A/E)	1 (F)	1 (K)	30	NPM1 + depletion of J stock = 0.43
NPM26	3	4 (A/E)	1 (F)	4 (K)	30	NPM2 + depletion of J stock = 0.43
NPM27	2	1 (A/E)	1 (G)	-	-	NPM3 + depletion of J stock = 0.43
NPM28	2	4 (A/E)	1 (G)	-	-	NPM4 + depletion of J stock = 0.43
NPM29	3	1 (A/B)	1 (F/H)	1 (K)	30	NPM1 + O stock in sub-Area 10
NPM30	3	4 (A/B)	1 (F/H)	4 (K)	30	NPM2 + O stock in sub-Area 10
NPM31	2	1 (A/B)	1 (G/I)	-	-	NPM3 + O stock in sub-Area 10
NPM32	2	4 (A/B)	1 (G/I)	-	-	NPM4 + O stock in sub-Area 10
NPM33	3	1 (A/B)	1 (J)	1 (K)	30	NPM1 + O-W mixing in sub-Area 8
NPM34	3	4 (A/B)	1 (J)	4 (K)	30	NPM2 + O-W mixing in sub-Area 8
NPM35	3	1 (A/B)	1 (J)	1 (L)	30	NPM1 + no W stock in sub-Area 8
NPM36	3	4 (A/B)	1 (J)	4 (L)	30	NPM2 + no W stock in sub-Area 8
NPM37	3	1 (A/B)	1 (J)	1 (L)	100	NPM1 + no W stock in sub-Area 8
NPM38	3	4 (A/B)	1 (J)	4 (L)	100	NPM2 + no W stock in sub-Area 8
NPM39	3	1 (A/B)	1 (F)	1 (M)	30	NPM1 + O-W mixing in sub-Areas 7+11
NPM40	3	4 (A/B)	1 (F)	4 (M)	30	NPM2 + O-W mixing in sub-Areas 7+11
NPM41	3	1 (A/B)	1 (F/H)	1 (K)	30	NPM1 + $g(0)$ = 0.5
NPM42	3	4 (A/B)	1 (F/H)	4 (K)	30	NPM2 + $g(0)$ = 0.5
NPM43	2	1 (A/B)	1 (G/I)	-	-	NPM3 + $g(0)$ = 0.5
NPM44	2	4 (A/B)	1 (G/I)	-	-	NPM4 + $g(0)$ = 0.5
NPM45	3	1 (A/B)	1 (F)	1 (K)	30	NPM1 + 150 incidental Korean catch/year (option Kii)
NPM46	3	4 (A/B)	1 (F)	4 (K)	30	NPM2 + 150 incidental Korean catch/year
NPM47	2	1 (A/B)	1 (G)	-	-	NPM3 + 150 incidental Korean catch/year
NPM48	2	4 (A/B)	1 (G)	-	-	NPM4 + 150 incidental Korean catch/year

Given the fact of migration, *Small Areas* may need to be developed somewhat differently from earlier approaches.

MEDIUM AREAS

Medium Areas are supposed to represent the known or suspected range of distinct biological stocks. Only one *Medium Area* (sub-areas 2, 3, 4, 7, 8, 9, 10, 11 and 12) is defined in the North Pacific because future surveys will not cover most of the sub-areas.

LARGE AREA

There is no *Large Area.*

COMBINATION AREAS

The *Combination area* comprises all sub-areas 7, 8, 9, 11, 12 (i.e. a 'West Pacific - East of Japan' combination area).

Management procedure variants

The following three management variants will be considered for each of the trials listed in Section G for each of the *Small Area* definitions, following selection of conditioning choices and the Japanese incidental catch option as detailed in section G.

(a) Catch limit calculations by *Small Area*, no *capping*, no *cascading*.
(b) Catch limit calculations by *Small Area* with *Medium Area capping*, no *cascading* (initially base-case trials only because results with *capping* are unlikely to differ much from those with no *capping* and no *cascading*)
(c) *Cascading* over the *Combination Area*.

If 4 out of the 16 base-case options outlined above are retained this gives 48 trials × 4 *Small Area* options × 2 procedure variants ((a) and (c)) × 2 options related to sub-areas with catches + 4 base-case trials × 4 *Small Area* options × 1 procedure variant (b) × 2 options related to sub-areas = 800 trials in all. The number of options and procedures must be restricted for many of the trials. An initial suggestion is:

(i) 4 base-case trials × 4 *Small Area* options × 2 variants × 2 sub-area options = 64 trials;
(ii) other trials × 2 *Small Area* options ((a) and (c)) × 1 variant (a) × 1 sub-area option (a) = 88 trials.

Trial NPM1 will be conducted first to reduce the number of *Small Area* options, procedure variants, and options related to sub-areas with catches. The remainder of the trials under (i) will then be conducted for those options which were not deleted based on the results of trial NPM1.

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 will be 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_{1998}) 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.

The continuing catch statistic is defined as follows.

First, the 'sustainable yield' function of population size is defined as:

$$S_Y(P) = \begin{cases} \text{MSY} & \text{for } P > \text{MSYL} \\ \text{long-term equilibrium RY} & \text{for } P < \text{MSYL} \end{cases}$$

Next the average catch over the final ten years of the simulation, $\overline{C}$, and the average 'sustainable yield' over this period, $\overline{SY}$, are calculated. The continuing catch statistic is then defined as the minimum of $\overline{C}$ and $\overline{SY}$.

REFERENCES

Anonymous. 1997. Illegal trade in whale meat. CITES Document 10.40.1 presented to the Tenth Meeting of the Conference of the Parties, Harare (Zimbabwe), 9-20 June 1997. 4pp.

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.

International Whaling Commission. 1991. Report of the Scientific Committee, Annex D. Report of the sub-committee on management procedures. *Rep. int. Whal. Commn* 41:90-112C.

International Whaling Commission. 1992. 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. 1993. Report of the Scientific Committee, Annex I. Report of the working group on implementation trials. *Rep. int. Whal. Commn* 43:153-96.

International Whaling Commission. 1997a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 47:59-257.

International Whaling Commission. 1997b. Report of the Scientific Committee, Annex J, Appendix 3. Estimates of mixing between J and O stocks. *Rep. int. Whal. Commn* 47:214-5.

International Whaling Commission. 1997c. 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. 1997d. Report of the Scientific Committee, Annex J. Report of the working group on North Pacific minke whale trials, Appendix 5. Future surveys. *Rep. int. Whal. Commn* 47:225-6.

International Whaling Commission. 1998. Report of the Scientific Committee. Annex H. Report of the Sub-Committee on the Other Great Whales. *Rep. int. Whal. Commn* 48: 183-202.

Mills, J., Ishihara, A., Sakaguchi, I., Kang, S., Parry-Jones, R. and Phipps, M. 1997. *CITES 1997.* Whale meat trade in East Asia: a review of the markets in 1997. TRAFFIC International, Cambridge. 26pp.

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. 9pp.

Pastene, L., Goto, M. and Kishino, H. 1998. An estimate of mixing proportion of 'J' and 'O' stocks minke whales in Sub-area II based on mitochondrial DNA haplotype data. *Rep. int. Whal. Commn* 48: 471-74.

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 7

BYCATCHES OF MINKE WHALES IN KOREAN WATERS

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Baleen whales were abundant in the waters of the Korean peninsular until the early 19th century when foreign whaling fleets began large-scale whaling. It was not until after World War II that Korean fishermen began taking minke whales. The total catch of minke whales from 1962 to the ban on commercial whaling in 1986 was 13,734 animals. The taking of all cetaceans in Korean waters has been banned by the Ministry of Marine Affairs and Fisheries (MOMAF, Notice No. 85-17) since 1 January 1986.

In recent years, an increase in the population of minke whales in Korean waters is suggested by the increased bycatch and more frequent sightings in coastal waters.

Bycatches have been controlled since 1996 under the MOMAF guidelines on the prohibition of whale catching in Korean waters. These guidelines were revised in December 1997 in order to facilitate biological sampling from the bycatch, including the DNA sampling of market whale meat. Biological sampling was carried out under the revised guidelines by the fisheries extension service of MOMAF located in fisheries ports, in collaboration with the National Fisheries Research and Development Institute (NFRDI). The tracing of whale meat distribution was the responsibility of the fisheries authorities of regional governments.

Table 1

Bycatch of minke whales by region and fishing gear during 1996 and 1997. KN: Kyeong-Nam province (southeastern part of South Korea); PS: Pusan City (southeastern extremity of South Korea); KB: Kyeong-Buk province (central part of the east coast of South Korea); KW: Kang-Won province (northern part of the east coast of South Korea).

					Total	
Fishing gear	KN	PS	KB	KW	*n*	%
1996						
Set-net	1		16	14	32	24.8
Coastal trap	2		44		45	34.9
Offshore trap			5		5	3.9
Coastal drift gillnet			33	2	35	27.1
Offshore drift gillnet			5		5	3.9
Coastal gillnet			3	2	5	3.9
Others			1	1	2	1.6
Total	3		107	19	129	100.0
%	2.3		82.9	14.7		
1997						
Set-net	1		16	19	36	46.2
Coastal trap	2		16		18	23.1
Offshore trap			6		6	7.7
Coastal drift gillnet			7	3	10	12.8
Offshore drift gillnet			1		1	1.3
Coastal gillnet				3	3	3.8
Others		1	3		4	5.1
Total	3	1	49	25	78	100.0
%	3.8	1.2	62.8	32.1		

Table 2

Bycatch of minke whales by month and region in Korean waters in 1996 and 1997. For abbreviations see Table 1.

Month	KN	PS	KB	KW	Total
1996					
Jan.			4	3	7
Feb.			2		2
Mar.			2		2
Apr.			7	1	8
May	1		6	4	11
Jun.	1		5	1	7
Jul.	1		6	1	8
Aug.			6		6
Sep.			7		7
Oct.			25	1	26
Nov.			11		11
Dec.			26	8	34
Total	3		107	19	129
1997					
Jan.			16	2	18
Feb.			2	3	5
Mar.			1		1
Apr.			7	4	11
May			6	5	11
Jun.	1	1	4	2	8
Jul.	2				2
Aug.			2	1	3
Sep.			5	1	6
Oct.			4	2	6
Nov.			1	3	4
Dec.	3	1	1	2	3
Total			49	25	78

Table 3

Reported strandings of minke whales in Korean waters in 1997.

Area	No.	Remarks
Offshore of Kang-won province	2	Decayed and drifting in the sea
Kyeong-Buk province	1	Decayed on the beach

Table 4

Number of minke whales reported by the Mun-Whoi Broadcasting Company (MBC) in its sea survey on cetaceans in the coastal waters of the East Sea from 19-31 May 1997.

Date	No.	Area
19 May 1997	1	Kyeong-Nam (14km from Tae-Bun port)
22 May 1997	5	Kyeong-Buk (15km from Kang-Gu port)
31 May 1997	1	Kang-Won (2km from Samchuk port)

Table 5

Number of minke whales reported by the Education Broadcasting Company (EBS) in its sea survey on cetaceans in the coastal waters of the East Sea from April-November 1997.

Date	No.	Area
Apr.-Nov.	27	Near Kuryong-Po waters, Kyeong-Buk province

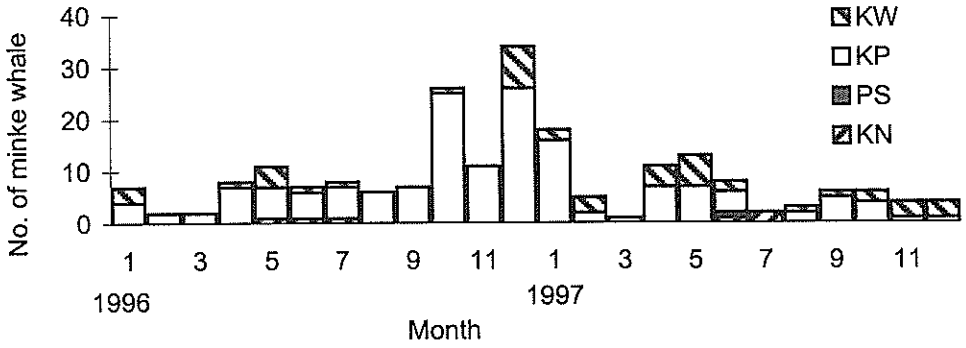


Fig. 1. Minke whale bycatch by month and region from coastal fishing in Korean waters, 1996 and 1997. KN: Kyeong-Nam province; PS: Pusan city; KB: Kyeong-Buk province; KW: Kang-Won province.

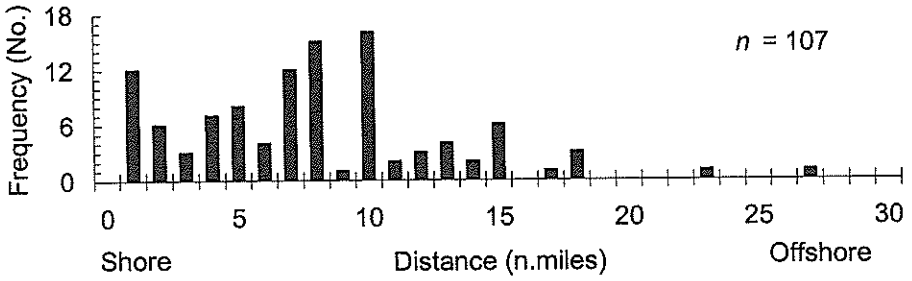


Fig. 2. Location of minke whale bycatch, Kyeong-Buk province, 1996. Distance from shore corresponds to fishing gear location.

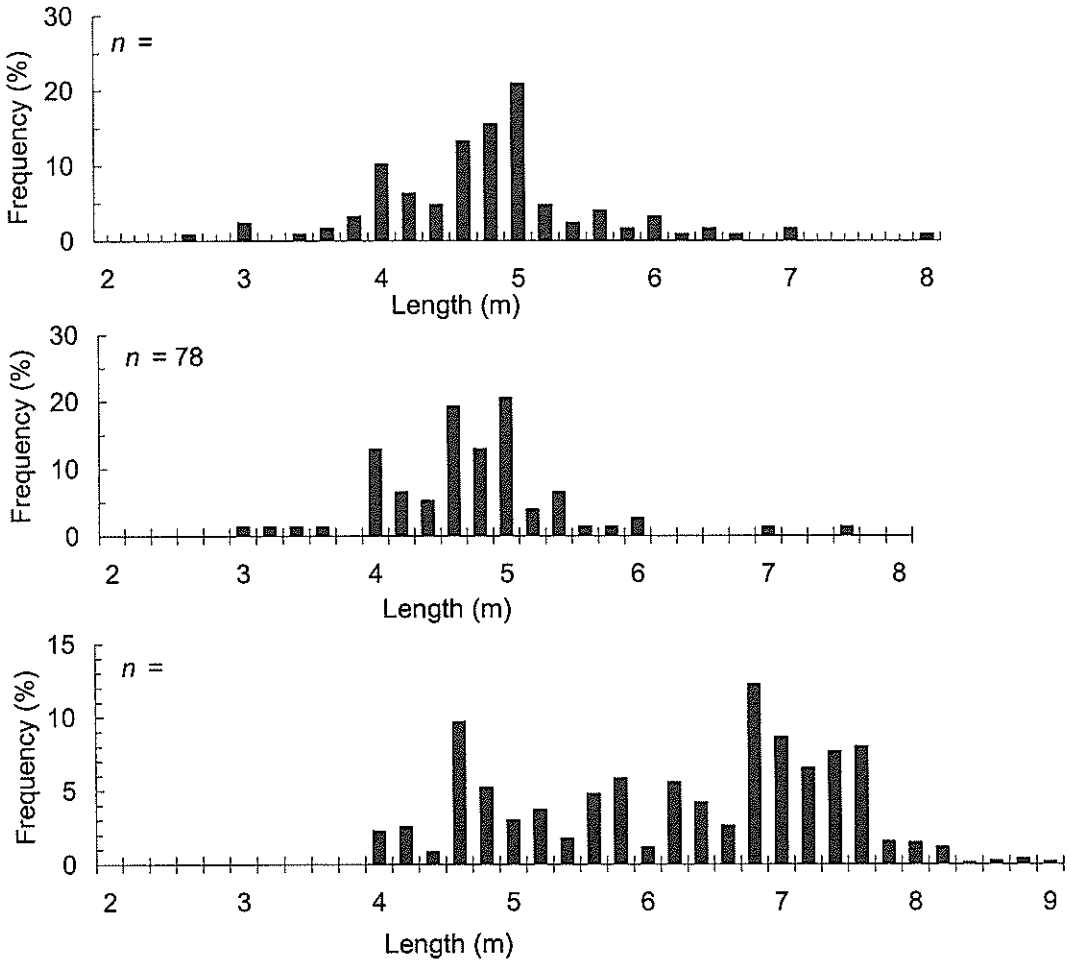


Fig. 3. Body length distribution of minke whale bycatch: 1996 (top); 1997 (middle); commercial take (bottom).

Bycatch data for minke whales were collected by MOMAF from January 1996 to December 1997, according to MOMAF guidelines (Notice No. 85-17). If a fisherman finds dead cetaceans entangled in his fishing gear, he is obliged to report his bycatch to the local marine police agent. The agent then reports the information to the police

inspection division and the fisheries authority of the regional government. The species is identified by examining the inspection report and the photographs submitted by the police. Body length data are also submitted by the police, measured from the tip of mouth to the corner of fluke.

Bycatch data for minke whales from the coastal fisheries are presented in Table 1, by region and fishing gear. There were 129 animals in 1996 and 78 in 1997; Kyeong-Buk province took 82.9% and Kang-Won 14.7% in 1996, with 62.8% and 32.1%, respectively, in 1997. This shows that most entanglement occurred in the East Sea of Korea. The types of fishing gear that caused most entanglement were trap nets, gillnets and setnets (38.8%, 34.9% and 24.8%, respectively, in 1996, and 30.8%, 22.9% and 46.2%, in 1997).

Bycatches by month and region are presented in Table 2 and Fig. 1. Greatest numbers were from October 1996-January 1997, followed by the months between April-June.

Bycatch positions in Kyeong-Buk province in 1996 are presented in Fig. 2. Most bycatches occurred within 20 n.miles of the shore, corresponding to the location of coastal fishing gear.

Fig. 3 plots body lengths of minke whales from recent bycatches and from the commercial take between 1982 and 1986. Lengths ranged from 2.5-8.0m with a mode of 4-5m in 1996 and 3.0-7.6m with a mode of 4-5m in 1997. The commercial catch range was 4-9m with two peaks between 4-5m and 6-8m during the combined 1982 to 1986 period. Thus bycaught animals were generally smaller than those commercially taken and included length classes of 2.5-4m which did not appear in the commercial take.

In 1997, two minke whales in Kang-Won province and one in Kyeong-Buk province were reported, with photographs by marine police, as stranded but decayed (Table 3).

From 19-31 May 1997, Mun-Whoi Broadcasting Company (MBC) conducted a non line-transect survey for cetaceans in Korean waters following random tracks set in the coastal waters of the East Sea, using a chartered squid angling vessel *Dong Bang Ho* (60 G/T). It recorded on video tape seven minke whales encountered within a distance of 14km from the coast (Table 4). The Education Broadcasting Company (EBS) carried out four surveys in different months (between March and November 1997) along a random line set in the South and East Sea. The aim was to investigate whale species in Korean Waters for a documentary programme. It reported (video tape and photographs) to the NFRDI that a total of 27 minke whales were encountered during the surveys (Table 5).

Appendix 8

REPORT OF THE INTERSESSIONAL CORRESPONDENCE GROUP ON NORTH PACIFIC SIGHTINGS SURVEY STEERING GROUP (NPSSSG)

Members: Smith (Chair), Borchers, Butterworth, Hatanaka, Kato, Miyashita, Øien, Polacheck, Palka, Skaug.

This Correspondence Group was established during the 1997 meeting of the Scientific Committee to provide oversight for planned sightings surveys of the North Pacific minke and Bryde's whales (see IWC, 1998, item 7.1.2). Oversight for the minke whale survey was thought useful because Japan anticipated adopting a new sightings survey methodology. Oversight for the Bryde's whale survey was thought useful because the Committee has not previously evaluated the conduct and results of the several surveys that have been conducted, and because a systematic survey over four years was anticipated.

General responsibilities for both surveys included making arrangements for participation in the surveys by Committee representatives and analysis of earlier survey data to assist in planning. Based on the discussion when the Committee reviewed draft survey plans in 1997, specific tasks were identified as needing to be addressed in preparing survey plans. These are listed below, with a brief summary of progress under each.

Minke whale survey

1. Arrange for Scientific Committee participation in the survey

Japan will cover travel, salary and on board costs for participants. Applications were planned to be solicited through the Secretariat. Qualifications for and candidates for participation have not been discussed within the group.

2. Identify how to adapt Norwegian sightings survey methods to the North Pacific for use on Japanese survey vessels

Comments were made in reviewing the January draft proposal that addressed this issue. Particularly important was the use of binoculars and its effect on sightings distances. It is unclear how this might affect the applicability of the Norwegian survey methodology.

3. Select the analysis method to be used

No discussion.

4. Review draft survey plan to be circulated by Japanese scientists

A revised draft survey plan was circulated and comments received. Comments are reproduced here because there was relatively little discussion of them. Comments relative to both survey plans are in Adjunct 1, and those relative to the minke whale survey are in Adjunct 2.

5. Submit minke whale survey plan for Scientific Committee review in Oman

A plan was submitted (SC/50/RMP4).

Bryde's whale survey

1. Arrange for Scientific Committee participation in the survey

Japan will cover travel, salary and on board costs for participants. Applications were planned to be solicited through the Secretariat. Qualifications for and candidates for participation have not been discussed within the group.

2. Submit previous data to IWC Secretariat
Data were submitted in mid-December.

3. Make data and more detailed data summaries available to Steering Group members
Shimada and Miyashita are planning to prepare a paper for the annual meeting. Shimada provided revisions of those data in Shimada and Miyashita (1997) to the Correspondence Group on Specification of Implementation Simulation Trials for the Western North Pacific Bryde's Whale.

4. Evaluate effects of platform and observer heterogeneity
Okamura, Miyashita and Shimada are planning to prepare a paper for the annual meeting.

5. Evaluate spatial and temporal pattern of previous survey
Shimada and Miyashita are planning to prepare a paper for the annual meeting using a GLM approach.

6. Develop method of estimating abundance from previously collected data, accounting for platform, observer, spatial and temporal heterogeneity
Not discussed.

7. Develop method of estimating variance of abundance estimates, accounting for co-variances across areas and surveys
Not discussed.

8. Review draft survey plan to be circulated by Japanese scientists
A revised draft survey plan was circulated and comments received. Comments are reproduced here because there was relatively little discussion of them. Comments relative to both survey plans are in Adjunct 1, and those relative to the Bryde's whale survey are in Adjunct 3.

9. Submit North Pacific Bryde's whale survey plan for Scientific Committee review in Oman
A plan was submitted (SC/50/RMP5).

Summary
Several of the specific tasks identified were completed by the group. Draft survey plans were reviewed, but there was little discussion of the reviews in the group. Thus, how the various comments have been accommodated will require further discussion. Little progress was made for either survey on selecting analysis methods and for the Bryde's whale survey on examining previously collected data. Thus, further discussion of analysis methods and results of analyses of previous data will be required. Finally, qualifications and selection of individuals to represent the Committee will need to be discussed.

Adjunct 1. General Comments on Survey Protocols for Japanese Sightings Surveys

Distance and angle estimation/testing
There is a need to estimate radial sightings distances more precisely by using reticle binoculars. This is especially true with the Bryde's whale proposal which will use 7x binoculars as the primary search method. The same method can also be used with many minke whale sightings (although, perhaps not all can be relocated using binoculars after being sighted by eye). Linking groups seen by independent teams will be aided by more accurate distances. Also, potential bias can be eliminated. Are radial distances, distances from the bow of the ship to the animal, or from the platform to the animal group?

It would be better if more precise estimates of radial distance were obtained. However it was indicated that reticle binoculars were not easy to use aboard the *Shonans* - the ones available had to be held at an angle and were very uncomfortable. Perhaps there are better reticle binoculars on the market than those currently used by SOWER/IDCR.

One way to avoid having to record the port/starboard variable is to make the sighting angles range from 0-360°. So sightings seen on the starboard side are 0-90 degrees and those on the port side are 270-360°. If the angle board is labelled like this then there will not be any confusion as to whether the sighting is on the starboard or port side. The same angle board and labelling convention would also be helpful when reporting the swim direction variable.

If the surveys are to be run using the same observers as those used during IDCR/SOWER cruises, then it does not make sense to change the method of recording sighting angles. Many of the observers have up to 20 years experience of the present recording methods either during IDCR or JARPA and it would inevitably lead to confusion if a different set of angles are used. Besides, during closing mode the Captain requires the information in terms of Port or Starboard to move the ship towards the sighting.

The distance and angle estimation experiments should focus on the range of distances that will be encountered in the survey. For example, with minke whales, if the search area is 1,500m, then training and testing should focus on that range. For the minke whale experiment, if the ship is going to be travelling at 10kts from some distanct point heading towards the buoy at the same time the observers are recording distances, then the ship will cover the 1,500m in about 5 mins. Will this be enough time to do what you want? If there are several buoys out then will the team leader indicate which buoy to look at? The problem with looking at one buoy and travelling towards it is the distance guesses are correlated, because it is obvious that the next distance has to be less than the last distance; using several buoys might remove some of this auto-correlation. Also, remember to take into account the difference between where the observers are standing and where the radar is located.

The auto-correlation problem is unlikely to be a problem if the same method is used as during IDCR/SOWER cruises. Observers are located in the mess during the trials and only move to the observation platforms for one attempt (measurement). They then return to the mess until their number is called again (each observer has a unique number).

In situations like NILS it is obviously important to train observers to record distances and angles because the observers have little experience. However, the Japanese observers have many years experience - and probably each have their own 'error' for distance and angle. Thus it may not be a good idea to conduct extensive training as one would have to conduct extensive testing as well, and this is extremely time consuming.

Analysis methods
In choosing the method used to estimate $g(0)$, an *a-priori* power analysis should be done to see if anticipated sample sizes (based on previous surveys) will be adequate. This is especially a concern with the SCANS-type method because only duplicate sightings are used for abundance estimation. For Bryde's whales, $g(0)$ is probably quite high and most of

the tracker's sightings will be seen by the primary team. This may not be true for minke whales. The IDCR approach is probably not the most appropriate method. If the secondary observer position has a variable number of observers; this will introduce a high level of heterogeneity.

Weather codes for rain, fog, fog patches, etc. do not specify the distance and angles within which these codes apply. Fog located 3 n.miles behind the vessel does not affect sightings as much as rain on the trackline 0.5 n.miles from the vessel. Some attempt should be made to standardise these measures. Also, swell height should be recorded (in addition to Beaufort Sea state).

Adjunct 2. Comments on Survey Protocols for Minke Whale Sightings Surveys

General

Is the only purpose to obtain minke whale abundance estimates? Are there any other important species that need to be considered during the planning of the protocols?

A formal classroom training session before anyone gets on the ship is helpful. This way everyone can become familiar with procedures.

After a few days of data collection, team/cruise leaders should review the data and inform the observers how they can improve, i.e. rounding angles or distances, not tracking animals, not concentrating in the 45° sectors, etc.

An expert familiar with the Norwegian survey protocol should accompany the first minke whale cruise. Modifications to field protocols are inevitable on the first of this type of survey.

Distance and angle experiments

Seen in light of the need for dive time observations, it would be best to spend time there than doing several sets of experiments. Perhaps one mid-way experiment is sufficient, and instead use all opportunities to do distance/angle training underway. Use of recorders with accurate timing for the dive time experiments is suggested.

Allocation of survey effort

All available time is put into one transect for each of the blocks. Looking into the figure, this might seem reasonable, but there is also an option for running two transects, at least in OSW and PA. This would perhaps increase the chances of having one basic coverage within a smaller time frame. It is not clear how the expected migration directions of minke whales within the blocks are; is this taken care of, and is there any strategy for the sequence of covering blocks?

Timing

It is of major importance for the duplicate identification that the observers activate the tape recorder immediately after a whale has been detected. Measuring of distance and angle should be done after activating the tape.

Listening to tapes

It is an advantage if team leaders listen to the tapes at the end of the day. In this way observers that do not follow the protocol can be corrected.

Searching and tracking

Use of binoculars or naked eyes: the procedures referred to here are based on 'Norwegian' conditions. In Japanese waters blows are seldom seen from minkes, and the naked eye is preferred by whalers (which we primarily use as observers). The important thing here is to be consistent and go for one of them. If observers are used to binoculars, it would be best to go for them. That implies, however, that search angles and ahead-sector has to be reconsidered from what was used in NILS-95. Relevant earlier data must be studied to decide on these matters. This seems to be a point for consideration as the Bryde's surveys use other directives (for binocular search). Acceptable weather conditions for primary search must be adjusted to expected cues (see above).

Naked eye versus binoculars

A question: will an observer using binoculars automatically search further out (at longer distance) than an observer using the naked eye? If, at the extreme, only the horizon is searched, it will cause problems in the analysis if hazard probability models are to be used. This especially applies to Schweder's method, but also to the Skaug method which the protocol mentions. Thus the protocol should ensure that all distances are searched, also with binoculars.

Table 1 shows cues of minke whales which led to the first sightings recorded during the last Japanese sighting cruises in the North Pacific in August and September of 1983-1996. During these cruises, binoculars were used for searching. A blow can be sometimes be seen in the northern-most area of the Okhotsk Sea where the air temperature is cold. In the other area, a blow cannot be seen.

Table 1

Cues of minke whales in the North Pacific in August and September 1983-1996.

Cue	Number	%
Body	275	65.9
Blow	66	15.8
Body and blow	10	2.4
Body under water	4	1.0
Jump or splash	49	11.8
Ring	11	2.6
Other	2	0.5
	417	100.0

Search protocol

To ensure the trackline is covered, it might be a good idea to have each observer survey 5-10° to the other side of their main viewing area. Thus, the port observer surveys from 45° port to 10° starboard. If observers are not supposed to search on the opposite side, there may be an increased tendency to round to zero degrees. Also, there is no reason to confine search between 45° left and right. Despite instructions to confine search to 45° right to 45° left, the Norwegian found an almost uniform distribution of sighting angles to 90°.

Is 1,500m ahead a sufficient distance for the maximum distance? What has previous data indicated in the North Pacific? Is there an obvious blow?

There are three people per observation team and at any time two are on watch. So do the observers rotate positions, two on watch and one off watch, where each position is for one hour?

Basing the efficiency parameter on each topman involves too many combinations and there may not be enough data to produce precise estimates. To avoid this problem, it would much easier to simply assign an observer to one team and the team to one platform. This will limit the variability and allow reduction in bias by including team within platform as a covariate, if needed.

Are there any obstacles in front of either of the platforms?

Search by naked eyes only may result in bias if minke whales are avoiding the vessel at close range. It might be better to detect whales further from the ship, before they have a chance to react.

Acceptable sightings conditions for minke whale surveys should probably be limited to Beaufort 0-3 (if practical). Beaufort 4 it is almost impossible to see minke whales (they are more difficult to see in the North Pacific than in the Antarctic).

Data recording

Obviously, the swim direction and appearance category are redundant and given the swim direction is recorded correctly then the appearance category does not have to be recorded.

How often does the computer record position: once a minute, once an hour?

Any weather factors that might be used in the analysis as covariates should be recorded as frequently as possible, more frequently than the once an hour that has been suggested. This will improve the analysis.

How is the start and end of a transect recorded on the sightings survey activity and weather form?

Will the recorded speed reflect the speed through the water or over ground? If possible, it would be nice to record both, since both speeds can be useful.

Does each observer carry around their own tape recorder, and stay on the same platform? Should the observer state these facts onto the tape recorder to make transcribing less confusing?

Is pod size the best guess for the entire pod or the pod size that came up at that surfacing?

Both cue and tracking mode (whether observer is tracking or not) are variables to be recorded on the survey sightings form, so they should also be discussed under the section Protocol of Observers/Reporting/2. Particulars.

Analysis method

The analysis method assumes that minke whales are usually solitary. Is that true for this area?

How will data collected from platforms other than the primary and secondary platforms be used?

Before using Skaug's new models it would seem wise to test out the model on both the Norwegian minke whales and the simulated datasets that are already available. If the method results in biased or imprecise estimates, then it would not be good to use it on this new data.

Transect layout

Do the minke whales migrate through this area or is there some general movement patterns that the animals follow? If so, then the tracklines should not follow this movement pattern.

Dive times

Following minke whales at 500m is likely to affect their behavior and 1km would be better if sightings conditions allow. It is important to record every surfacing, not just time at first surfacing and time at diving. Acceptable sightings conditions for dive-time studies should be defined *a priori* to be Beaufort 0-2 and swell heights of less than 1.5m. Missed surfacings are inevitable with whitecaps. Recording the relative distance and bearing for each surfacing and dive does not seem practical.

A tape recorder or computer should be used to record the data. A computer could be used by pressing a key to indicate when the animal surfaced and pressing another key when the animal goes down. The computer could automatically log the times to 100th of a second. This would accurately record short dives. Attaching a time-depth recorder (possibly with suction-cup mounted tag with a flotation device) would produce more accurate information of a typical dive pattern when the ship is not present. The ship could circle the tagged animal to see how the dive patterns change in the presence of a survey ship, not a ship chasing the animal.

Adjunct 3. Comments on Survey Protocols for Bryde's Whale Sightings Surveys

General

If the estimation of $g(0)$ is necessary for this species and there is only one ship that has an IO platform then is it worth the other two ships going out this year? How will it be determined when to do 'other experiments and observations'? What type of sample sizes will be needed?

Search protocol

Consideration should be given to getting an outside expert experienced with 25x binoculars if they are going to be used in a tracking experiment. Why will the ship be running at 11.5 knots for this survey and 10 knots for the minke whale survey?

Data recording

The reticles in the 7 × 50 binoculars can be used to accurately estimate the radial distance. Will they be used? Will the binoculars be mounted on a stable tripod or monopod or will the observer be holding the binoculars maybe with a handheld stand?

Will high and low pod sizes for the Bryde's whales be recorded?

Why do the observers call the sightings down to researchers who record the data for this survey and the observers record their own sightings on tape recorders for the minke whales? It seems awkward to have someone else who is not on the sighting platform record the data when the observer himself or herself could just as easily record the data with less chance of a miscommunication mistake?

How is the time of the initial sighting recorded? Are the times approximate or nearly exact? Timing will be important for matching between platforms.

Analysis methods

How will the data collected from the Captain and helmsman be used in that abundance estimate? Will they be recording when they are dedicated to looking for animals or when they are running the ship and doing their other jobs?

Transect layout

The idea of spreading out the actual survey effort over the entire study area would be a good way to get coverage.

Dive times

Dive times should also be recorded for Bryde's whales on an opportunistic basis.

REFERENCES

International Whaling Commission. 1998. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48: 53-127.

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.

Appendix 9

MINKE WHALE ABUNDANCE IN THE CM MANAGEMENT AREA FROM NASS95 - ICELANDIC DATA: REQUIREMENTS UNDER THE RMS

N. Øien

The guidelines and requirements referred to here are given in IWC (1997, pp.227-28). Sections of paragraph 2 on requirements are summarised below with comments in italics.

2.1 Oversight by the Scientific Committee: Design, conduct, verification and analysis of data shall be under oversight by the Scientific Committee. *Iceland is not a member of the IWC and the survey was therefore planned under another body.*

2.2 Notification and planning: This includes review of plans for survey design, data collection, verification and analysis **in advance** of the survey. *A planning meeting for the survey (NASS95) was held in Tromsø in December 1994 and there were members of the IWC Scientific Committee present.*

Notification of the Secretariat at least 4 months prior to their start.??

When 'standard methodology' (defined by DESS and standard line transect analysis) is used, as it was in the Icelandic survey, oversight is not required beyond that sufficient to ensure that the 'standard methodology' is followed. This may involve participation in cruise planning meetings, the survey itself and post-cruise meetings, but necessary involvement is to be decided by the Scientific Committee itself. However, the non-member status of Iceland may make this a bit different?

2.3 Survey conduct: Eventual Scientific Committee representatives should submit independent reports to be considered at a post-cruise meeting, etc. *No IWC Scientific Committee participation, neither is it strictly required for 'standard' surveys.*

2.4 Survey documentation and data provision and verification: Documentation to be provided to the Secretariat no later than six months prior to the meeting of the Scientific Committee in which data from the survey are to be used as input to the CLA:

1. Cruise planning report. *Not available.*
2. Field instructions and example data sheets. *Not available for NASS95, but similar to NASS87 and NASS89 (for which extensive planning meetings were held).*
3. Cruise summary report. *Exists as a NAMMCO document, but not submitted to IWC.*
4. Documentation of any experiments conducted, e.g. g(0) experiments. *None conducted.*
5. Documentation of methods used to estimate distances and angles to sighted groups. *Distance experiments were conducted, but no documentation published.*
6. Specification of data verification procedure. *Verification conducted, but no published document.*
7. Documentation of observations excluded for any reason. *Not applicable.*
8. Description of analysis methodology planned to be used, including factors or covariates to be used. *Standard line transect with g(0) = 1.*
9. Documentation of additional information related to the conduct of the survey necessary for interpretation of the data. *Notes given in information file for the data.*
10. Data provided to Secretariat. *Not within the required time frame.*

2.5 Data analysis: These analyses fall into the category 'standard', and the following rules are to be followed:

(a) circulate analyses to the Scientific Committee 3 months prior to the meeting they are to be used; *not done*
(b) any alternative analyses to be circulated 2 months prior to the meeting. *Not done.*

REFERENCE

International Whaling Commission. 1997. Report of the Scientific Committee, Annex K. Requirements and Guidelines for Conducting Surveys and Analysing Data within the Revised Management Scheme. *Rep. int. Whal. Commn* 47:227-35.

Appendix 10

REPORT OF THE INTERSESSIONAL CORRESPONDENCE GROUP ON THE SPECIFICATION OF *IMPLEMENTATION SIMULATION TRIALS* FOR THE WESTERN NORTH PACIFIC BRYDE'S WHALES

Members: Allison, Butterworth, Goto, Hammond, Hatanaka, Kato, Miyashita, Oshumi, Palka, Pastene, Perrin, Punt, Smith, Yagi.

This Correspondence Group was established during the 1997 meeting of the Scientific Committee to advance progress on the seven tasks identified by the *Ad hoc* Working Group on the Specification of *Implementation Simulation Trials* for the western North Pacific Bryde's Whales (IWC, 1998). Completion of these tasks 'would assist in, and simplify, the development of plausible stock structure hypotheses and hence the construction of trials' (IWC, 1998).

Extraction of the historical catch and abundance data for the western North Pacific (tasks 1 and 2)
Shimada (SC/50/RMP16) presents estimates of abundance by 5° × 5° square based on data collected from 1988–1996. The estimates exclude the area around Kochi. Estimates of abundance are also provided by 5° latitude band (10°N–45°N).

Summary of the mark-recapture information for North Pacific Bryde's whales as it relates to movement between areas (task 3)
Kishiro (1996) examined movements of Bryde's whales in the western North Pacific using marks recovered by Japanese and Soviet whaling vessels. Kishiro (SC/50/RMP18) provides plots of the mark-recapture data by month of release and month of recapture.

Provision of information on the likely areas and timing of future harvesting (task 4)
Adjunct 1 lists the information on the likely areas and timing of future harvests provided by Hatanaka in consultation with other Japanese scientists.

Joint analysis of the samples from SC/49/NP5 and SC/49/NP6 (task 5)
The main purpose of this task is to extend the geographical coverage of the mtDNA sequencing analysis presented in SC/49/NP5 by incorporating data used in Yoshida *et al.* (1997). SC/50/RMP9 examined Bryde's whale samples from two longitudinal sectors in the western North Pacific: Gr-1 ($n=79$) and Gr-2 ($n=71$). The Gr-1 involved samples obtained during past whaling operations in Taiji, Ogasawara and biopsy samples collected in that sector. The Gr-2 involved samples taken during past whaling operations in the central western North Pacific and biopsy samples collected in that sector. For comparison, Bryde's whale samples from three outgroups were used: south Javan ($n=23$), south Fijian ($n=24$) and Peru ($n=24$). The outgroups samples were obtained during past scientific or commercial whaling operations. As in Pastene *et al.* (1997), the statistical analysis in SC/50/RMP9 was based on both haplotype and sequencing statistics.

Summary of the information (particularly as regards distribution and abundance) about Bryde's whales in other areas, including local forms (tasks 6 and 7)
SC/50/CAWS6 summarises information about Bryde's whales in the eastern South Pacific. This information is based on data derived from historical whaling operations off Chile and Peru and from the literature. Bryde's whales are rarely seen around Hawaii, although those waters are certainly within their range (Minasian *et al.*, 1987). Minasian *et al.* (1987) note that it is most likely that the Bryde's whales around Hawaii are a part of the population of the offshore form. These comments and the fact that Bryde's whales are not a target for whale watching off Hawaii could be argued to imply that the local form is not found around the Hawaiian Islands. However, it was noted that there has never been a systematic survey of whales in the western Leeward Hawaiian Islands and there is no whale watching in these islands. Furthermore, it was noted that the shallow water area around the Caroline Islands and northern Kiribati is nearly as large as that around the Solomon Islands where the local form is found.

Other issues
It was noted that if trials are constructed which consider only that area in which only a single (western North Pacific) stock is found, hypotheses regarding the relationship between the proportion of the stock in the area being surveyed and the size of the whole population may have to be developed. SC/50/RMP11 (Hatanaka) contrasted a range of alternative stock-structure hypotheses for the western North Pacific Bryde's whales.

REFERENCES

International Whaling Commission. 1998. Report of the Scientific Committee. Annex R. Report of the *ad hoc* Working Group on Preparation for the Specification of *Implementation Simulation Trials* for Western North Pacific Bryde's Whales. *Rep. int. Whal. Commn* 48: 290-91.
Kishiro, T. 1996. Movements of marked Bryde's whales in the western North Pacific. *Rep. int. Whal. Commn* 46:421-8.
Minasian, S.M., Balcomb, K.C., III and Foster, L.S. 1987. *The Whales of Hawaii, including all Species of Marine Mammals in Hawaiian and Adjacent Waters*. Marine Mammal Fund. 99pp.
Pastene, L.A., Goto, M., Palsboll, P.J. and Kato, H. 1997. Population structure of the Bryde's whale (*Balaenoptera edeni*) in the North Pacific based on analysis of mitochondrial DNA control region sequences. Paper SC/49/NP5 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 12pp.
Yoshida, H., Kato, H. and Kishiro, T. 1997. Phylogenetic comparison of Bryde's whales off Kochi with the whales in western North Pacific and off Solomon Islands by mitochondrial DNA sequence analyses. Paper SC/49/NP6 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 7pp.

Adjunct 1. Information on the Areas and Timing of Future Harvesting

Compiled by Hiroshi Hatanaka of Seikai National Fisheries Research Institute, Japan.

Area of non-harvesting
200 n.mile zones of countries other than Japan (actually no permission to enter and, at the same time, to avoid local resident form) (Wada, 1997).

20 n.mile zone off southern Japan (west of 36°E including the Kochi area and Ryukyu Islands, to avoid local resident form) (Yoshida *et al.*, 1997).

Area south of 10°N (operationally difficult because of the many islands in the area).

Timing of the harvest
May–September (i.e. excluding the breeding and parturition seasons, and including past fishery season).

Basic information:

Breeding season (December to April) (Ohsumi, 1995)
Parturition season (October to March) (Ohsumi, 1995)
Past fishing season (April to September) (Kishiro, 1996)
Season in which abundance data were obtained (July to September) (Shimada and Miyashita, 1997).

REFERENCES

Kishiro, T. 1996. Movements of marked Bryde's whales in the western North Pacific. *Rep. int. Whal. Commn* 46:421-8.
Ohsumi, S. 1995. A review of population studies of the North Pacific Bryde's whale stocks (revised). Paper SC/47/NP14 presented to the IWC Scientific Committee, May 1995 (unpublished). 35pp.
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.
Wada, S. 1997. A new species of baleen whale, *Balaenoptera olseni* sp. N. form Indian Ocean and Solomon Sea. Paper SC/49/NP7 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 27pp.
Yoshida, H., Kato, H. and Kishiro, T. 1997. Phylogenetic comparison of Bryde's whales off Kochi with the whales in western North Pacific and off Solomon Islands by mitochondrial DNA sequence analyses. Paper SC/49/NP6 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 7pp.

Appendix 11

CONSIDERATION OF THE FORM OF BRYDE'S WHALES AROUND OCEANIC/ISOLATED ISLANDS, ESPECIALLY IN THE LEEWARD HAWAIIAN ISLANDS AREA

H. Hatanaka, S. Ohsumi, H. Kato and T. Miyashita

The possibility and plausibility of an hypothesis that a coastal/resident form (or small/dwarf type) of Bryde's whale is found in waters around oceanic/isolated islands is discussed here, in particular the Leeward Hawaiian Islands area, in order to contribute towards the specification of *Implementation Simulation Trials* for western North Pacific Bryde's whales.

Given the differences described below, the Leeward Hawaiian area (Hawaiian Ridge) can be divided into two sub-areas: the Hawaiian Islands group (in the southern part) and the Midway Islands group (in the northern part).

1. Hawaiian Islands

There is a substantial human population in this area and whale watching is popular. Despite high effort however, Bryde's whales are seldom seen around Hawaii, and are most likely to be the offshore form (Minasian *et al.*, 1987). No coastal/resident group has been found. This information suggests that the animals around Hawaii should be treated as the offshore form in trial specifications.

2. Midway Islands

The human population is small and there has been no whale watching around these islands. However, the following information is available.

(1) Differing characteristics of the island groups: oceanic/isolated islands, e.g. Ogasawara and Hawaii, suggest the offshore form; large/close-to-continent islands, e.g. Kochi and the Philippines suggest the coastal/resident form. This indicates that the Midway Islands can be expected to be of the oceanic/isolated and the offshore form.

(2) The Midway Islands stretch like a chain from the Hawaiian Islands. Oceanographic conditions are the same for both island groups. It is reasonable to deduce that if a coastal/resident form does not exist off Hawaii, it will not exist off Midway.

(3) It is biologically doubtful that a small population is independently sustainable around small, isolated islands. Although considering fish, an expert group emphasised the importance of maintaining breeding populations with an effective size of at least 50 for short-term fitness and of at least 500 for long-term survival; this will also avoid 'genetic bottlenecks' created by the reduction of breeding populations to small sizes for one or more generations (FAO Fish.Tech.Paper, No.217). If a coastal/resident stock of several hundred/thousand exists around Midway it would have been observed by whalers, as this area was once part of a Japanese pelagic whaling ground.

(4) A total of 240 Bryde's whales were taken around Midway by Japanese pelagic whaling, between 1971 and 1979, from five blocks. All animals were measured and checked by inspectors (including scientists) on the factory ship but no dwarf/small type or anomalous animals were observed.

(5) A total of seven animals used for mark-recapture and genetic analyses were taken near Midway (see fig. 7 of SC/50/RMP11), and these data indicate that the animals were all of the offshore form. The mark-recapture data show that all of the 15 whales marked or captured within island blocks moved to, or came from, offshore blocks, i.e. no whales were recaptured in the same island block in which they were marked (SC/50/RMP18). This indicates strongly that animals around oceanic islands are not resident but migrant. In the case of Midway Islands blocks, three tagged animals were caught after being marked at low latitudes.

(6) Wada (1997) found that a coastal/resident form has only been recorded on the Asian side of the North Pacific, and was not found around the Ogasawara Islands. This pattern of distribution suggests that this form does not reach the Midway Islands region.

In conclusion, the above information suggests that the Bryde's whales found around the Midway Islands should be treated as the offshore form.

3. Other Oceanic/isolated Islands

The available information for the other three main island groups is summarised below.

(a) Kiribati Island Group
This area is further from the Solomon Islands than the distance between Kochi and Ogasawara Islands. Items (1) and (3) in the previous section are applicable.

(b) Micronesia (Caroline Island) Group
The distance between this area and the Solomon Islands group is similar to that between Kochi and Ogasawara. Items (1), (3) and (5) above are applicable. The number of specimens is three.

(c) Northern Mariana Island Group
This island group is on the Marianas Ridge which is connected to the Honshu Ridge from the Japanese mainland through the Izu and Ogasawara Islands. The situation seems to be similar to the Ogasawara Islands group in which case items (1), (3) and (7) are applicable.

In conclusion, the available information suggests that a hypothesis that a coastal/resident form is found around any of the island groups is difficult to support. Low plausibility should be given to this scenario.

4. Solomon Islands

It is known that a dwarf form of Bryde's whale is found around the Solomon Islands. The Solomon Islands are close to the islands of New Guinea, which in turn are connected through the chain of Indonesian Islands to the Asian

continent. Six specimens of the dwarf form were all caught within one day on the west side of the Solomon Islands – an area surrounded by islands both of the Solomon and New Guinea groups. The available information suggests that the behaviour and ecology of this form differs from that of the offshore form. We believe that is unlikely that its habitat will include distant isolated/oceanic islands.

REFERENCES

Minasian, S.M., Balcomb, K.C., III and Foster, L.S. 1987. *The Whales of Hawaii, including all Species of Marine Mammals in Hawaiian and Adjacent Waters*. Marine Mammal Fund. 99pp.

Wada, S. 1997. A review of Bryde's whale taxonomy for the Indian Ocean and Solomon Sea. Paper SC/49/NP7 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 27pp.

Appendix 12

COMMENTS ON SC/50/RMP11

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(1) It is assumed in SC/50/RMP11 that the Kochi and Solomons Islands small forms are conspecific and therefore that their ecologies must be the same, leading to the use of 20 n.miles offshore (which works for Kochi) for an offshore limit for the small forms everywhere. However,
   (a) the most recent genetic results (for cytochrome *b*, which is more appropriate for species-level analyses; A. Dizon, pers. comm.) are not consistent with the hypothesis of a single small-form species (the Kochi whales are a sister taxon to the large-form Bryde's whale clade, while the Philippine 'Bryde's whales' lie outside the sei-Bryde's whale clade; i.e., ((fin)((Phil)((sei)((largetype)(Kochi))))); and
   (b) seven Solomons small-form whales were caught far offshore in the Solomons Sea, over 60 n.miles from the nearest land, in depths of ~1-5km (from Ohsumi, 1978 and hydrographic chart).

(2) The assertion that 'it is quite doubtful biologically that a small population exists in such an isolated small area, in viewpoint of permanency and sustainability of population' has no basis in what is known about these whales and their known and likely habitats.
   (a) In point of fact, the various island groups in the West Pacific have very large shallow-water areas and inter-island depths (and distances) comparable to those in which the Solomon Islands whales (and the three Javan small-type whales) were taken.
   (b) The range of the South African inshore form (SC/50/CAWS13) is comparable in area to that of several of the major island groups in the West Pacific and Central North Pacific.
   (c) Local populations of animals do not necessarily remain stable or permanent. They may fluctuate in size, or they may become extinct and re-established through colonization from a different population of the same species (in a period short in geological time but long in terms of human perceptions and needs).

(3) The results of mark/recapture and genetic analyses (SC/50/RMP9) do not 'negate indirectly' the island-group stock hypothesis. The presence of large-form whales in some of the 5° blocks, which include some very deep water far from islands, does not negate the possibility of the presence of small-form whales in some of those same blocks. Negative evidence from small sample sizes is not conclusive, especially considering in this case that some island-group areas have not been surveyed or sampled. In addition, the cited absence of reports of small-type whales by whale watchers in the Bonins and main Hawaiian Islands cannot be considered definitive, as such lay information is not reliable. In any case, it should be kept in mind that the purpose of the 5° block scheme is not to identify all areas in which large-form whales are known to occur, but rather to identify areas in which small-form whales may occur, as a precautionary approach.

(4) Absence of small-type whales in the Bonin Islands whaling statistics cannot be used as a reliable indication of absence of small-type whales in the region. Body length could have been falsified by the whaling companies, as was done for sperm whales. Small-type whales could have been depleted there, or they could have remained undiscovered. Note that the Kochi population of small-type whales was discovered only very recently, after the end of commercial whaling.

(5) In view of the above points, the plausibility of 'Hypothesis 2' (small-form whales resident in island-group areas) cannot be considered to be 'extremely low'.

(6) The hypothesis that a pelagic stock or stocks of large-type Bryde's whales could straddle the Equator seasonally (Hatanaka's 'Hypothesis 3') was based on an analysis of catch positions for 'sei' whales taken by the MV *Sierra* in the southeast Atlantic in the 1970s (Best, 1996). This analysis indicated that the distribution of offshore animals ranged across the Equator and as far as 3°N in the (southern) winter. Conversely, during the (southern) summer, catches of Bryde's whales were made in equatorial regions as far south as 1°S, and of 'sei' whales as far south as 8°S, at the same time that the bulk of the offshore population was south of 15°S; these equatorial catches are presumed to represent Bryde's whales from the northeast Atlantic on their (northern) wintering ground. Hence the region 5-8° either side of the Equator could be inhabited by a northern stock of Bryde's whales at one time of year and by a southern stock at another time of year. This point is actually tacitly accepted in SC/50/RMP11, by denoting the southern boundary of the offshore stock in the western Pacific as 5°S (SC/50/RMP11, figs 8 and 9).

However, the point is more than just drawing boundaries on a map. If the likely seasonal changes in the distribution of the offshore stock are not correctly

recognised, there is the possibility that sighting survey estimates made in tropical regions in the northern summer could be allocated to the wrong stock, thus inflating estimates of abundance. Similarly, Bryde's whales marked in tropical regions in the northern summer may not all belong to the western North Pacific population, and the failure to obtain any recoveries of these marks in the whaling operations farther north in the western North Pacific would tend to inflate mark-recapture estimates of population size.

To avoid these pitfalls, it is necessary to stratify sighting and marking data appropriately, perhaps by excluding sightings made and marks placed south of 10°S in the northern summer, when estimating population size.

REFERENCES

Best, P.B. 1996. Evidence of migration by Bryde's whales from the offshore population in the southeast Atlantic. *Rep. int. Whal. Commn* 46:315-31.

Ohsumi, S. 1978. Provisional report on the Bryde's whale caught under special permit in the Southern Hemisphere. *Rep. int. Whal. Commn* 28:281-7.

Appendix 13

SIGHTINGS AND ABUNDANCE ESTIMATES FOR WESTERN NORTH PACIFIC BRYDE'S WHALES

Hroyuki Shimada and Tomio Miyashita

This corresponds to task 5 for the Bryde's whale sightings survey of the NPSSSG.

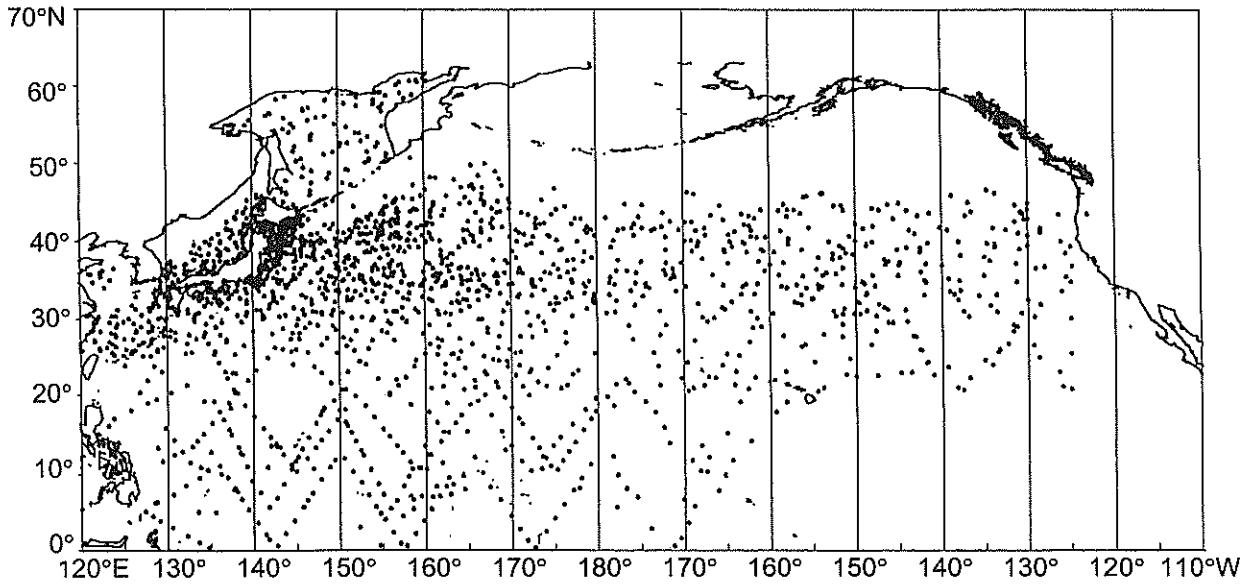


Fig. 1. Noon positions with sighting effort in August and September 1988-1996.

Table 1

Summary of effort data of sightings cruises used for the western North Pacific Bryde's whale abundance estimate by vessel, date and location (5° square). S: squid jigger (with top barrel); C: catcher boat (with top barrel); Tu: tuna long liner (without top barrel); Tr: trawler (without top barrel unless until 1995).

RV	Type	Year	Month	Lat.(N)	130E	135E	140E	145E	150E	155E	160E	165E	170E	175E	180	175W	170W	165W	160W	Total
KS2	S	1995	Aug.	10									228	145						372
				15								60	277	256						593
				20								68		132						200
			Sep.	10								210	298							508
				15							78	42	163	63						346
				20							71			47						118
		1996	Aug.	0	289															289
				5	223															223
				10	279	137														416
				15		275														275
			Sep.	20	100															100
KY1	C	1990	Sep.	35	103	66														170
				40		111														111
		1991	Aug.	35			269	102	11											382
				40			340	120												459
			Sep.	25		80														80
				30		178	341													519
		1992	Sep.	40			46	20												66
		1993	Aug.	30					184		11									195
				35				45	76	110	205									436
				40				163		186	38									387
			Sep.	20					124	201										325
				25			6	119	172	35	203									534
				30				210			144									353
		1994	Sep.	35	141	730	23													894
				40		484														484
SM2	C	1988	Aug.	35												49	116	113	108	386
				40			71	56	15				11	11	109	90				363
			Sep.	30			59	34	101	101	95	106	36				78	109	106	825
				35												54				54
		1989	Aug.	30		13				66	246	57		37	174	131			310	1,034
				35			88	101	126	89	110	288	350	292	246	389	69	306	386	2,840
				40													358	157		515
			Sep.	25													119	144	346	609
				30		106	47					110	59	115	113	86	245	144		1,025
				35				125	139	141	100					16				521
		1990	Aug.	30		13	22													35
				35			82	117	101	55									130	484
				40						25	64	75	64	109	81	11	80	114	8	632
			Sep.	30		137	124	12										112	115	501
				35				29	71	83	111	103	24	24	27	79	121			670
		1992	Aug.	25			281	523	324											1,128
				30				26												26
				35						363	402									765
				40						89	65									155
			Sep.	25	551	579	348													1,478
				30	51	20	4													76
		1993	Aug.	10						384	387	256	692	84						1,803
				15					256	69	290	777		385						1,777
			Sep.	10			284	144												428
				15		133	189	80	220											621
				20		129			1											131
		1994	Aug.	0		5	533	51		520	39									1,148
				5		104		285	307		486									1,182
				10				165	193											359
			Sep.	0						65										65
				5		229				198	387									814
				10	55	151				45	333									583
		1995	Aug.	0								39	416	54						509
				5								148		364						512
				10								101		290						391
			Sep.	0								37	298							336
				5								154								154
				10								129								129
		1996	Aug.	45						122	100	214								436
				50								31								31
			Sep.	40							138	77								215
				45							6	234								240

cont...

Table 1 continued.

RV	Type	Year	Month	Lat.(N)	130E	135E	140E	145E	150E	155E	160E	165E	170E	175E	180	175W	170W	165W	160W	Total
T11	C	1996	Aug.	5		88	491		147	429										1,154
				10		177	76		152	171	31									606
				15							199									199
			Sep.	10			21	173	26											219
				15				365	187											552
T15	C	1988	Sep.	35			149													149
				40			1,029	447												1,476
T18	C	1991	Aug.	20							109									109
				25							143									143
				35									81	2						83
				40								52	21		52					125
			Sep.	20							61	184								246
				25								100	243							343
				30									163							163
		1992	Sep.	30	90															90
				35	1,004	371														1,376
		1993	Aug.	10	358															358
				15	81	162														243
				20		374	160													534
				25			149													149
			Sep.	20		104														104
				25	391	98														489
				30	150															150
T25	C	1988	Aug.	30			287	297	146											729
				35			69	246	122	315										752
				40			36		303	185										523
			Sep.	30	69	74				89	348	81								662
				35			6	100	57	144	308	21								636
				40			84	22	79	271	8	76								540
		1989	Aug.	20				218	231											449
				25			161	138	189											488
				30			305	239	208											751
				35				268	309											576
				40			32	83												115
			Sep.	20							35									35
				25			7	121	173	94	434									830
				30	33	105	76			326	136									675
				35					110		255									365
				40				26	71	191	128									416
		1990	Aug.	35			35	155	84											274
				40			337	88	198	275	162	301	43							1,404
				45						74	204	305	14							597
				50							40	11								51
			Sep.	20					126	110	339		236	273						1,085
				25			129	121			71	450	81	219						1,072
				30	88	110					149	216	109							672
				35				90	28	109	89									316
				40				47												47
		1991	Aug.	30						103										103
				35			847	144		24										1,015
				40			3													3
			Sep.	25			63	14	92											169
				30				75	19	5										99
		1992	Aug.	30				758	437	474	542									2,211
				35				3	10	2										15
			Sep.	30	482	362	293	131												1,268
		1993	Aug.	30								192		173						365
				35								148	2	248						398
				40									258	68						327
			Sep.	20								87	330	2						419
				25								206		139						345
				30							28	102								130
H12	Tu	1988	Aug.	30										128	125	198	422	145	192	1,208
				35				129	140	114	139	133	136					202	194	1,185
				40															249	249
			Sep.	35									57	97		14	353			519
				40				102	144	75	78	50	42		207	282	36	352	118	1,484
KSY	Tu	1989	Aug.	20															77	77
(H12)			Sep.	35			119	53	31	147		101		42						492
				40					2			70	40	106	155	78	89	135	208	882
		1990	Aug.	35			44	125	117	67					3			271		626
				40				226	150	147	84	96	150	181	29			3	197	1,262

cont...

Table 1 continued.

RV	Type	Year	Month	Lat.(N)	130E	135E	140E	145E	150E	155E	160E	165E	170E	175E	180	175W	170W	165W	160W	Total
			Sep.	30								36	68							104
				35			120	61	30	114	111	81	51	72				120	120	879
				40												69	205	31	12	317
HS1	Tu	1988	Aug.	30										157	196	37				390
				35			51	131						163	193	395				934
				40				27	83	18		149	314	9	330	316				1,246
			Sep.	30									188	235						424
				35			171	96	182	106		226	138							917
		1989	Aug.	20							136	445	48							629
				25						77	92		415							585
				30						100			86	212	188					585
				35			37	92						16	278					423
				40									49	429						478
			Sep.	30					109	25		327								461
				35			157	93	68		198	114	203							832
				40									193							193
		1990	Aug.	20												373	379			752
				25											280	55	35	284		653
				30								111	232	228	121			54	83	829
				35			48			4	84	18	139	143						437
				40			79	138	93	49										358
			Sep.	15															1	1
				20														77	188	265
				25												93	145	79		316
				30									110	104	108					405
				35			53	140	99	91	56	92							94	625
		1991	Aug.	20													114			114
				30															210	210
				35													159	174		333
				40												41	162	22	100	324
			Sep.	20												88	98			185
				25												238				238
				30										53	171	5				228
				35										12	64					76
		1992	Aug.	30			194													194
				35			432	841	744	48										2,065
				40			46	179	526											751
			Sep.	30	84	1,030	27													1,141
				35		23														23
		1994	Aug.	25	111															111
				35	232															232
			Sep.	35	834	434														1,267
		1995	Aug.	40				7	511	619										1,136
			Sep.	35			10													10
				40			100		155	398										652
SHU	Tr	1991	Aug.	30		28	76													103
				35		16	781													797
				40			244													244
			Sep.	40			657	21												678
		1992	Aug.	30		39	203													242
				35		28	1,268	13												1,309
				40			571	8												579
			Sep.	40			581	214												794
		1993	Aug.	25	266															266
				30	468	341														809
		1995	Aug.	30		55	64													118
				35		5	740													745
				40			76													76
		1996	Aug.	30		53	127													180
				35		17	266													283

Table 2 continued.

RV	Type	Year	Month	Lat.(N)	130E	135E	140E	145E	150E	155E	160E	165E	170E	175E	180	175W	170W	165W	160W	Total
			Sep.	30								0	0							0
				35			0	0	0	0	0	0	0	0				0	0	0
				40												0	0	0	0	0
HS1	Tu	1988	Aug.	30										0	3	1				4
				35			0	0						0	1	7				8
				40				0	0	0		0	1	0	1	0				2
			Sep.	30									0	0						0
				35			0	0	1	0		1	2							4
		1989	Aug.	20							0	3	0							3
				25						0	0		0							0
				30						0			0	0	1					1
				35			0	0						0	0					0
				40									0	0						0
			Sep.	30					0	0		3								3
				35			1	0	0		0	0	0							1
				40									0							0
		1990	Aug.	20												1	0			1
				25											0	0	0	0		0
				30								1	0	2	0			0	0	3
				35			0			0	3	0	0	2						5
				40			0	0	0	0										0
			Sep.	15															0	0
				20														0	0	0
				25												1	0	0		1
				30									3	0	0				1	4
				35			0	0	0	0	0	1							0	1
		1991	Aug.	20													0			0
				30															0	0
				35													2	0		2
				40												0	0	0	0	0
			Sep.	20												0	0			0
				25												6				6
				30										0	0	0				0
				35										0	0					0
		1992	Aug.	30			0													0
				35			0	2	7	0										9
				40			0	0	0											0
			Sep.	30	0	0	0													0
				35		0														0
		1994	Aug.	25	0															0
				35	0															0
			Sep.	35	0	0														0
		1995	Aug.	40				0	0	0										0
			Sep.	35			0													0
				40			0		0	0										0
SHU	Tr	1991	Aug.	30		0	0													0
				35		0	0													0
				40			0													0
			Sep.	40			0	0												0
		1992	Aug.	30		0	0													0
				35		0	0	0												0
				40			0	0												0
			Sep.	40			0	0												0
		1993	Aug.	25	0															0
				30	0	0														0
		1995	Aug.	30		0	0													0
				35		0	0													0
				40			0													0
		1996	Aug.	30		0	0													0
				35		0	0													0

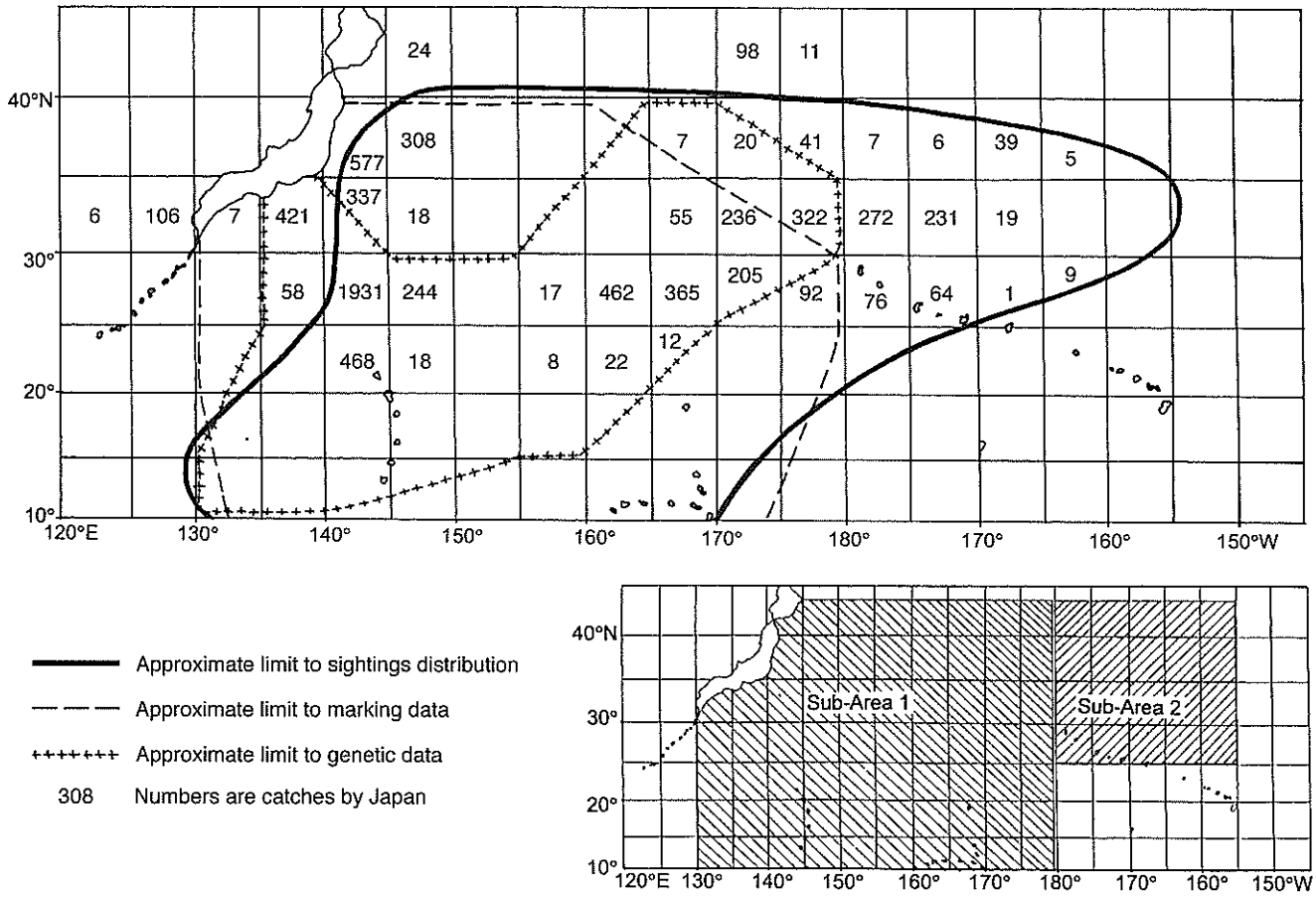
Table 3

Revised abundance estimate of Bryde's whales in the North Pacific by 5° squares excluding off Kochi in August and September 1988-1996.

5° square	Area (n.miles^2)	Effort (n.miles)	No. of sightings	No. of animals	Population	CV	95% CI	Islands
0-5°N, 170-175°E	89,600	714	1	1	56	0.882	11, 296	Yes
5-10°N, 150-155°E	88,937	453	1	2	175	0.789	38, 808	Yes
5-10°N, 155-160°E	88,937	627	4	4	252	0.603	77, 827	Yes
5-10°N, 160-165°E	88,937	873	2	2	91	1.166	13, 653	Yes
10-15°N, 130-135°E	87,611	693	10	19	1,045	0.509	376, 2,906	No
10-15°N, 135-140°E	87,611	464	7	10	841	0.489	307, 2,306	Yes
10-15°N, 140-145°E	87,611	381	1	1	102	0.767	19, 541	Yes
10-15°N, 145-150°E	87,611	483	9	10	808	0.491	302, 2,164	Yes
10-15°N, 150-155°E	87,611	371	6	7	736	0.604	208, 2,601	No
10-15°N, 155-160°E	87,611	600	8	10	650	0.576	200, 2,110	No
10-15°N, 170-175°E	87,611	1,218	3	3	96	0.696	26, 360	No
15-20°N, 135-140°E	85,635	570	3	3	201	0.740	48, 836	No
15-20°N, 140-145°E	85,635	188	2	2	405	0.993	11, 14,296	Yes
15-20°N, 145-150°E	85,635	446	2	2	171	0.686	43, 681	Yes
15-20°N, 150-155°E	85,635	663	6	9	518	0.924	95, 2,823	No
15-20°N, 155-160°E	85,635	69	2	2	1,103	0.709	316, 3,854	No
15-20°N, 160-165°E	85,635	566	3	4	269	0.863	54, 1,335	No
20-25°N, 135-140°E	83,013	608	1	1	61	0.675	15, 244	No
20-25°N, 145-150°E	83,013	218	1	1	170	0.914	25, 1,143	No
20-25°N, 150-155°E	83,013	483	5	5	383	0.531	126, 1,162	No
20-25°N, 155-160°E	83,013	311	9	13	1,545	0.513	533, 4,477	No
20-25°N, 160-165°E	83,013	751	2	3	148	0.719	36, 602	No
20-25°N, 165-170°E	83,013	784	4	5	236	0.516	86, 647	No
20-25°N, 170-175°E	83,013	615	10	12	721	0.542	250, 2,080	No
20-25°N, 175°E-180°	83,013	454	3	3	244	0.730	58, 1,029	No
20-25°N, 175-170°W	83,013	461	1	2	160	0.772	34, 753	Yes
25-30°N, 145-150°E	79,775	1,037	1	1	34	0.850	7, 162	No
25-30°N, 150-155°E	79,775	950	3	4	149	0.599	47, 478	No
20-30°N, 155-160°E	79,775	207	3	3	514	0.741	107, 2,458	No
25-30°N, 160-165°E	79,775	943	1	1	38	1.181	5, 268	No
25-30°N, 170-175°E	79,775	739	3	4	192	0.597	59, 628	No
25-30°N, 175°E-180°	79,775	358	7	18	1,784	1.889	104, 30,611	Yes
25-30°N, 175-170°W	79,775	385	7	9	822	0.674	217, 3,120	Yes
30-35°N, 145-150°E	75,934	1,783	1	1	19	1.122	3, 123	No
30-35°N, 150-155°E	75,934	1,202	4	4	112	0.634	33, 381	No
30-35°N, 155-160°E	75,934	1,356	8	11	274	0.409	122, 616	No
30-35°N, 160-165°E	75,934	1,946	14	21	365	0.448	151, 879	No
30-35°N, 165-170°E	75,934	1,504	20	38	831	0.458	377, 2,051	No
30-35°N, 170-175°E	75,934	1,108	18	37	1,128	0.315	603, 2,110	No
30-35°N, 175°E-180°	75,934	1,594	13	23	488	0.559	166, 1,435	No
30-35°N, 180°-175°W	75,934	1,482	5	7	160	0.590	52, 491	No
30-35°N, 175-170°W	75,934	672	4	6	302	0.847	62, 1,478	No
30-35°N, 170-165°W	75,934	989	4	5	171	1.036	28, 1,054	No
30-35°N, 160-155°W	75,934	1,409	1	1	24	1.119	4, 160	No
35-40°N, 140-145°E	54,344	5,951	1	1	4	0.880	1, 20	No
35-40°N, 145-150°E	71,505	3,524	5	7	63	0.524	23, 173	No
35-40°N, 150-155°E	71,505	2,919	29	44	480	0.323	253, 911	No
35-40°N, 155-160°E	71,505	2,354	36	42	498	0.298	274, 907	No
35-40°N, 160-165°E	71,505	2,378	14	16	214	0.287	120, 381	No
35-40°N, 165-170°E	71,505	1,612	10	18	342	0.431	144, 811	No
35-40°N, 170-175°E	71,505	1,530	9	15	312	0.442	129, 755	No
35-40°N, 175°E-180°	71,505	1,403	28	46	887	0.319	466, 1,687	No
35-40°N, 180°-175°W	71,505	1,056	1	1	30	0.642	8, 107	No
35-40°N, 175-170°W	71,505	1,402	9	15	341	0.376	160, 727	No
35-40°N, 170-165°W	71,505	887	2	2	72	0.802	16, 325	No
35-40°N, 165-160°W	71,505	1,491	1	1	21	0.632	6, 72	No
35-40°N, 160-155°W	71,505	1,417	2	3	67	1.298	8, 539	No
40-45°N, 160-165°E	66,525	766	1	1	39	0.691	10, 145	No
40-45°N, 165-170°E	66,525	945	1	1	31	1.026	5, 185	No
40-45°N, 170-175°E	66,525	1,185	1	2	50	0.745	12, 200	No
40-45°N, 180-175°W	66,525	963	1	3	92	0.601	28, 299	No
Total	4,802,818	65,506	374	548	22,136	0.186	15,017, 32,629	

Appendix 14

SUMMARY OF INFORMATION FOR DETERMINING STOCK BOUNDARIES FOR *IMPLEMENTATION SIMULATION TRIALS* FOR WESTERN NORTH PACIFIC BRYDE'S WHALES AND AGREED BOUNDARIES FOR THE WESTERN STOCK AND TWO SUB-AREAS



Annex E
Report of the Sub-Committee on Other Great Whales

Members: Zeh (Convenor), Addison, Baker, Baldwin, Bannister, Berggren, Best, Borchers, Born, Borodin, Brownell, Butterworth, Carlson, Childerhouse, Clapham, Clark, Clarke, Cooke, DeMaster, Donahue, Donovan, Ensor, Findlay, Friday, Fujise, George, Goto, Hakamada, Hammond, Hatanaka, Hester, Hiby, Kasuya, Kato, Kawachi, Kawahara, Kim, Kock, Leaper, Lens, Melnikov, Mikhalev, Moronuki, Nishiwaki, Ohsumi, Øien, Okamura, Pastene, Pérez-Cortés, Perrin, Pinedo, Polacheck, Punt, Reeves, Robineau, Rojas Bracho, Rooney, Shimadzu, Slooten, Smith, Stachowitsch, Swartz, Tanaka, E., Tanaka, S., Tanakura, Thiele, Tomita, Van Waerebeek, Von Bismarck, Wade, Walløe, Witting, Yagi, Yamamura.

1. CONVENOR'S WELCOME AND OPENING REMARKS, ELECTION OF CHAIR, APPOINTMENT OF RAPPORTEUR

Zeh was elected Chair. She noted that because of time limitations, the major emphases of the sub-committee would be on new information relating to distribution and abundance, questions of subspecies and stock identity, and new catch information where appropriate. Documents relating to the Comprehensive Assessment of sperm whales and North Atlantic humpback whales would not be discussed in detail, but considered more in relation to how they might give direction to an assessment at the next (or a subsequent) meeting.

Best acted as rapporteur.

2. ADOPTION OF AGENDA

The adopted Agenda is given as Appendix I.

3. REVIEW OF DOCUMENTS

Documents considered by the sub-committee included SC/50/CAWS1-4, 7-12, 14-16, 18-40, SC/50/O3, 5, 14, 16, 18, RMP6, SC/50/Rep 1, 2, 4, McCauley *et al.* (1998b), Chaloupka and Osmond (1998), Baker and Medrano-Gonzalez (1998), Smith *et al.* (1998), McCauley *et al.* (1998a), Childerhouse and Dawson (1998) and Childerhouse *et al.* (1998).

4. SOUTHERN HEMISPHERE BLUE WHALES

4.1 Reports of the SOWER cruises

Findlay summarised the report of the 1997/98 IWC/SOWER blue whale cruise (SC/50/Rep2), the third to be undertaken as part of the IWC's research programme on Southern Hemisphere blue whales. The cruise was conducted in the southeastern Pacific Ocean off the coast of Chile during December 1997 and January 1998. The objective of the cruise was to obtain scientific information relevant to developing onboard identification methods for distinguishing between true and pygmy blue whales. Two summer concentrations of blue whales were identified off the coast of Chile by the SOWER planning meeting for the cruise, namely off Iquique (~18°S) and off Valparaiso (~34°S). The two vessels *Shonan Maru* and *Shonan Maru No. 2* departed Iquique on 12 December 1997. The *Shonan Maru* proceeded directly southwards to 38°S and searched northwards to cover the Valparaiso/Talcahuano concentration, while the *Shonan Maru No. 2* surveyed from 18°30'S southwards, covering the Iquique concentration. The vessels were to meet after two weeks and then to proceed to the region of highest concentration found during the initial two weeks of survey. As a result of sightings of blue whales made during the southward transit of the *Shonan Maru* in the region of Antofagasta-La Serena, the *Shonan Maru No. 2* surveyed this area en route southwards. A total of 389hrs 58mins of searching was carried out by both vessels combined, during which some 4,454 n.miles of trackline were surveyed. In total, 39 sightings of 47 blue whales (and 1 sighting of 1 like-blue whale) were made, of which 37 sightings of 45 animals were identified as pygmy blue whales and 2 sightings of 2 animals as 'undetermined' blue whales. Experimental work included collecting 19 biopsies from blue whales, and 462 still photographs, and 180.11min of video footage of blue whales were exposed for individual identification, morphological and behavioural analysis. Dive-time experiments were undertaken for 20 blue whales for a total of 16hrs 20min, and 225hrs 13min of acoustic monitoring was carried out: blue whale calls recorded ranged in frequency from 9-44Hz and from 1-32 seconds in duration. Both vessels arrived in Punta Arenas, Chile (53°S) on 10 January 1998. A list of recommendations for future blue whale cruises is included in the report.

It was asked during discussion whether the distribution of blue whales on the cruise had shown any noticeable effects of the strong 1997/98 El Niño event. The reply was that there was not much historical data on blue whale distribution in the area from which conclusions could be drawn, apart from catch positions for which there were no associated effort data. In any case, the cruise was probably located too far south to feel the full effects of the El Niño. Nevertheless, Brownell proposed that efforts should be made to obtain appropriate satellite imagery data for the area and time of the cruise, so that the observed distribution of blue whales could be plotted against oceanographic features.

In reply to a question regarding what criteria had been used for distinguishing between blue and pygmy blue whales on the cruise, Findlay replied that the identifications were all provisional and had been made by the topmen. The criteria they had used (e.g. blowhole shape, head shape, etc.) had

been systematically recorded on the sighting data sheet. The boatswains on both vessels had also had previous experience with chasing and catching pygmy blue whales before protection. It was recommended that a paper should be submitted to next year's meeting, documenting the criteria used on each of the three blue whale cruises for identifying the two blue whale forms, listing the results and the personnel responsible for making the identifications, and providing an analysis of the photographic and video material in support of the criteria used. Kato pointed out that much of this had already been done for the first two cruises (SC/50/CAWS1), and that the 1997/98 cruise material had been preliminarily evaluated, but only for the purposes of individual identification.

Ensor summarised SC/50/Rep1, in which the results of the 1997/98 IWC/SOWER cruise to Area IIW (60°-25°W) were presented. Although the primary objective of this cruise had been to estimate the abundance of minke whales south of 60°S, two of the 30 available research days had been allocated for research on blue whales. Eleven sightings of 18 blue whales were made in the research area; eight of these sightings (14 animals) were identified as true blue whales, two sightings (3 animals) as pygmy blue whales and one sighting (1 animal) as an 'undetermined' blue whale. Research was conducted on 10 groups of blue whales for a total of 14.42 hours, during which time biopsies were obtained from 3 true blue and 3 pygmy blue whales, acoustic monitoring was carried out for 13hrs 25mins, dive-time experiments were run for 2.83 hours, video-taping of surfacing behaviour was recorded for 26min 47secs, and 8 true blue and 2 pygmy blue whales were photographed for identification purposes.

4.2 Progress towards assessment

4.2.1 Abundance and trends

The sub-committee noted that, due to problems of accessing the DESS database from Cape Town, it had not been possible to develop revised estimates of blue whale abundance from the IDCR/SOWER cruise programme in time for this meeting. It looked forward to receiving such estimates at the next Scientific Committee meeting.

Best introduced SC/50/CAWS14, which had been written with a view to possible future developments in the IWC's research programme on southern blue whales. Catches of blue whales off Walvis Bay, Namibia, in the 1920s had been substantial, and size composition data for 681 whales revealed that 12.3% of the catch was more than 79ft in length. This was bigger than the maximum recorded length of a pygmy blue whale, indicating that these were probably true blue whales. Catches peaked strongly in July/August. There were at least six apparent cow-calf pairs included in the catch, and the region had the reputation of being resorted to by particularly large, fat females. If the area is a winter 'breeding ground' for true blue whales, this would offer new opportunities for monitoring their status.

In reply to a question, Best stated that although there were no locations available for these catches, extrapolation from information on the offshore distribution of blue whales off the west coast of South Africa would suggest that the whales were between 60 and 95 n.miles offshore. This was well outside territorial waters, but of course within the EEZ of Namibia. Clapham pointed out that, if experience with North Atlantic humpback whales could be drawn on, assessing the status of blue whales on a breeding ground might not be straightforward, and would have to take into account possible structuring and segregation by sex or reproductive condition. The sub-committee agreed to refer further discussion of this matter to a group planning the future of the SOWER cruises, under Kato.

4.2.2 Subspecies and stocks

The sub-committee stated its concern that reliable distinction between true and pygmy blue whales in the field was becoming increasingly important, given that the results of the 1996/97 SOWER cruise had indicated that the simple geographical separation of the two forms in summer previously used may no longer be entirely valid. This meant that sightings estimates in high latitudes in summer may contain some proportion of pygmy blue whales.

The surfacing behaviour of putative true and pygmy blue whales had been recorded on the first two blue whale cruises, using high-resolution digital video recording. In SC/50/CAWS1, Kato and Komiya analysed 12hrs 56mins of these recordings, representing 4 surfacings by 4 true blue whales and 103 surfacings by 45 pygmy blue whales. Seven patterns of surfacing were identified, based on whether the snout or whole rostrum surfaced first, whether the back was rounded or not, whether the dorsal fin was exposed or not, and finally whether the keel of the caudal peduncle was exposed or not. Although the sample size of true blue whales was very small, there appeared to be a definite difference in surfacing behaviour between true and pygmy blue whales. Whereas pygmy blue whales never exposed the caudal keel (and rarely their dorsal fin), true blue whales seemingly always exposed both. The authors recommended that more data should be collected from true blue whales, that the biological context of different surfacing behaviours should be investigated, and that other morphological features (especially those involving the nasal region of the skull) should be examined.

The sub-committee welcomed this analysis as an objective approach to investigating behavioural differences between the two forms of blue whale, and looked forward to a fuller analysis next year, in which the results of the 1997/98 blue whale and SOWER cruises would be included. This would *inter alia* increase the sample size for true blue whales. Concern was expressed, however, that the process of closing with the whales to obtain video footage may be altering surfacing behaviour, so that the difference in behaviour seen between the two forms might be partly a result of the true blue whales having been filmed at a greater distance from the vessel. Brownell reported that blue whales in the Maldives, believed to be pygmy blue whales, fluked frequently, even during boat approaches.

In SC/50/CAWS23, 23 sightings of blue whales made in the vicinity of the Galapagos Islands between 1978 and 1995 were discussed. All but one occurred in the austral winter or spring. Some apparent feeding behaviour was observed, and the region seemed to be a productive habitat. One animal was observed with dorsal scarring possibly attributed to contact with ice. The paper concluded that the whales could either be Southern Hemisphere animals on their wintering grounds, or members of a resident Eastern Tropical Pacific stock.

Kato reported that he had examined photographs of animals from the Galapagos region, including a sequence showing surfacing behaviour, and that from morphological and behavioural characters he had concluded that these whales resembled true blue whales.

Thiele reported on incidental sightings of more than 60 blue whales made on one day from a ro-ro ferry in a fjord in southern Chile in January 1998. Some of these animals were

apparently feeding at a frontal zone between oceanic and glacial meltwater. A single cow-calf pair had been seen from the same ferry in November 1997.

In discussion, Thiele stated that the observers (who had just left the blue whale cruise) believed that the animals they had seen looked similar to the blue whales seen on that cruise and identified as pygmy blue whales by the boatswains on the *Shonan* boats. There were historical catch records for the area. It was pointed out that future surveys of such areas would require permission for access to territorial waters, as the whales had been found within 12 n.miles of the coast.

Clark reported on an analysis of sounds recorded in the vicinity of blue whales off Chile on the 1997/98 blue whale cruise (SC/50/CAWS29). During 13 approaches to blue whales for biopsy attempts that were acoustically monitored, a total of 20 very low frequency calls was recorded during eight approaches. All these calls were similar, having a fundamental frequency of about 11Hz with up to five harmonics and lasting up to 60 seconds. As such they were typical of blue-whale type vocalisations, but were unique in the consistency of the fundamental harmonic and the production of multiple harmonics, creating a harsh, growly quality. Such calls were only recorded in the context of one of the boats closing with the whale for biopsy, and were characteristic of calls made by other animals in an agonistic or threatening context.

In response to a query regarding what the results of the three cruises to date could tell us about any acoustic distinction between true blue and pygmy blue whales, Clark summarised as follows. All the recordings made in the Antarctic in 1996/97 in the vicinity of putative true blue whales differed greatly from anything recorded on the cruises off Australia in 1995/96, south of Madagascar in 1996/97 or off Chile in 1997/98. Preliminary reports from the 1997/98 Antarctic SOWER cruise suggested that calls similar to those recorded in the Antarctic in 1996/97 had been heard. It therefore appeared that true blue whales may produce different vocalisations from pygmy blue whales. The best documented comparison was between pygmy blue whales sampled south of Madagascar in November/December 1996 and blue whales recorded in the Antarctic the same summer (IWC, 1998b; Ljungblad, 1997): these were as distinct as the calls of North Atlantic or North Pacific populations of blue whales. Clark reported, however, that he had not had access to Australian recordings for analysis, and had not yet been sent any 'non-growl' recordings from Chile. He was therefore unable to comment on possible acoustic differences between 'populations' of pygmy blue whales off Australia, Madagascar and Chile. A small group under Clark was asked to draw up a working paper describing the current situation regarding the quantity, availability and disposition of acoustic recordings from the blue whale and SOWER cruises, and the state of their analyses. Their report is attached as Appendix 2.

4.2.3 Other

Following problems experienced on previous blue whale cruises with obtaining biopsies from whales that were difficult to approach, Larsen had developed a more powerful delivery system based on a Remington Rolling Block System rifle, adapted to fire darts of a diameter of 26mm using 9mm blank ammunition (SC/50/O15). The gun also carried an electronic aiming device and a valve for adjusting gas pressure. Field trials on humpback whales off Provincetown had been promising, but it had not been possible to get the gun to Chile in time for the 1997/98 blue whale cruise.

The sub-committee agreed that the question of using this new system on future blue whale cruises should be referred to the small planning group that had been set up under Kato.

5. RIGHT WHALES

5.1 Report of the Cape Town workshop

Bannister summarised the report of the special meeting on the Comprehensive Assessment of right whales that was held in Cape Town in March 1998 (SC/50/Rep4) – see Appendix 3.

In discussion of the report, most members of the sub-committee did not agree that there are any data to support the statement attributed to Best, regarding the possibility that some recovery must have taken place in the western North Atlantic population following protection in 1935, with a possible slow recovery until at least the 1980s (SC/50/Rep4, section 10.1).

Clapham, Wade and Baker commented that the regression given in SC/50/Rep4, annex G, item 2, may not reflect a population increase in western North Atlantic right whale adult females between 1985 and 1997 but rather a 'rate of discovery' of newly observed parous females over the period.

As regards the use of sloughed skin for DNA analysis (SC/50/Rep4 section 9.1.2.2), Clapham commented that although DNA yield from sloughed skin was sometimes lower than from biopsies, sloughed skin was nonetheless a valuable source of genetic material and its collection from right whales should be encouraged.

In discussing the issue of so-called relict populations, the sub-committee felt it was important that the recommendation in section 11 of the report should be extended to cover not only right whales in the eastern North Pacific, but also those in the eastern North Atlantic.

The sub-committee commended the organisers of the meeting and agreed to forward its recommendations to the Scientific Committee. Best, however, expressed reservations over recommending the creation of a Southern Hemisphere Right Whale Consortium, on the grounds that it was unnecessary, and that the time and funds envisaged could be much better spent in support of actual research programmes.

5.2 Action arising

A summary of the most important recommendations for which action by the Commission might be required will be prepared by Bannister and presented to the Scientific Committee in Plenary.

Although the results of the special meeting represented a major advance in understanding the status of right whales worldwide, the sub-committee felt that there were still a number of outstanding questions regarding the status of the population in the western North Atlantic. Although the population was known to be small (*ca.* 300 individuals), and well below its unexploited size, its current dynamics were unclear. At the same time, it was subject to a range of anthropogenic threats, including ship strikes and fishery entanglements, some of which were proving fatal. The sub-committee therefore recommended to the Scientific Committee that the Comprehensive Assessment of the western North Atlantic right whale should be a priority topic for next year's meeting, with its objectives being to establish the current status and dynamics of the population. It was proposed that three days be reserved for this topic, possibly immediately preceding next year's Scientific Committee

meeting. A budget should be developed that would allow for a number of invited participants to attend. It was recommended that a steering committee under Clapham be established.

5.3 Other

De Master introduced SC/50/CAWS18, in which the sightings of two groups of right whales, a single animal and a group of 5-7, in one day were reported for the southeast Bering Sea in the summer of 1997. The paper produced a population estimate from these two sightings, and deduced from the distribution of sightings since 1985 that there has been a shift in distribution since the mid-twentieth century.

In discussion of this document, members of the sub-committee expressed several reservations about the findings of the paper. Specifically, they were concerned over the validity of a population estimate based on only two sightings, and believed that the associated CV (already 106%) had been under-estimated because the uncertainty associated with the use of an effective search width for another species (humpback whales) had not been included. They also considered that it was not possible to conclude that there had been a shift in habitat usage because the survey had not covered the main area in which sightings had been made in the twentieth century.

6. SOUTHERN HEMISPHERE HUMPBACK WHALES

6.1 Progress in catch and marking data coding

Allison reported that no catch data had been coded since the last meeting, and it appeared that most individual catch data available for southern humpback whales had been coded already.

6.2 Establishment of Southern Hemisphere directory and Antarctic catalogue

Last year the sub-committee on Southern Hemisphere humpback whales had recommended that a centralised directory of Southern Hemisphere humpback whale identification photographs be established, and it was recommended that the IWC Secretariat create and maintain the directory. A suggested format for such a directory had been published in IWC (1997b, p.134). The Secretary reported that no progress with the creation of the directory had been possible, given the short time since the 1997 meeting. After referring the matter to a small group under Carlson, the sub-committee recommended that the IWC Secretariat continue with arrangements to create the directory.

Last year the sub-committee on Southern Hemisphere humpback whales had also recommended that Carlson be nominated and funded to undertake certain tasks related to the establishment of a centralised catalogue of humpback whale identification photographs from the Antarctic. Carlson reported that, as instructed, she had inspected both the JARPA and IDCR collections of photographs and assessed them for quality and distinctiveness for matching. She had also approached the College of the Atlantic to determine whether they would be interested in taking on the responsibility for such a catalogue, which would include creating separate catalogues for lateral views from each side. The College of the Atlantic had replied positively, and a specific proposal was contained in Appendix 4, which also contains the results of further discussions of a small group convened by Carlson.

In sub-committee discussion, some members raised concerns about the appropriateness of such a catalogue, and whether consideration should be given to having it in an electronic form rather than as a physical catalogue. After referring the matter to the small group under Carlson, the sub-committee recommended that the Commission should proceed with arrangements for a contract to be drawn up with College of the Atlantic to create an IWC Antarctic catalogue of humpback whale photographs, provided that such a contract contains written specifications of (a) how the catalogue is to be made available to researchers, under what conditions and in what format; and (b) what protection will be afforded for the proprietary rights of any contributors to the catalogue.

6.3 Progress towards assessment

6.3.1 Abundance and trends

Nishiwaki presented an analysis of the humpback whale sightings in Area IV during JARPA 1997/98 (SC/50/CAWS8). In 21,594.4 n.miles of searching in closing mode, 117 primary sightings of 246 humpback whales were made by the dedicated sighting vessel, and 431 sightings of 819 humpback whales by three sighting and sampling vessels. For the first time since the JARPA programme started, humpback whales were the dominant species throughout the region surveyed. Densities were particularly high between 83°-108°E, even at the ice edge, and there was clear segregation from minke whales. Indices of abundance were clearly indicative of an increasing density of humpback whales from 1989/90 to 1997/98.

In answer to a query, Nishiwaki confirmed that the area coverage was comparable between years. The sub-committee was informed that it would be unwise to attempt to calculate a rate of increase from the JARPA abundance indices at present because there may have been undersampling of high density areas. This problem had arisen with minke whale abundance indices from the same surveys, and was the subject of a current IWC contract.

Thiele presented the results of a shipboard survey in Area IV during the 1995/96 summer, from the Australian ice-breaker *Aurora Australis* (SC/50/CAWS16). The ship was occupied on a krill acoustic survey, so searching was in passing mode only, but data collection procedures followed standard double-platform line transect methodology. The resultant population estimate for humpback whales was 900, with a CV of 0.46.

In clarification, Butterworth explained that the estimate had involved a considerable degree of extrapolation northwards (to 60°S) to make it comparable with those from the IDCR/SOWER programme. Although the resultant estimate in the strictly statistical sense was significantly different from the estimate of 3,309 (CV 0.445) from the second set of circumpolar IDCR cruises (SC/50/CAWS37), this should not be a matter of concern, not only for the reasons stated in SC/50/CAWS16 (different survey timing, 'additional variance', possibly lower $g(0)$), but also because the *Aurora Australis* survey was in passing mode, which would have produced a tendency to underestimate group size, and because particularly strict criteria had been used in accepting a sighting as identified. These factors might have combined to reduce the estimate of abundance. Nishiwaki pointed out that the estimate from the JARPA southern stratum in Area IV in 1995/96 was 760 (CV 0.31), which was not too different from the estimate in SC/50/CAWS16. However the effective search half-width from the *Aurora Australis* data was much narrower than that from JARPA or

IDCR/SOWER, and he queried whether this might be indicative of lower observer efficiency, a point also raised by Ohsumi, in referring to his paper that compared the sighting efficiency of experienced whalers and inexperienced observers (Ohsumi and Kasamatsu, 1982). In response, Butterworth cautioned against (a) accepting the JARPA abundance estimate, given the problems mentioned SC/49/Rep1, and (b) making a correlation between narrow *esw* and low $g(0)$, given that the former may have been affected by the strict species confirmation criteria used on the *Aurora Australis*.

In reply to a question about future cruises and how to improve the ability of observers to identify species at distance from the trackline, Thiele responded that the next survey was currently being conducted using 'big-eye' binoculars to improve species identification during passing mode. Butterworth commented that the utility of these estimates would be greatly improved if they could be incorporated with other data in a GLM approach to achieve better estimates of population size and particularly trend. In this respect, he would like to see distributional and environmental data for Area IV so that the potential importance of 'additional variance' could be evaluated. The sub-committee agreed that the evaluation and comparison of such sighting data would be greatly facilitated if the distributions of both angles and radial distances to sightings were given. In addition, it was important at the outset to decide on whether such cruises were designed to provide estimates of absolute or relative abundance, or were intended simply to relate whale density to environmental correlates. Certainly if the ultimate objective was to obtain estimates of absolute abundance, then experiments to calculate $g(0)$ would be required. The sub-committee considered that the issue of using such surveys to obtain estimates of trend should be referred to the proposed workshop on planning joint GLOBEC/SOWER/CCAMLR surveys. Thiele said that the Australian surveys were conducted to incorporate data from all disciplines to look at broad scale physical and biological patterns and processes in relation to cetacean distribution, but that they would provide estimates of abundance if enough sightings were made.

During the 1997/98 summer, sighting surveys were carried out in the Antarctic Peninsula area from the Brazilian Antarctic supply ship *Ary Rongel*, using line transect methodology (SC/50/CAWS36). Densities of humpback whales were obtained and 54 individuals photo-identified (including one match between 27 January and 7 March, suggesting some individuals might be resident for substantial periods during the summer).

The sub-committee was pleased to receive these results, and recognised that this was another instance of the possible use of a platform of opportunity for obtaining absolute or relative indices of abundance.

The results of an aerial surveillance programme over the Great Barrier Reef, Australia, from 1982 to 1996 were presented to the sub-committee (Chaloupka and Osmond, 1998). In year-round surveys a total of 414 sightings of 812 humpback whales had been made, including sightings of 25 cow-calf pairs with 27 individual calves. Most sightings were made in winter and spring, but occasional sightings north of 16°S in summer suggested a year-round residency. A crude birth rate of 0.072 was obtained from the incidence of calves, and a median calving rate of 0.3 calves per mature female per year calculated. Time series regression analysis of the annual trend in sightings suggested that the east Australian population was increasing at 3.9% (95% CI 1.95%, 5.7%) per year.

In discussion the sub-committee expressed a number of reservations over this paper and its analysis. There was insufficient information on the searching strategy and methodology used, and the experience of the observers and protocol used in recording sightings were unknown. Concern was also expressed over the reliability of calf counts from such flights, and there seemed to be no way of confirming many of the species identifications made. Although the time series of the flights (14 years) was extensive, the number of sightings made (an average of only 30 a year) was approximately what might be seen on one day in a shore-based survey at the peak of the season, so the efficiency of the surveys was presumably low. Thus while in principle such surveys could be used as indices of relative abundance, there had to be strict standardisation of techniques and effort for the results to give a reliable measure of trend. There was no indication from the paper that such standardisation had been carried out.

Butterworth presented an analysis of the sightings of humpback whales made on two, and an incomplete third, circumpolar IDCR/SOWER surveys, covering the period 1978/79 to 1995/96 (SC/50/CAWS37). He explained that there had been problems with gaining access to the DESS computer package from Cape Town, so that these estimates had only been prepared shortly before the meeting. He had subsequently been able to make the results of the three circumpolar surveys more comparable by adjusting for differential area coverage (Appendix 5). These estimates had used sighting rates by stratum, but *effective search half-widths* (*eshw*) and mean school sizes had been obtained by pooling over each set of surveys. Closing and passing mode estimates had been pooled, except for calculations of mean school size, which had used closing mode data only. He pointed out that the results for each Area had large CVs but those for each set of circumpolar surveys had CVs that were more acceptable. The results indicated an increase from 7,500 humpback whales in the first set of surveys to 11,800 in the second set and 15,700 whales in the third (as yet incomplete) set of surveys. Scaling up further, to take account of humpback whales north of 60°S, could be carried out using data from Japanese scouting vessels, but had not yet been done.

In reply to a question about how these results could be interpreted, Butterworth stressed that conclusions on possible rates of increase should not be based on comparisons by Area, as these estimates had large CVs and were subject to possible additional variance due to inter-survey shifts in distribution. Estimates based on sets of circumpolar surveys were more reliable, but CVs for the estimates in Appendix 5 had not yet been calculated, and the 'year' to which they referred was not clear because each set of estimates corresponded to a 6-year period. He did not think it appropriate to use them for estimating rates of increase as yet. Other questions raised concerned the scaling up procedure to adjust for incomplete area coverage, specifically whether the clumped nature of humpback whale distribution had been taken into account, and whether it would not be better to scale down to a common area rather than scaling up. Butterworth agreed that both might be more defensible procedures, although they were likely to lead to increased CVs.

When considering estimating trends from such data, several members mentioned the need to take so-called additional variance into account, and the suggestion was made that the effects of high-ice, low-ice years, for instance, might be investigated. Incorporating additional variance in this way might lead to an 'explanation' of variance and thus

bring the associated CVs down. Butterworth agreed that other variables could be introduced into these datasets using a Generalised Linear Model (GLM) approach.

Findlay introduced SC/50/CAWS25, which was prepared in response to a request from last year's sub-committee on Southern Hemisphere humpback whales. Catches of humpback whales by modern whaling in the Southern Hemisphere were reviewed, along with the number of catcher vessels operating in each of a number of whaling grounds. Grounds included the Falkland Islands Dependencies, Antarctic pelagic waters (including the Ross Sea prior to 1930), the west and east coasts of southern Africa (Gabon to Madagascar), Kerguelen Island, Australia, New Zealand, Brazil and the west coast of South America. Data were obtained from both published and unpublished sources, but did not include the undeclared catches of humpback whales by either the Soviet fleets or the *Olympic Challenger*. Brief reviews of the history of operation on each ground were reported. Crude catch per unit effort (CPUE) indices were calculated as annual catch per catcher vessel for each ground. Most grounds showed marked declines in the initial 10 years of whaling and thereafter were generally of two types. In the first type declines in the catch levels in the initial years of whaling resulted in the closure of the ground, followed by some recovery of the stock. In the second type, catches declined and remained low until the cessation of humpback whaling in October 1963. Estimates of abundance and population trends from after 1963 show Southern Hemisphere populations to be undergoing some recovery in all areas where surveys have been undertaken.

The sub-committee thanked Findlay for preparing this review. Some discussion followed on how the Comprehensive Assessment of southern humpback whales should now proceed, given the uncertainties in the locations of many catches (particularly the previously undeclared Soviet catch). Last year, the sub-committee had proposed a number of options for dividing feeding ground catches into putative breeding 'stocks', and it was proposed that a small group under Findlay would review what catch data were available, consider whether last year's proposed catch divisions were still appropriate, and discuss how the CPUE data might be utilised in an assessment.

The sub-committee accepted the plan of action as proposed by this Group, as below. No changes to the stock division (Fig. 1) accepted in 1997 were proposed.

Modelling of the pre-exploitation size of stocks will be carried out as recently done for southern right whales (SC/50/Rep4). The model described in SC/50/Rep4 (the population model used in the *Catch Limit Algorithm* of the RMP; IWC, 1993) will be run for stocks where some recent population estimates have been determined (stocks C, D and the east Australian component of stock E). Low latitude catches of humpback whales reported in SC/50/CAWS25 can be assigned to these stocks except for those from the Kerguelen Islands. For the purposes of these analyses the undeclared Soviet catches for which no catch position data are available will be assigned on a *pro rata* basis. Catches from the Kerguelen Islands will be equally divided between C and D. These analyses are intended as preliminary; both the population model used and options for allocating catches can be refined in the light of initial results obtained.

6.3.2 Stock structure

Baker introduced Baker and Medrano Gonzalez (1998) in which the distribution and worldwide diversity of humpback whale mtDNA lineages was described, using published sequences from 514 individuals (Baker *et al.*, 1993; 1998; Medrano-Gonzalez *et al.*, 1995; Palsbøll *et al.*, 1995; Larsen *et al.*, 1996). The samples represented 20 regional habitats, forming eight putative stocks among the three oceanic populations. Although the datasets differed somewhat in the length and position of the DNA control region sequenced, an evaluation of patterns of variation across the combined length showed them to be comparable for a relative assessment of diversity and geographic structure. Overall mtDNA diversity was partitioned hierarchically into oceans, stocks within oceans and regions within stocks. The regional differentiation of mtDNA lineages was most marked between feeding grounds of the North Pacific and North Atlantic. Differentiation was weakest (although statistically significant) among the four wintering grounds of the Southern Hemisphere. Comparisons of haplotype and nucleotide statistics showed considerable differences in the explained variance and permutation probabilities at each hierarchical division. Further consideration is required to determine which approach is most appropriate for analysis of stock structure of interest to the IWC. A phylogenetic reconstruction of the control region sequences allowed classification of all 514 samples into one of three clades or ancestral linkages, first described by Baker *et al.* (1993).

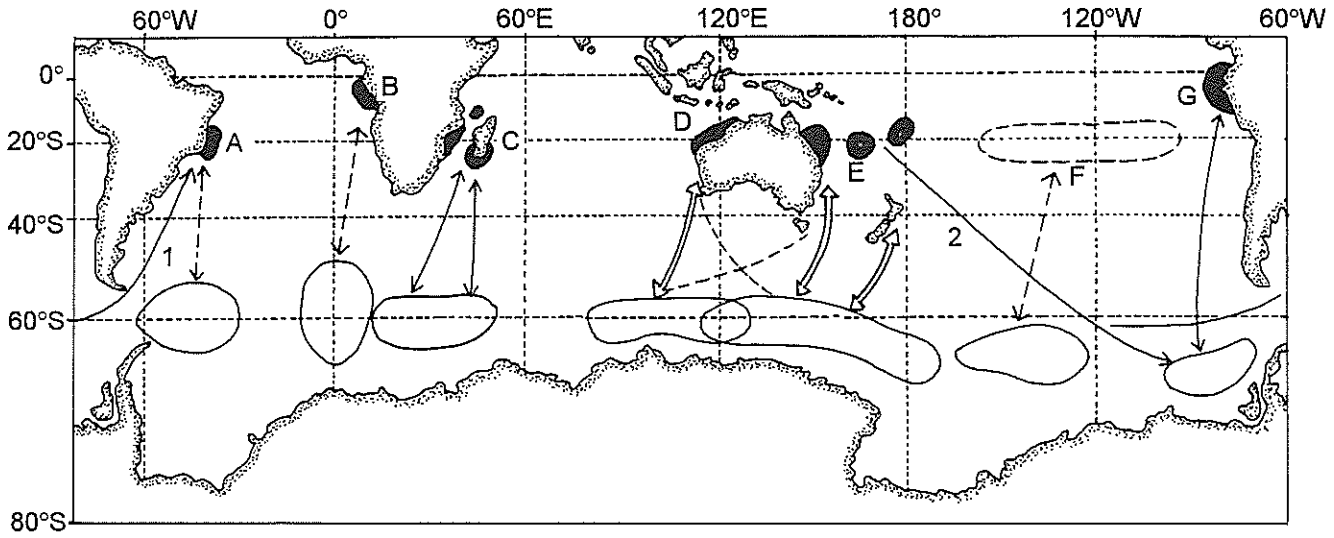


Fig. 1. Putative feeding grounds and migratory routes for Southern Hemisphere humpbacks (from *Rep. int. Whal. Commn* 48:181).

Each ocean is dominated by one clade, and, in the North Pacific and North Atlantic, a secondary clade seems to be the result of gene flow from the Southern Hemisphere. Only the Southern Hemisphere includes lineages from all three clades (although with differing regional frequencies). The patterns of clade distribution and lineage diversity in the North Pacific and North Atlantic appear to be influenced by an expansion of these populations into new feeding grounds following the retreat of the last ice age.

In response to a query why there was less differentiation among Southern Hemisphere localities than among regions within the North Atlantic or North Pacific, Baker replied that this might be because the analysis for the Southern Hemisphere was based on material from breeding grounds, whereas those for the North Atlantic and North Pacific were based on material from the feeding grounds. Pastene reported on a mtDNA analysis of feeding ground material from the Southern Hemisphere, in which only Area IV was differentiated from V, VI and I. A microsatellite analysis had failed to detect any significant difference between Areas IV, V and VI – Area I had not yet been examined.

Baker then introduced SC/50/CAWS35, describing a preliminary analysis of mtDNA variation and geographic structure of humpback whales from wintering grounds of Areas III, IV, V and VI and/or I. The analysis included previously published mtDNA sequences from Western Australia, East Australia, Tonga and Gorgona Island, Colombia (Baker *et al.*, 1998) and unpublished sequences from Madagascar (Antongil Bay), New Caledonia and coastal Colombia (Malaga Bay). The analysis was based on a consensus segment of 240bp of the control region from 176 individual whales. A total of 67 unique haplotypes was defined by variable sites within the consensus segment. A hierarchical analysis of molecular variance (AMOVA) also showed significant differences among four historical stocks or whaling management areas. However, an analysis of haplotype frequencies was not significant for stocks ($p = 0.059$), but showed more differences among pair-wise comparisons of wintering regions. Most pair-wise comparisons between wintering grounds were consistent with geographic distance or stock divisions in the haplotype analysis. Notable exceptions were the absence of difference between Madagascar and Western Australia, and the absence of difference between both these regions and New Caledonia. A larger set of samples is now available, representing several seasons, from Madagascar, Western Australia, New Caledonia, Tonga and Colombia. Further analyses of these samples are planned.

Concern was expressed about interpretation of some of the results; for instance, the non-significant difference between Madagascar and New Caledonia, compared to the significant difference between east and west coasts of Australia. Baker replied that this was probably largely the result of inadequate sample sizes. It was also pointed out that because of the high degree of variation shown in each region, large sample sizes might be needed to obtain adequate resolution. Pastene suggested that a larger segment of the control region needed to be analysed, and the possibility of inadvertent resampling of individuals on breeding grounds should be investigated. Clapham stressed the need to use a number of statistical techniques to analyse such data, because reliance on only one model might produce misleading results. It was also suggested that larger sample sizes might enable separate analyses by sex to be carried out, and the validity of the statistical comparisons depended greatly on how the samples were grouped when using an AMOVA design. Baker reported that microsatellite analysis also indicated a very high degree of individual variation in southern humpback whales.

In response to a query regarding how the genetic work could be advanced further, Baker said that there were some areas (notably both sides of the South Atlantic) where there was currently a lack of any genetic information, and there was a need for more samples from feeding areas. He was concerned that sampling in migratory corridors (rather than on breeding grounds) might produce misleading results, given experience in some areas of the North Pacific.

Pastene summarised genetic material collected by biopsy during JARPA (SC/50/O3). A total of 88 samples from humpback whales was now available, 7 from Area III, 47 from Area IV, 19 from Area V and 15 from Area VI. All except those collected in Areas III and IV last season have been analysed.

Ensor reported that biopsies had been collected from 10 humpback whales during the 1997/98 SOWER cruise (SC/50/Rep1). Eight of these had been from Area IIW and two from the recently described feeding aggregation on the border between Area II and III.

Mikhalev (SC/50/O18) reported on investigations, which had resulted in the discovery of several previously unreported recoveries of whale marks from the Soviet factory ship *Slava* in the Southern Hemisphere. For the period 1955-1966 a total of 51 recoveries had been found (including marks from both the Soviet and the Discovery marking schemes), of which 25 were from humpback whales: only six of the latter had been reported previously. The new information supports that obtained previously, in that migrations from Tonga, New Zealand and both coasts of Australia are linked to either Area IV or V. It was noted that these were probably only a small fraction of the number of recoveries actually made: in the 1959/60 season, for instance, it is known that 133 marks were recovered on either the *Slava* or *Sovietskaya Ukraina*, of which no further details existed. The need to obtain further information on not only mark recoveries but also marks fired under the Soviet scheme was stressed.

In response to a query, Mikhalev responded that he believed marking information might be available for about 1,000 marks fired under the Soviet scheme.

The sub-committee thanked Mikhalev for his efforts, and urged him and his colleagues to continue their invaluable work in retrieving catch and marking data from previous Soviet whaling operations.

Borodin requested that the following statement appear in the report. 'Last few years (IWC, 1997a, p.82, pp.137-8; IWC, 1998a, p.77) the Russian delegation made a statement about the necessity for independent experts with primary information of whaling (vessel logbooks, scientific reports, etc.) to present these materials on national level so that they may undergo an expert review. This has not been done. This year we repeat again our statement and the need [for] this statement to be included in reports'.

Recent information concerning humpback whales off Oman, and whether this population has any connection to the Southern Hemisphere, was provided by Baldwin (SC/50/CAWS21). In November 1997, 43 sightings of 72 humpback whales had been made in 22 days during an offshore seismic survey. Data on the general distribution and abundance of humpback whales in the region supported the notion that these whales were resident year-round in the northwest Indian Ocean, although their abundance off the

coast of Oman seemed to decline in summer. The recent status of the species in the area, following the Soviet catching in 1966, was in doubt.

In discussion it was pointed out that the Soviet catching, although of brief duration, had been extremely intensive, with 25 catchers sweeping the area. Accordingly, although the opportunistic surveys reported by Baldwin were of longer duration than the few days spent off Oman by the Soviets, the recent effort was likely to have been considerably lower than during the whaling operations. Thus, the lower sighting rates reported by Baldwin may not necessarily indicate that the stock remains depleted.

The sub-committee recommended that dedicated surveys should be carried out to establish the status of humpback whales in the northwest Indian Ocean, and that these should include the collection of biopsy material from which the genetic relationships of this interesting stock could be investigated (particularly since genetic material was now available from Madagascar to the south).

6.3.3 Further information on catches

Pinedo introduced SC/50/CAWS30, which had been prepared in response to a request from last year's sub-committee on Southern Hemisphere humpback whales. She had contacted a number of major libraries in Brazil for information on local whaling in colonial times, but no information had been found. As a consequence she had relied heavily on published material, particularly two books and a document reproduction (Ellis, 1958; Ellis, 1969; Ellis, 1972), and had also personally contacted the author of these. Whaling had started in 1602 and until 1801 continued under a Portuguese monopoly. Although colonial whaling had declined in the 19th century, takes continued up to the end of the 19th and into the beginning of the 20th century. Catches were seasonal, occurring in winter and spring, and were most probably confined to within approximately 6.6 km of the coast. Cow-calf pairs seemed to be targeted. The species involved were usually not stated, but descriptions and circumstantial evidence suggest that the catch was mainly composed of right whales. A complete series of catch statistics does not exist but Ellis (1969) lists at least 2,664 whales taken between 1761 and 1819. This figure contrasts markedly with that given by Richards (1993) of 14,904 right whales killed by shore stations from 1772 to 1814, a discrepancy which was probably due to an under-representation of shore stations in Ellis (1969). Only three humpback whales are known to have been taken, in 1801. Modern whaling in Brazil started in 1910 and continued (intermittently) until 1974. Although catch statistics are not always complete, and sometimes contradictory if more than one source exists, it is estimated that at least 1,334 humpback whales were taken in the Brazilian fishery between 1910 and 1963.

The sub-committee thanked Pinedo for her work. In discussion, the existence of a Brazilian open-boat fishery taking humpback whales contemporary to the onset of modern whaling in Brazil was mentioned, and a query raised whether these catches had been included in SC/50/CAWS30. Pinedo replied that records of these catches were not found in the archives of government departments in Brazil, but further investigations could be made, once the reference of the original source of the information relative to that operation (mentioned in Tonnessen and Johnsen, 1982) became available.

6.3.4 Other

Two papers submitted to the sub-committee concerned the effects of noise on humpback whales (McCauley *et al.*, 1998a; 1998b). Due to time constraints, these were not discussed, but the topic was considered to be important and might perhaps be more appropriately discussed by the Environment sub-committee in future.

6.4 Future special meeting

Before a special meeting to conduct a Comprehensive Assessment of Southern Hemisphere humpback whales could be planned, action was needed on a number of outstanding items.

The sub-committee noted progress in a number of areas, as reported above. While work is still required to complete many of those tasks, little or no action has yet been possible, given the short interval between the annual meetings and for other reasons, on a number of other tasks recommended last year. The latter are listed below, with reference to last year's report in brackets.

(i) *Acquisition and entry of revised Soviet catch data* (item 9.1.1) - Secretariat - no new data have been acquired.
(ii) *Investigation of the availability of original Soviet scheme marking data* (item 9.1.1) - Secretariat - ongoing.
(iii) Creation and maintenance of a centralised directory of Southern Hemisphere humpback whale photo-identification catalogues (item 9.1.3.1) - Secretariat - action required.
(iv) *Collection of biopsy samples from three main strata: breeding ground, feeding ground, migratory corridor* (item 9.2.1) - national groups - some action, see Item 6.3.2.
(v) *Monitoring of abundance to continue or be initiated where no survey programme exists* (item 9.2.3) - national groups - no new survey data have been reported this year.
(vi) *Inclusion of humpback whales as targets for biopsy and photo-identification in future Antarctic survey expeditions in the South Georgia region* (item 9.2.3.2) - national groups - no action reported.
(vii) *Researchers in photo-identification programmes to evaluate the likelihood of obtaining estimates of biological parameters* (item 9.3.3) - national groups/individual scientists - no action reported.
(viii) *Comparison of currently observed increase rates to be considered in conjunction with a review of demographic parameters for Southern Hemisphere humpbacks and a comparison with information on increase rates and demographic parameters for North Atlantic and (North Pacific) populations* (item 9.3.3) – Scientific Committee - no action.
(ix) *Progress report on retrieval of detailed Soviet catch data* (item 9.4) - relevant scientists - no action reported.

The sub-committee decided to set up an intersessional working group under Clapham to consider Item (viii). They would report back to the sub-committee at next year's meeting.

As regards Item (vii), the sub-committee felt that the most appropriate approach would be to encourage individual members to consult with researchers concerned with photo-identification on humpback whales in their region for this information.

In light of these outstanding matters requiring action the sub-committee agreed that it would be in a better position at the next meeting to decide when an assessment might occur.

7. NORTH ATLANTIC HUMPBACK WHALES

7.1 Report on progress towards assessment

Smith presented an update on the status of information on the North Atlantic humpback whale (Appendix 6). Considerable progress had been made, including papers published, in press or in preparation on abundance, trends, population structure, migration and breeding grounds, and catch data. The most important papers from the YONAH project are expected to be available by the end of 1998. Many other analyses are substantially developed, but the likely time frame of their availability is unclear; these include some critical areas such as analyses of trends in abundance and clarification of population structure, especially as it refers to specific breeding grounds. Thus, while it might be possible to undertake the Comprehensive Assessment in 1999, there was likely to be a substantial amount of information that would still be unavailable at that time. It was therefore suggested that the assessment should be carried out in the year 2000.

In discussion, Smith stressed that while every effort would be made to construct as comprehensive a catch history for the North Atlantic as possible, it was likely that the total catch will never be known completely, and this would constrain what could or could not be done in the Comprehensive Assessment.

Apart from an incomplete catch history, two main gaps for the assessment were identified. These concerned a lack of information on the distribution and abundance of humpback whales in the waters of the southeast Caribbean (Windward Islands) and off the Cape Verde Islands, and their relationship to humpback whales in the rest of the North Atlantic. In regards to the former, Carlson presented a summary of the individual identification photographs available for humpback whales from the eastern Caribbean (SC/50/CAWS28). There were only nine photographs of humpback whales from the eastern Caribbean amongst the 5,000 odd in the North Atlantic humpback whale catalogue. Two of the nine had been matched, one with Puerto Rico and the other with Newfoundland, while there was a third possible resighting in Greenland. This sample is too small and spatially and temporally diffuse to draw any meaningful conclusions, and further photographs, biopsy samples and song recordings were required to address this question.

Clapham presented a summary of information on the status and stock origin of humpback whales in the Windward Islands (SC/50/CAWS11). Although the general pattern of a maternally-directed fidelity to high-latitude feeding grounds in summer, and a general mixing on the breeding grounds in the waters in the northern part of the Antillean chain in winter, had been established for the North Atlantic, relatively little effort had been directed on studying humpback whales further south. Densities in the region appeared to be low, despite this being a principal whaling ground in the 19th century. This was also the area in which the subsistence hunt at Bequia was operating. The apparent failure of humpback whales to recover in this region raises the questions (a) from which feeding grounds in the North Atlantic do these whales originate, and (b) are they genetically distinct from the humpback whales that use the breeding range to the north? The paper proposed: (1) a study of logbooks from 19th century whaling ships visiting the Windward Islands to determine the historical distribution of the species, and to assist in survey design for the current population; (2) vessel surveys using visual and acoustic techniques to provide a clearer picture of current distribution and abundance; and (3) individual identification of whales using genetic or photographic techniques to investigate stock linkages and migratory behaviour.

In discussion of the paper, Hester and Swartz commented that such a programme would have a greater chance of success if it was carried out in cooperation with regional governments.

The possible use of acoustic methods in facilitating censuses was discussed. Clark reported that acoustic data originating from the SOSUS fixed hydrophone arrays since 1993 had shown that detection rates for singing humpback whales in the southeast Caribbean in winter were about one-third to one-half of those in the high density areas. These rates corresponded to the numbers of individual singers tracked per day, and it was not clear how this related to the total numbers of humpback whales in the area. Clark also described recent fieldwork in Hawaii combining visual and acoustic methods, in which it had been possible to locate individual singers acoustically out to 5-6 n.miles, and then to direct a boat with a GPS on to the whale so that it could be photographed and biopsied on surfacing. Such a technique might be especially useful in low density areas such as the southeast Caribbean.

In regards to the situation of the Cape Verde wintering ground, or the eastern North Atlantic stock, Clark summarised acoustic information suggesting the presence of an eastern component. SOSUS data collected since 1996 had shown that singing humpback whales could be heard in the Norwegian Sea in winter, while others proceeded south past Ireland towards Spain. The number of animals involved was small, in the tens per day. This pattern had persisted for two years. The sub-committee noted that this remnant stock or population remained uncharacterised by photo-identification or genetic information.

The sub-committee recommended that the possibility of collaborative research on humpback whales in the southeast Caribbean be explored with national authorities in the area and the use of combined acoustic and visual methods be investigated to facilitate the collection of abundance and individual identification data.

Smith announced that the possibility of further research on humpback whales in the northeastern Atlantic was being considered, including a logbook survey in the Cape Verde Islands and an integration of all published information on humpback whales in the northeast Atlantic as a whole.

7.2 Action arising

Given the progress noted above, and the likely time frame for the availability of other analyses, the sub-committee recommended that a Comprehensive Assessment of North Atlantic humpback whales be carried out by the Scientific Committee in the year 2000.

It was pointed out that this population was subject to a small aboriginal take at Bequia in the West Indies (and had in the recent past been subject to an aboriginal hunt in Greenland). There was justification therefore in giving the Comprehensive Assessment of this stock some priority over other humpback whale stocks.

8. NORTH PACIFIC HUMPBACK WHALES

SC/50/CAWS31 provided a summary of the status of the North Pacific Humpback Whale Fluke Catalogue maintained by the National Marine Mammal Laboratory, Seattle USA. To date, over 24,000 photographs of humpback whale tails from all regions in the North Pacific from at least 16 different research groups have been accessioned into the catalogue. Based on recent efforts by all of the cooperating research groups to match photographs previously submitted to the catalogue with recently submitted photographs, 1,010 resights of individual whales from at least a five year period were reported. Further, 116 and 5 resights of individual whales were reported from periods spanning 15 and 20 years, respectively. In addition, the catalogue is currently being used to ascertain the extent to which calf mortality and the average reproductive interval can be estimated from the catalogue. For example, following the completion of a two-part workshop on estimating calf mortality in North Pacific humpback whales, analysis of data on 58 adult female whales with calves sighted in Hawaii that were subsequently sighted in Alaska in the same year was begun. Information on the fraction of these 58 females seen with calves following the breeding season in waters off Alaska will be used to estimate rates of calf mortality.

DeMaster reported that a paper recently completed by Calambokidis *et al.* (1997) provided abundance estimates for North Pacific humpback whales from the years 1991-1993. The estimates were based on mark-resight methodology. Estimates of basin-wide abundance and abundance for three stocks of North Pacific humpback whales were reported. Recognising some of the caveats identified by the authors in undertaking this analysis, the estimated number of humpback whales in the North Pacific between 1991 and 1993 was approximately 6,000.

The sub-committee welcomed these results, and encouraged the authors to submit papers or reports on their work.

9. SPERM WHALES

9.1 Report of the intersessional group

Brownell introduced the report of the intersessional sperm whale group that had been set up at last year's Scientific Committee meeting to review plans for a Comprehensive Assessment of sperm whales (Appendix 7). The group had agreed to recommend that the Comprehensive Assessment start with a focus on North Pacific sperm whales. The following studies were proposed:

(i) a review of mark-recapture data and joint US-Japanese genetic studies;
(ii) a preliminary abundance estimate for the western North Pacific, based on sightings;
(iii) a review of past abundance estimates and models;
(iv) a review of historical catch data;
(v) a review of sperm whale regulation in the North Pacific;
(vi) life history, social behaviour, ecosystem considerations and current anthropogenic mortality.

Brownell stated that the sub-committee might only be able to make progress initially with abundance estimation.

9.2 Action arising

The sub-committee briefly discussed the possibility of undertaking a Comprehensive Assessment of North Pacific sperm whales, as suggested in Appendix 7. It was agreed that before making any decision on this matter, the historical catch series needed to be reviewed, to see what problems existed and how they might be overcome. The matter was considered further under Item 9.5.

9.3 Abundance and trends

Nishiwaki introduced SC/50/CAWS9, in which estimates of current abundance and distribution of large male sperm whales in Antarctic Areas IV and V had been calculated using sightings data originating from JARPA surveys from 1989/90 to 1995/96. These covered the area from 60°S to the ice edge and from 70°E to 170°W. Sperm whales were widely distributed in Areas IV and V in each year. There was a high density area from 70°E to 100°E, and they were rarely found within Prydz Bay and the Ross Sea, there being no sighting south of 73°S in the Ross Sea. Abundance estimates for sperm whales in Area IV ranged from 2,946 to 4,289, and for Area V from 2,207 to 3,146 animals. These results are consistent with those from the second and third IDCR/SOWER Antarctic circumpolar surveys. However the possible effect of under-surveying of high-density areas, as noted for JARPA estimates of minke whales, was not considered in this paper. Estimates of abundance when corrected for animals missed on the trackline became 9,206–13,403 for Area IV and 6,897–9,838 in Area V: estimated biomass values (uncorrected for fluid loss during dissection) were 254,000–367,000 tonnes in Area IV and 189,000–270,000 tonnes in Area V.

In discussion it was noted that the corrected estimates used a $g(0)$ value of 0.32 obtained from simulation studies by Kasamatsu and Joyce (1995).

Butterworth introduced the results of analyses of sperm whale sightings from IDCR/SOWER cruises to the Antarctic between 1978/79 and 1995/96 (SC/50/CAWS37). These gave estimates of 5,461 (CV 0.44), 11,369 (CV 0.18) and 7,867 (CV 0.19) for the first, second and third (incomplete) circumpolar sets of surveys. It was noted that the estimated value for $f(0)$ (the inverse of the *eshw*) was very different for the first set of surveys (1.985 n.mile^{-1}) than for the latter two (0.989 and 0.825 n.mile^{-1} respectively). The reasons for this difference were unknown. In Appendix 5, he had updated these estimates to take into account the different area coverage between circumpolar sets, producing corrected values of 7,900, 13,000 and 14,300 whales respectively. These estimates only referred to the large male component of the population, and also assumed that $g(0)$ was 1; to this extent therefore they might be considered negatively biased. The apparent increasing trend was noted, but caution was expressed over its interpretation.

In relation to the above two papers, the sub-committee concluded that although it was highly unlikely that $g(0)$ for sperm whales was 1.0, it was not appropriate at this stage to adopt a lower value until the assumptions behind its calculation had been thoroughly examined. It was also probably not advisable to apply a $g(0)$ estimate from one geographical region to the species as a whole. These papers had illustrated two general problems with sightings surveys of sperm whales: the lack of a generally agreed estimate for $g(0)$ in this case, and the segregation by sex and size class of the species. Kato also expressed his concern over the estimation of mean school size in sperm whales, especially where there was a loose association of individuals/pods.

Paper SC/50/CAWS2 had been prepared in response to a request of the intersessional sperm whale group (Appendix 7), and analysed sightings data obtained from Japanese whale sighting vessels in the North Pacific between 1982 and

1996. In 341,199 n.miles of searching, a total of 1,412 sightings of 5,310 sperm whales had been made. Although surveys had taken place in 11 months of the year, effort had been concentrated in August and September, and most consistently allocated in the western half of the North Pacific. If analysis was confined to the area 20°-50° N, 130° E-180°, and data for 1994 and 1996 excluded because of low effort, a significant rate of increase (11% a year) was obtained. A line transect estimate for the western North Pacific (0°-50° N, 130°E–180°), uncorrected for $g(0)$ or loose associations of single animals, was 25,816 (CV 0.11). A correction for association increased the estimate to 32,676, and a correction for the value for $g(0)$ of 0.32 of Kasamatsu and Joyce (1995) increased it still further to 102,112 (CV 0.155).

In discussion, the opinion was expressed that if the data were sufficient, a more appropriate estimate of abundance for such a large region would be obtained by stratifying by area.

Brownell presented SC/50/CAWS20, in which a combined visual and acoustic survey for sperm whales was conducted in the eastern temperate North Pacific between March and June 1997. Sperm whales were detected acoustically using a towed hydrophone array, and 60 acoustic detections were made in 14,500km of searching. Mean group size was estimated by visual observation of 20 of the acoustically detected groups, which were found by directing the ship to the location from which the sounds came. Visual survey was carried out for 8,080 km, resulting in eight sightings (excluding acoustic detections that were seen visually later). The estimate of $f(0)$ used in the visually-based estimate of abundance was based on 281 sightings of sperm whales from previous surveys in the eastern Pacific. Because of the small number of sightings it had not been possible to integrate the visual and acoustic data to estimate detection probabilities. The acoustically based estimate of 39,200 (CV 0.60) sperm whales was not significantly different from the visual estimate of 24,000 (CV 0.46) whales. Acoustic techniques substantially increased the number of sperm whales detected on the survey by increasing the range of detection and allowing night-time survey. However the acoustic surveys could not replace visual methods for estimating group size.

Following this paper, questions were raised about how to estimate school sizes acoustically. Leaper referred to a paper by Gillespie (1997) which described a computer program for separating vocalisations from individual sperm whales which allows the number of vocalising whales to be counted. Alternative methods using estimated click rates per individual have also been used. Zeh commented from her experience of bowhead whale acoustic censuses that she was not optimistic that tracking individuals would be a feasible method of estimating group size, except perhaps for small schools. Zeh also noted that in the survey described in SC/50/CAWS20, schools detected acoustically were closed with for visual confirmation of group size. This could introduce a bias if, for instance, larger schools could be detected at greater distances, due to a more favourable signal/noise ratio. There may also be problems obtaining detection probabilities by integrating visual and acoustic cues, as the probability of seeing a whale at the surface may be negatively correlated with the probability of hearing it underwater. This can lead to overestimation of abundance because detection probabilities are underestimated.

Nevertheless the sub-committee recognised the potential value of acoustic techniques in estimating sperm whale abundance, and recommended that researchers active in the field cooperate and integrate their results to the greatest extent possible, and encouraged the submission of further papers on the topic to further Scientific Committee meetings.

Slooten introduced several documents concerning recent research on abundance estimation of sperm whales at the University of Otago, New Zealand (SC/50/CAWS39; Childerhouse and Dawson, 1998; Childerhouse *et al.*, 1998). Research on sperm whales at Kaikoura (42°S) has used mark-recapture and acoustic surveys to study distribution and abundance. Mark-recapture estimates are based on photographic identification data (Childerhouse *et al.*, 1995). Almost all sperm whales encountered at Kaikoura are single males, and all can be photographically identified. Photographs are graded on both photographic quality and distinctiveness. The stability of ID markings has been checked by treating tail flukes as if they are double tagged and looking at each side of each fluke independently (Childerhouse *et al.*, 1996). Photo-identification data have also been used to study seasonal changes in distribution and abundance. Of 135 identified individuals, about half (63) are seen repeatedly, during summer and winter (for up to 10 seasons). The other half (72 individuals) apparently transited through the area and have only been seen in one season. Mark-recapture models will be developed to take account of this population structure. There were significant differences in distribution, abundance and diving behaviour between summer and winter (SC/50/CAWS38; SC/50/CAWS39), which are apparently related to prey distribution (SC/50/CAWS38). Work is in progress to look at finer-scale changes in distribution and abundance by season, and correlations with environmental variables.

Acoustic surveys off Kaikoura have used directional and omnidirectional hydrophones. This work can be used to complement, or as an alternative to, the towed hydrophone array methods described in SC/50/CAWS20. Directional hydrophones are used from small vessels, including a 7m hard-hulled inflatable. This makes it possible to: (a) carry out small-scale work on distribution, abundance, movements and acoustic behaviour; (b) track individuals in order to study diving behaviour and acoustic behaviour; and (c) calibrate visual and acoustic surveys, and measure group size acoustically. A computer program has been developed to count the number of clicks in a sperm whale recording. Work is continuing to calibrate and ground-truth acoustic surveys by recording individual whales for complete dive cycles, estimating the click rate per individual, and estimating the range of the directional and omnidirectional hydrophones. Stereophotography (Dawson *et al.*, 1995) can be used to answer questions about movements and population structure. For example, in Kaikoura some of the largest individuals are resident in the area and there is no sign that they leave at the onset of the breeding season (SC/50/CAWS39).

On the subject of photo-identification, the sub-committee stressed the importance of evaluating photographs separately for quality and distinctiveness. Quantitative evaluation of these criteria was needed; different matchers should be compared in their scores, for instance, and possible changes in these criteria with time investigated. It was suggested that a compilation of photo-identification efforts on sperm whales (as done for humpback whales, for instance) should be considered, and this was referred to the intersessional group planning the sperm whale stock assessment.

It was agreed that a major topic of the Comprehensive Assessment should be a discussion of the best method of assessing sperm whale abundance.

9.4 Stock structure

Brownell spoke on a progress report on genetic data for North Pacific sperm whales (SC/50/CAWS19). The mtDNA control region and six microsatellites were being investigated in historical samples from the Japanese whaling industry and in contemporary samples from biopsies, strandings, etc. Analyses at the Southwest Fisheries Centre in the USA are concentrating on the eastern North Pacific - preliminary results indicate a striking subdivision between samples taken within about 300km of the coast and those offshore as far east as Hawaii. However this result had to be interpreted with caution because the offshore samples were collected 20 years earlier than the coastal samples, and nuclear gene frequencies may change quite rapidly because of sperm whale social structure and the likely effects of relative male depletion. Recommendations were that: (a) an empirical investigation of shifts in gene frequency through time should be made using historical samples from the Japanese whaling industry; (b) samples from whole groups of sperm whales should be investigated for social structure; and (c) future sampling should concentrate on taking fewer samples from more schools, rather than multiple sampling of a few schools.

As regards (b), Kato reported that the only samples remaining from Japanese Special Permit catches of whole schools might be teeth and he enquired whether these could be used for genetic analysis. Baker replied that teeth were good candidates for genetic work, even after moderate heating that might have been necessary for cleaning. It was important to be sure, however, that one was dealing with unique individuals. The sub-committee recommended that the use of sperm whale teeth for genetic analysis be examined further, and that the collection of material from mass strandings of sperm whales should be strongly encouraged.

9.5 Catches

The sub-committee welcomed document SC/50/CAWS24 on density-dependent habitat selection and the modelling of sperm whale exploitation. It was appreciated that this was an important paper, especially its conclusion that the movement of sperm whales in response to greater resource availability may make CPUE a very poor measure of local depletion, and the inferences for estimating the size of stocks from sightings surveys. However due to a lack of time the sub-committee did not discuss its contents in detail.

Mikhalev (SC/50/CAWS40) described Soviet catching of sperm whales in the Arabian Sea and biological information from the catch. Two Soviet expeditions took a total of 954 sperm whales including 750 females over four seasons (1963-66), but only reported a catch of 424 whales including 75 females to the Bureau of International Whaling Statistics. The distribution of catches was very similar to that for 19th century whaling. The author concluded that evidence (high incidence of ambergris, absence of oval scarring) indicated that this was a discrete population separated from the rest of the Indian Ocean.

In response to queries regarding his conclusion that sperm whales have a gestation period of less than one year, Mikhalev replied that he believed the simultaneous presence of groups of large and small foetuses in the data pointed to a supplementary period of conceptions. In response to other queries he responded that although extensive marking of sperm whales had occurred in the area, there had been no recoveries in the data he had available. Little biological material, apart from a few small foetuses, remained from these catches.

Yagi questioned the accuracy of the data presented, asking whether it had been peer-reviewed or made available to other scientists. Mikhalev responded that the information on past USSR catches had been collated by Zemsky, Berzin, Tormosov and himself, each of whom (from different laboratories) had sailed with one or other of the four Soviet fleets that had operated in the Southern Hemisphere, and must be considered the foremost experts in the field. He in fact had personally witnessed the sperm whaling in the Arabian Sea.

Brownell introduced a summary of information on USSR pelagic catches of sperm whales in the North Pacific between 1949 and 1979 (SC/50/CAWS27). Yearly fleet summaries for some seasons were provided by the late Dr A.A. Berzin to the authors, relating to the *Vladivostok* fleet during the period 1963-1978 and the *Danij Vostok* fleet during the period 1963-1979. A comparison with official catch statistics submitted to BIWS by the Soviet authorities revealed serious inconsistencies. The total USSR catches for six years (1966, 1967, 1970, 1971, 1972 and 1973), for instance, was officially declared as 37,275 whales, whereas the Berzin data indicated that 66,950 sperm whales were actually caught (or 1.8 times the official catch). Furthermore, the Berzin data revealed that in the years 1966, 1967, 1970 and 1971, the true catch of males was 1.3 times, but the female catch 9.6 times, greater than the official records for these two expeditions. The authors believed that similar under-reporting of sperm whale catches occurred on other Soviet whaling expeditions in the North Pacific, at least until 1972, when the International Observer Scheme (IOS) came into effect. They estimated that about 180,000 sperm whales may have been taken by Soviet whaling expeditions between 1949 and 1979, or about 60% higher than the officially reported catch.

In discussion, Brownell cautioned against assuming that the IOS was completely effective in stopping under-reporting of sperm whale catches in the North Pacific, as experience from one Soviet factory ship in the Southern Hemisphere was that some under-reporting continued after the IOS was introduced. In response to queries he stated that there was no information on the locations of the undeclared catches, and he did not know if any biological data were available for these whales.

Kasuya then introduced SC/50/CAWS10, in which he stated there was some evidence of statistical manipulation in the Japanese coastal sperm whale fishery. Official length composition data frequently featured an unrealistically large number of individuals at or just above the minimum length, compared to the number just below that length. The sex ratio in samples of whales examined by biologists (and an International Observer) differed greatly from that in the official statistics, with females being markedly under-represented in official statistics compared to the samples examined in ten seasons between 1959 and 1985. A catcher-boat log from 1959-61, when a Japanese domestic quota for sperm whales had just been introduced, differed from official figures for the numbers of whales killed by the company concerned; towards the end of each season, the number of sperm whale kills listed in the log exceeded the total declared for that month by the company concerned. The author concluded that the extent of such discrepancies was unknown, and was likely to differ greatly with month, year and company concerned, but was probably sufficient to render the catch statistics from coastal sperm whaling unreliable for the purposes of the Comprehensive Assessment. He stressed the need for further effort to discover independent sources of statistical information.

Okamoto and Moronuki stated that it was the policy of the Japanese Government to provide the most accurate statistics possible to the IWC, and that they were not convinced that the information provided in SC/50/CAWS10 was any more reliable, given that it referred to some 40 years ago, nor that it was necessarily representative of the whole time series of catches. At this stage they considered that it was essential that these allegations should be thoroughly investigated before any conclusions were drawn as to the reliability of the data. Ohsumi pointed out that some features of the official statistics were similar to those seen in statistics of other nations taking sperm whales, and that for the purposes of the Comprehensive Assessment it was necessary to recognise when such data were inaccurate and to make appropriate adjustments.

A number of speakers agreed with the latter sentiment, and in particular that if there was to be progress with the Comprehensive Assessment of this stock then efforts should be directed at attempting to compile as accurate a catch series as possible. If exact figures could not be found, then realistic upper bounds should be sought to express the range of uncertainty. Brownell noted that the problem of sperm whale catches being recorded as Baird's beaked whales in the small-type whaling operations in Japanese waters was discussed in the Scientific Committee as early as 1976 (Balcomb and Goebel, 1977), and more recently by Kasuya *et al.* (1997). However no action had been taken to correct these statistics. A small group under Ohsumi was therefore set up to work intersessionally on developing a catch series that could be used in the Comprehensive Assessment. The exact terms of reference of the group would be developed in consultations between Ohsumi and Brownell.

Ohsumi then presented his review of the history of Japanese regulatory measures for sperm whaling in the North Pacific (SC/50/CAWS12). This had been prepared in response to a request from the intersessional group on the Comprehensive Assessment of sperm whales under Brownell. Regulatory measures were introduced as early as 1909, and included in turn, limitations on effort, catch (by whaling classification), minimum (and later maximum) size, catch of lactating females, season, and whaling ground.

The sub-committee welcomed this paper, and suggested that similar compilations of national regulations and restrictions (including enforcement) should be prepared as part of future Comprehensive Assessments.

9.6 Other

The presence of sperm whales off the coast of Oman was confirmed by six sightings between 1994 and 1997, including single animals and groups of up to 24-50 animals (SC/50/CAWS22). Three of these sightings occurred in the Gulf of Oman and three in the Arabian Sea. A further sighting of 4-6 sperm whales, including a large male, was made off the United Arab Emirates in July 1995.

Interactions between sperm whales and trawlers were recorded in the northwest Atlantic, with sighting rates being about 30 times greater when the net was being hauled than at other times (SC/50/O16). It appeared likely that the whales were all males and feeding on fish escaping from the net.

10. SOUTHERN HEMISPHERE MINKE WHALES

Fujise described progress on work to address outstanding issues regarding JARPA that had been raised at last year's meeting (Appendix 8). This included developing methods to correct bias in abundance estimates, stock definition, statistical analysis of mtDNA, a pilot study on nuclear DNA, availability of low-latitude genetic material, analysis of morphometrics, examination of stock boundaries between Areas IV and V, a segregation study, recalculations of biological parameters by biological stock, a mesoscale survey plan for ecosystem and environmental change. In addition, the Scientific Committee had discussed the availability of samples from past commercial whaling for stock identification analysis and the problem of representativeness of samples. Results of some of this work are discussed below.

Although the interval since the last meeting had been unusually short, the sub-committee felt it was helpful to receive this progress report, and looked forward to more detailed responses at the next Scientific Committee meeting.

10.1 1997/98 Antarctic cruise results

Ensor introduced SC/50/Rep1, the cruise report of the 1997/98 SOWER Antarctic cruise. The Japanese Government had supplied two research vessels, the *Shonan Maru* and the *Shonan Maru No. 2*, and for the first time four researchers were carried on each vessel. The target area to be surveyed was Area IIW (between longitudes 60° and 30°W) and south of 60°S. This was the third survey of Area II, the previous cruises being in 1981/82 and 1986/87. The ships left Punta Arenas on 14 January and arrived at Cape Town on 26 February 1998. Two days were reserved for blue whale research. A total of 3,008 n.miles was surveyed on effort in the research area, and 200 sightings of 422 minke whales were made. Survey coverage was affected by the ice edge, which reached the normal northern boundary of the research area in places, forcing the northern boundary to be moved to 58°S. Sufficient progress was made to enable extension of the coverage westwards to 25°W. Experiments conducted included estimated distance and angle, and biopsies were taken from 6 blue, 10 humpback, 5 southern right, 3 sei, 3 killer whales and 3 short-beaked common dolphins. South of the main ice edge, satellite imagery indicated a large (approximately 100,000 n.mile^2) area of open water in the southern Weddell Sea which the survey vessels could not enter because of an ice barrier. This might have accounted for the number of minke whales seen being less than expected, as they were presumably able to pass under the ice and into this ice-free area.

Kato expressed his thanks to Ensor and his colleagues for their leadership and hard work under difficult conditions. He pointed out that the survey had also encountered a large number of fin whales (39 sightings of 204 animals), but relatively low minke whale sighting rates. He asked whether this could be correlated with the unusual ice conditions. Ensor replied that the fin whales were mainly observed north of the usual survey area, in relatively warm water; therefore the detection of fin whales appeared not to be influenced by the unusual ice conditions. However, the lower minke sighting rate might have been due to minkes being in the large open water area that could not be surveyed.

The sub-committee expressed its thanks to the Japanese Government for the generous provision of these vessels, and to Ensor and the other researchers for their efforts.

Nishiwaki reported on the results of the 1997/98 JARPA survey (SC/50/CAWS8). This had been conducted in Area IV and the eastern part of Area III from 17 December 1997 to 14 March 1998. One dedicated sighting vessel and three sighting/sampling vessels were engaged in a sightings

survey in closing mode. The sighting vessel covered 5,136 n.miles and made 127 primary sightings of 243 minke whales, while the three sighting/sampling vessels searched a total of 16,462 n.miles and made 545 primary sightings of 1,130 minke whales. A total of 526 minke whales was targeted for sampling, of which 438 were caught (110 from Area III and 328 from Area IV). The proportion of sexually mature animals was very low amongst the females (22.7%) in Area IV, and immature females dominated in the southern stratum. It was suspected that most of the mature females had moved into ice-free waters inside the pack-ice edge where the research vessel could not enter. It was suggested that one of the probable reasons for the character of the present survey results was the different shape of the ice edge.

In discussion, the question of the implications of the apparent environmental effect on the observed maturity rate in females was raised, particularly as it related to the success of the JARPA programme in obtaining representative samples. Nishiwaki replied that it was not known whether the trend would continue, and further study was needed to compare the data with previous results.

10.2 Subspecies and stocks

Field characters for distinguishing between the two forms of southern minke whale were described and illustrated in SC/50/CAWS15. This was important if abundance estimates from sightings surveys were to be correctly allocated.

The results of RFLP analysis of the mitochondrial DNA (mtDNA) in minke whales from Areas V and VI sampled during the JARPA survey of the 1996/97 austral summer season were presented in SC/50/CAWS4. Samples were divided into three longitudinal sectors: Area V Western (130°E-160°E), Area V Eastern (160°E-170°W) and Area VI Western (170°W-140°W) and two time periods, early and late in the survey season. A total of 361 whales was examined (VW-late $n=98$; VE-early $n=67$; VE-late $n=105$; VIW-early $n=91$). For comparison the group VIW-early of the 1985/86 commercial season was used ($n=134$). Quantification of the mtDNA differentiation among area/time groups was carried out using the Analysis of Molecular Variance (AMOVA). No significant differences were found among the area/time groups of the 1996/97 survey. The combined sample of the 1996/97 survey showed significant differences with a standard sample of the 'western stock' but not with a sample of the 'core stock'. The same results were found when each of the area/time groups of the 1996/97 survey and the group VIW early 1985/86 were compared with the standard samples. A comparison among survey seasons for different area/time groups suggested that yearly variation seems to occur in Area IIIE and Area IVW.

The sub-committee noted that this study confirmed that the 'western' stock was different from the others studied, which were all similar.

A preliminary examination of mitochondrial DNA heterogeneity in Antarctic minke whales considering temporal, longitudinal and latitudinal (distance from the ice-edge) factors was presented in SC/50/CAWS7. A total of 563 samples from Area IV taken during the 1989/90 and 1991/92 JARPA surveys was used in this exercise. AMOVA was used to test for: (a) the latitudinal factor in total Area IV (dividing offshore and ice-edge samples by a line at 60 miles from the ice edge); (b) the longitudinal (Area IV western and eastern) and latitudinal factors; and (c) the latitudinal, longitudinal and temporal factors (early and late period in the survey season). The only source of mtDNA heterogeneity was attributed to minke whales from the western part of Area IV taken in offshore areas in the early period of the survey season.

The sub-committee noted that this study concluded that the differences in the 'western' stock were attributable to an early, offshore component, and that because the commercial catch had been mainly near the ice edge, the analysis of past commercial catches would not be particularly useful for stock identification.

10.3 Abundance and trends

Polacheck presented SC/50/CAWS32, which examined VPA analyses of Southern Hemisphere minke whales in Areas IV and V by Butterworth *et al.* (1997; 1999). Butterworth *et al.* (1999) had concluded from their analyses that there was an increasing trend in recruitment in this stock prior to the period of exploitation. SC/50/CAWS32 investigated the effect of changing two key assumptions in the VPA formulation of Butterworth *et al.* (1999), the assumptions with respect to selectivity and separability among the older age classes during the period of the commercial catches. This investigation was carried out by replacing these assumptions with the assumption that there was no temporal trend in recruitment prior to exploitation and examining whether the data on current abundance could be fit under this assumption and whether the resulting apparent selectivities for the commercial catches were plausible. If the assumption of no temporal trend proved to be inconsistent with current abundance data or if it led to implausible selectivity curves, this would support the conclusions of Butterworth *et al.* (1999).

SC/50/CAWS32 concluded that constant pre-exploitation recruitment was consistent with the basic input data and population dynamics model of Butterworth *et al.* (1999). A lack of pre-exploitation recruitment trend implied a dome-shaped selectivity curve for the commercial catches with a decrease after age 17-26. The results of Butterworth *et al.* (1999) also implied a dome shape and a decrease in catch at older ages. However, the peak in the selectivity curves in Butterworth *et al.* (1999) occurred at somewhat older ages (23-29). SC/50/CAWS32 discussed factors affecting realized selectivities that could have led to the estimated selectivity curves. These included the possibility that older animals found refuge in portions of Areas IV and V where there was little whaling effort or in the pack ice where whalers could not follow.

SC/50/CAWS32 concluded that the VPA modelling framework, by itself and given the available data, appeared unable to resolve the issue of the pre-exploitation trends in recruitment. It concluded that the estimates were critically dependent upon assumptions either about trends in past recruitment or selectivities and separability in the commercial catch. Within the VPA context, it was concluded that a resolution would require convincing external evidence favouring a specific selectivity pattern. Polacheck suggested that a way forward would be a more detailed examination of the spatial/temporal pattern of the age compositional data from the catches than had yet been carried out and more complete tests of sensitivity to assumptions than were reported in Butterworth *et al.* (1999).

Butterworth responded that the selectivity assumptions in Butterworth *et al.* (1999) had been motivated on two independent grounds, biological and statistical. On the biological front, increasing selectivity with age was suggested by whalers' desire to take larger, hence older, animals and the fact that whaling took place close to the ice

edge where older animals tended to predominate. He drew attention to table 4 of Butterworth *et al.* (1999), which showed an increasing trend in the age of animals caught in Area IV by degree latitude from 61° to 66°S. He noted, in response to suggestions in SC/50/CAWS32 that differential male/female availability might be confounding the results, that Butterworth *et al.* (1999) had shown that key results were essentially unchanged when analyses were conducted on a sex-disaggregated basis. He considered that the possibilities suggested by Polacheck to explain the age-selectivity curves resulting from the assumption of no trend in recruitment prior to exploitation were inadequate to explain the large fraction of otherwise takeable whales implied to be unavailable by these curves.

On the statistical front, Butterworth noted that the conclusions of Butterworth *et al.* (1999) regarding the historic increase in recruitment were unchanged when the slope of the commercial selectivity at age from ages 22 to 30 was treated as an estimable parameter. He agreed with Polacheck that this analysis was conditional on the assumption that the maximum in commercial selectivity with age would occur beyond age 21. He believed that other runs of the model, not reported in Butterworth *et al.* (1999), had led to rejection of alternative assumptions regarding that maximum age on the basis of likelihood ratio tests. However, the relevant outputs would have to be checked, and that was not possible in the time before the sub-committee would conclude its work. Furthermore, the analyses of SC/50/CAWS32 made no allowance for any pattern in selectivity in the commercial catch as is conventional in the application of VPA to fisheries, and hence ignored the information content of these data with respect to the historic recruitment trend.

Hatanaka noted that the low selectivity for older ages in SC/50/CAWS32 is inconsistent with the actual situation. He anticipated that these analyses using age data can elucidate the real trend of recruitment, and emphasised that such valuable data are obtained only by lethal sampling.

Ohsumi noted that the assumption of SC/50/CAWS32 that there was no temporal trend in recruitment prior to exploitation was contradicted not only by the analyses of Butterworth *et al.* (1999) but also by analyses of Kato (1987), Kato and Sakuramoto (1991), Thomson *et al.* (1997) and Butterworth *et al.* (1997) that showed a decline in age at sexual maturity and by anecdotal reports from whalers. Polacheck reiterated that his results do not indicate that there was no trend but rather that the VPA modelling framework without selectivity assumptions similar to those in Butterworth *et al.* (1999) is unable to resolve the question. He noted that if data on encounter rates over time were available, an analysis incorporating these data into the VPA framework might provide evidence for a trend. Polacheck also noted that the same data used in Butterworth *et al.* (1999) to indicate a latitudinal trend in age near the ice edge also showed an equally high mean age between 59° and 61°S as at the ice edge. Polacheck further noted that the role and dependence on the selectivity assumptions in Butterworth *et al.* (1999) were substantially different than in most conventional fisheries applications. This is because of the low cumulative fishing mortality rates and the small amount of external information available for fitting the VPA model in this case.

Smith noted that new information presented under Item 10.1 supported the possibility of animals being south of the pack ice edge. Large areas of open water are noted to have existed during the periods of the SOWER and JARPA surveys, unavailable for sampling. He also noted that the factory vessels apparently tended to be 5-20 n.miles north of the ice edge (de la Mare, 1997). Thus the possibility of age selectivity within 60 n.miles of the ice edge needed to be further explored. This general issue also raises the possibility that JARPA age samples are not representative for older animals, as has previously been shown for younger animals.

The sub-committee agreed that, although some analyses of age and sex distributions of minke whales as a function of latitude (Ohsumi and Masaki, 1975; Kato, 1982; 1983; Kato *et al.*, 1991) had been conducted, the accumulating JARPA data permitted the examination of age and sex gradients approaching the ice edge on a finer scale (e.g. within 60 n.miles) than had been done. Longitudinal effects in these distributions could also be further examined. It was agreed that conducting such analyses should be added to the list of tasks identified for JARPA. These analyses might shed some light on what assumptions regarding selectivity of the commercial catch are most reasonable.

The sub-committee also agreed that additional sensitivity tests which encompassed a wide range of selectivity patterns might help to resolve this issue. Since there was no time to complete and consider these, the sub-committee was unable to reach agreement at this meeting regarding whether or not the selectivity assumptions of Butterworth *et al.* (1999) were supported.

Working papers elaborating on and providing a rationale for the comments summarised above were prepared by Butterworth, Punt and Polacheck. These are included in Appendices 9-11.

In SC/50/CAWS34 minke school density is estimated from the first six IWC/IDCR independent observer (IO) surveys from 1985/86 to 1990/91, using methods which model heterogeneity due to covariates such as school size and sea state in addition to perpendicular distance. Incorporating these covariates reduces bias in estimated density by about 15% compared to the case in which the IO data are analysed using only perpendicular distance. However, comparison with standard line transect results indicates that the estimates of density obtained from the analysis of IO data remain substantially negatively biased even when heterogeneity due to school size and sea state is modelled. The IO analysis methods are vulnerable to bias from heterogeneity in school surfacing patterns if both platforms search the same region of sea simultaneously. Plots of first sighting distances ahead of the vessel of sightings by the two independent platforms show that they do search the same region at the same time, and this is believed to be the primary source of bias in the IO analysis. The authors conclude that if unbiased estimates of density are to be obtained from IWC Antarctic surveys in the future without assuming certain detection on the trackline, it is important to separate the regions that the two independent platforms search. In particular, consideration should be given to using the search procedure suggested by Buckland and Turnock (1992).

In discussion, Butterworth drew attention to the fact that the implications of this paper were that the design of IO experiments on the SOWER cruises needs to be reconsidered. The sub-committee agreed to refer this issue to the proposed SOWER planning meeting in Tokyo, but it was suggested that an immediate and comprehensive change in procedure may be undesirable, in that it could cause problems of comparability with previous estimates. The Buckland-Turnock Method might be used experimentally for part of the IO mode survey.

10.4 Other

SC/50/O3 described several research projects conducted on Antarctic minke whales at the Institute of Cetacean Research (ICR). Age composition and reproductive status of the minke whales sampled are being investigated. Genetic variation at the mitochondrial and nuclear DNA (microsatellites) levels is being examined to investigate stock structure in Areas IV and V. Methods of correction of sampling bias are being explored and a revision of the abundance estimation under JARPA is being carried out. Other research underway included analysis of stomach contents, accumulation of heavy metals and organochlorines as well as several physiological studies.

Seven strandings of minke whales along the São Paulo State coast of Brazil between 1986 and 1987 included at least three of the dwarf form and two of the ordinary (dark shoulder) form (SC/50/O5).

11. OTHER SPECIES AND/OR STOCKS

SC/50/CAWS6 and 13 on Bryde's whales were considered by the RMP sub-committee. Information on a number of species off Brazil in SC/50/O5 was welcomed but was not discussed due to lack of time.

12. OTHER ISSUES

12.1 Future SOWER cruises

12.1.1 Report of intersessional group

The report of this group was considered by the small group under Kato (Item 12.1.2).

12.1.2 Planning for 1998/99 cruise

A small group under Kato was formed to consider this Item.

The sub-committee recommended that the 1998/99 cruise should take place principally in Area IV south of 60°S, but with the possibility of including sections of eastern Area III where blue whale concentrations might be found. The cruise would include at least 11 days of dedicated time for blue whale research. The sub-committee also recommended that there should be a planning meeting for this cruise in Tokyo, and that funds should be provided for the attendance of the cruise-leader, a sightings specialist and an acoustics specialist. Details were considered and will be reported to the full committee.

12.2 Acoustics – report of intersessional correspondence group

Swartz reported on progress made by this group since the last meeting (SC/50/O14).

The sub-committee endorsed the proposal that a library of whale sounds be compiled, with a view to archiving representative samples and making copies available to interested researchers: the preferred format was digital, for ease of exchange. The working group was encouraged to continue its work during the coming year and to expand the scope of the acoustic methods considered.

With regard to recordings of blue whales (Item 4.2.2 and Appendix 2), the sub-committee recommended that all blue whale recordings from the SOWER cruises should be gathered in one place and put in a format that makes them accessible to researchers. It was agreed that a working group under Clark would be set up to coordinate the process, which should involve all the stake-holders in the blue whale recordings made to date. The aim would be to provide a properly archived and annotated series of sounds, the analysis of which would be presented at the next IWC meeting. It was estimated that a sum of $3,000 would be required to cover the costs of analysis, and a total of $3,000 for editing and archiving the sounds onto CD ROM.

12.3 Mathematically-based techniques for recognition analysis

The sub-committee was disappointed that no progress had been made on this topic since the last meeting, although they recognised that there had been problems in getting the right people to this meeting as invited participants.

The sub-committee was informed that the computerised right whale matching programme developed by Hiby under an original IWC (and later IFAW) contract was now complete, and had been demonstrated at the right whale workshop. Hiby was now investigating a similar possible system for humpback whale flukes.

12.4 Biopsy sampling – collection of behavioural data

Clapham reported on the results of an intersessional working group. A draft data form was designed which standardised collection of the necessary information. This was now submitted to the Scientific Committee for comment.

In discussion it was stressed that the form was mainly intended for genetics analysts who required associated behavioural information, and that other researchers were free to modify it to suit their species/area of interest. However the form contained the basic information required, and while items could be added, none should be deleted.

The sub-committee recommended that the basic form should be adopted (once comments had been incorporated) and that consideration should then be given to making the form available electronically through the Secretariat.

13. PRIORITIES AND DIRECTIONS FOR FUTURE SCIENTIFIC COMMITTEE WORK (LONG TERM)

Future priority items are presented in Table 1.

The sub-committee noted that this list did not preclude papers on other subjects appropriate to the sub-committee's terms of reference being submitted in any year, but these might only be discussed in full if their subject matter was pertinent to a priority topic at that meeting.

The Southern Hemisphere humpback assessment planned for 1999 would only be preliminary given outstanding issues of catch allocation and stock identity. These problems were unlikely to be solved in the immediate future, but the results of the preliminary assessments might help establish how critical the uncertainties were in each case.

Brownell noted the problems related to stock structure have been a major problem for all assessments in this committee since it started. If the committee was interested in the Comprehensive Assessment of North Pacific sperm whales, it should start work as soon as possible. To start this work as soon as possible, it was necessary to pool the North Pacific sperm whale samples from the United States and Japanese collections. The people and funding were available to start work on this project immediately.

Table 1

Future priority items. For detailed descriptions of the work proposed see the indicated Agenda Items. Items are not prioritised within each year. This schedule will be reviewed and revised each year.

Year	Item
1999	Southern Hemisphere blue whales
	Differentiating forms (Item 4.2.2)
	Abundance estimates (Item 4.2.1)
	Western North Atlantic right whales
	Abundance, trends, and vital rates (intersessional meeting – Item 5.2)
	Southern Hemisphere Humpback Whales
	Preliminary stock assessments (Item 6.3.1)[1]
	Comparative data from northern stocks (intersessional group – Item 6.4)
	Southern Hemisphere minke whales
	Recruitment trends, (VPA analysis) (Item 10.3)
	Abundance estimation
	(IO approaches, GAM-based estimates) (Item 10.3)
2000	Southern Hemisphere blue whales
	Review of catch and survey data to identify geographic areas of concentration for future study (Item 4.2.1)
	North Atlantic humpback whales
	Comprehensive Assessment (Item 7.1)
	North Pacific sperm whales
	Abundance estimation methods (Item 9.3)
	Southern Hemisphere minke whales
	Abundance estimates (Item 10.3)
2001	Southern Hemisphere humpback whales
	Stock structure (Item 6.3.2)
	North Pacific sperm whales
	Stock structure (Item 9.4)
	Southern Hemisphere minke whales
	Stock structure (Item 10.2)
After 2001	Southern Hemisphere blue whales
	Comprehensive Assessment
	Southern Hemisphere humpback whales
	Comprehensive Assessment
	North Pacific humpback whales
	Comprehensive Assessment
	North Pacific sperm whales
	Modelling - catch history
	Multi-species ecosystem considerations
	North Pacific
	Southern Hemisphere

[1] See text.

Ohsumi noted that large amounts of data have accumulated on various species from which it might be possible to examine multi-species problems, and there was a need to prepare for a future examination.

14. ADOPTION OF REPORT

The report was adopted on 6th May 1998.

REFERENCES

Baker, C.S. and Medrano-González, L. 1998. World-wide distribution and diversity of humpback whale mitochondrial DNA lineages. *In:* C.J. Pfeiffer (ed.) *Molecular and Cell Biology of Marine Mammals.* Krieger Publishing Co, Melbourne, FL.

Baker, C.S., Perry, A., Bannister, J.L., Weinrich, M.T., Abernethy, R.B., Calambokidis, J., Lien, J., Lambertsen, R.H., Urban, J., Vasquez, O., Clapham, P.J., Alling, A., O'Brien, S.J. and Palumbi, S.R. 1993. Abundant mitochondrial DNA variation and world-wide population structure in humpback whales. *Proc. Natl Acad. Sci. USA* 90:8239-43.

Baker, C.S., Flores-González, L., Abernethy, B., Rosenbaum, H.C., Slade, R.W., Capella, J. and Bannister, J.L. 1998. Mitochondrial DNA variation and maternal gene flow among humpback whales of the Southern Hemisphere. *Mar. Mammal Sci.* [In press].

Balcomb, K.C. and Goebel, C.A. 1977. Some information on a *Berardius bairdii* fishery in Japan. *Rep. int. Whal. Commn* 27:485-6.

Buckland, S.T. and Turnock, B.J. 1992. A robust line transect method. *Biometrics* 48:901-9.

Butterworth, D.S., Thomson, R.B. and Kato, H. 1997. An initial analysis of updated transition phase data for minke whales in Antarctic Area IV. *Rep. int. Whal. Commn* 47:445-50.

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). [In Press].

Calambokidis, J., Steiger, G.H., Straley, J.M., Quinn II, T.J., Herman, L.M., Cerchio, S., Salden, D.R., Yamaguchi, M., Sato, F., Urbán R, J., Jacobsen, J., von Ziegesar, O., Balcomb, K.C., Gabriele, C.M., Dahlheim, M.E., Higashi, N., Uchida, S., Ford, J.K.B., Miyamura, Y., Ladrón de Guevara P, P., Mizroch, S., Schlender, A. and Rasmussen, K. 1997. Abundance and population structure of humpback whales in the North Pacific basin. Contract report submitted to NMFS. 72pp.

Chaloupka, M. and Osmond, M. 1998. Spatial and seasonal distribution of humpback whales in the Great Barrier Reef region. (Unpublished). 25pp.

Childerhouse, S.J. and Dawson, S.M. 1998. Stability of fluke marks used in individual photoidentification of male sperm whales at Kaikoura, New Zealand. (Unpublished).

Childerhouse, S.J., Dawson, S.M. and Slooten, E. 1995. Abundance and seasonal residence of sperm whales at Kaikoura, New Zealand. *Can. J. Zool.* 73(4):723-31.

Childerhouse, S.J., Dawson, S.M. and Slooten, E. 1996. Stability of fluke marks used in individual photo-identification of sperm whales at Kaikoura, New Zealand. *Mar. Mammal Sci.* 12:447-51.

Dawson, S.M., Chessum, C.J., Hunt, P.J. and Slooten, E. 1995. An inexpensive, stereophotographic technique to measure sperm whales from small boats. *Rep. int. Whal. Commn* 45: 431-6.

de la Mare, W.K. 1997. Abrupt mid-twentieth-century decline in Antarctic sea-ice extent from whaling records. *Nature London* 389:57-60.

Ellis. 1958. Aspectos da pesca da balea no Brasil colonial. *Coleção da Revista de História* 14:1-125. Sao Paulo.

Ellis. 1969. *A Baleia no Brasil Colonial.* Ediçoes Melhoramentos, Editora da Universidade de São Paulo, Sao Paulo, Brasil. 235pp.

Ellis. 1972. A Questao do Mar Territorial Brasileiro às Vésperas da Independência - A propósito de um documento inédito de José Bonifácio de Andrada e Silva. pp. 237-70. *In: D. Pedro I e Dona Leopoldina Perante a História.* Ediçao Especial do Instituto Histórico e Geográfico de Sao Paulo.

Gillespie, D. 1997. An acoustic survey for sperm whales in the Southern Ocean sanctuary conducted from the *RSV Aurora Australis. Rep. int. Whal. Commn* 47:897-907.

International Whaling Commission. 1993. Report of the Scientific Committee. *Rep. int. Whal. Commn* 43:55-228.

International Whaling Commission. 1997a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 47:59-257.

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. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48:55-302.

International Whaling Commission. 1998b. Report of the Scientific Committee. Annex H. Report of the Sub-Committee on the Other Great Whales. *Rep. int. Whal. Commn* 48:183-202.

Kasamatsu, F. and Joyce, G.G. 1995. Current status of Odontocetes in the Antarctic. *Antarct. Sci.* 7(4):365-79.

Kasuya, T., Brownell, R.L. and Balcomb, K.C. 1997. Life history of Baird's beaked whales off the Pacific coast of Japan. *Rep. int. Whal. Commn* 47:969-79.

Kato, H. 1982. Some biological parameters for the Antarctic minke whale. *Rep. int. Whal. Commn* 32:935-45.

Kato, H. 1983. Some considerations on the decline in age at sexual maturity of the Antarctic minke whale. *Rep. int. Whal. Commn* 33:393-9.

Kato, H. 1987. Density dependent changes in growth parameters of the southern minke whale. *Sci. Rep. Whales Res. Inst., Tokyo* 38:47-73.

Kato, H. and Sakuramoto, K. 1991. Age at sexual maturity of southern minke whales: a review and some additional analyses. *Rep. int. Whal. Commn* 41:331-7.

Kato, H., Fujise, Y. and Kishino, H. 1991. Age structure and segregation of southern minke whales by the data obtained during Japanese research take in 1988/89. *Rep. int. Whal. Commn* 41:287-92.

Kramer, D.L. and Weary, D.M. 1991. Exploration versus exploitation: A field study of time allocation to environmental tracking by foraging chipmunks. *Anim. Behav.* 41:443-9.

Larsen, A.H., Sigurjonsson, J., Oien, N., Vikingsson, G. and Palsboll, P.J. 1996. Population genetic analysis of mitochondrial and nuclear genetic loci in skin biopsies collected from central and northeastern North Atlantic humpback whales (*Megapetera novaeangliae*): population identity and migratory destinations. *Proc. R. Soc. Lond. Ser. B.* 263:1611-8.

Ljungblad, D.K., Stafford, K.M., Shimada, H. and Matsuoka, K. 1997. Sounds attributed to blue whales recorded off the southwest coast of Australia in December 1995. *Rep. int. Whal. Commn* 47:435-9.

Ljungblad, D.K., Clark, C.W. and Shimada, H. 1998. A comparison of sounds attributed to pygmy blue whales (*Balaenoptera musculus brevicauda*) recorded south of the Madagascar Plateau and those attributed to 'true' blue whales (*Balaenoptera musculus*) recorded of Antarctica. *Rep. int. Whal. Commn* 48:439-42.

McCauley, R.D., Cato, D.H. and Jeffery, A.F. 1998a. A study of the impacts of vessel noise on humpback whales in Hervey Bay. (Unpublished).

McCauley, R.D., Jenner, M.-N., McCabe, K.A. and Murdoch, J. 1998b. The response of humpback whales (*Megaptera novaeangliae*) to offshore seismic survey noise: preliminary results of observations about a working seismic vessel and experimental exposures. *APPEA Journal* :692-706.

Medrano-González, L., Aguayo, A.L., Urbán-Ramirez, J. and Baker, C.S. 1995. Diversity and distribution of mitochondrial DNA lineages among humpback whales, *Megaptera noveangliae* in the Mexican Pacific Ocean. *Can. J. Zool.* 73:1735-43.

Ohsumi, S. and Kasamatsu, F. 1982. Whale sighting efficiency of the crew onboard ocean research vessels in BIOMASS/FIBEX. pp. 108-19. *In: Memoirs of National Institute of Polar Research.* (Special Issue 23). Edn. National Institute of Polar Research, Japan.

Ohsumi, S. and Masaki, Y. 1975. Biological parameters of the Antarctic minke whale at the virginal population level. *J. Fish. Res. Board Can.* 32(7):995-1004.

Palsbøll, P.J., Clapham, P.J., Mattila, D.K., Larsen, F., Sears, R., Siegismund, H.R., Sigurjónsson, J., Vasquez, O. and Arctander, P. 1995. Distribution of mtDNA haplotypes in North Atlantic humpback whales: the influence of behavior on population structure. *Mar. Ecol. Prog. Ser.* 116:1-10.

Richards, R. 1993. *Into the South Seas: The Southern Whale Fishery Comes of Age on the Brazil Banks 1765 to 1812.* The Paramatta Press, Wellington. 128pp.

Smith, T.D., Allen, J., Friday, N. and Clapham. 1998. Status of information on the North Atlantic humpback whale. Annex H, Appendix 7. *Rep. int. Whal. Commn* 48

Thomson, R.B., Butterworth, D.S. and Kato, H. 1997. Has the age at maturity of Southern Hemisphere minke whales, as indicated by transition phase readings, declined over recent decades? Paper SC/M97/7 presented to the IWC Scientific Committee Intersessional Working Group to Review Data and Results from JARPA, May 1997, Tokyo.

Tonnessen, J.N. and Johnsen, A.O. 1982. *The History of Modern Whaling.* C. Hurst & Co., London. i-xx+798pp.

Würsig, B., Clark, C.W., Dorsey, E.M., Richardson, W.J. and Wells, R.S. 1983. Normal behaviour of bowheads, 1982. pp. 25-115. *In:* W.J. Richardson (ed.) *Behaviour, Disturbance Responses and Distribution of Bowhead Whales* Balaena mysticetus *in the Eastern Beaufort Sea, 1982.* LGL Ecological Research Associates Inc., Bryan, TX. for U.S. Minerals Management Service, 12203 Sunrise Valley Dr., Reston, VA 22091.

Appendix 1

AGENDA

1. Convenor's opening remarks, election of Chair, appointment of rapporteurs
2. Adoption of Agenda
3. Review of available documents
4. Southern Hemisphere blue whales
   - 4.1 Reports of the SOWER cruises
   - 4.2 Progress towards assessment
     - 4.2.1 Abundance and trends
     - 4.2.2 Subspecies and stocks
     - 4.2.3 Other
5. Right whales
   - 5.1 Report of the Cape Town Workshop
   - 5.2 Action arising
   - 5.3 Other
6. Southern Hemisphere humpback whales
   - 6.1 Progress in catch and marking data coding
   - 6.2 Establishment of Southern Hemisphere directory and Antarctic catalogue
   - 6.3 Progress towards assessment
     - 6.3.1 Abundance and trends
     - 6.3.2 Stock structure
     - 6.3.3 Further information on catches
     - 6.3.4 Other
   - 6.4 Future special meeting
7. North Atlantic humpback whales
   - 7.1 Report on progress towards assessment
   - 7.2 Action arising
8. North Pacific humpback whales
9. Sperm whales
   - 9.1 Report of the intersessional group (Brownell)
   - 9.2 Action arising
   - 9.3 Abundance and trends
   - 9.4 Stock structure
   - 9.5 Catches
   - 9.6 Other
10. Southern Hemisphere minke whales
    - 10.1 1997/98 Antarctic cruise results
    - 10.2 Subspecies and stocks
    - 10.3 Abundance and trends
    - 10.4 Other
11. Other species and/or stocks
12. Other issues
    - 12.1 Future SOWER cruises
      - 12.1.1 Report of intersessional group

12.1.2 Planning for 1998/99 cruise
12.2 Acoustics – report of intersessional correspondence group
12.3 Mathematically-based techniques for recognition analysis
12.4 Biopsy sampling – collection of behavioural data – report of intersessional group

13. Priorities and directions for future Scientific Committee work (longer term)

14. Publication of documents

15. Adoption of report

Appendix 2

SOUTHERN OCEAN ACOUSTIC RECORDINGS

Clark, Bannister, Findlay

Since 1995 there has been a deliberate effort as part of the SOWER program to explore field techniques for differentiating between pygmy and 'true' blue whales. This has resulted in a collection of acoustic recordings, some of which contain blue whale sounds (Ljungblad *et al.*, 1996; 1997; SC/50/CAWS29). Members of the sub-committee expressed an interest in knowing more about the status of the recording collection and the analyses of these data.

The total number of hours of tape recordings could not be determined at this time, but there is in the order of several hundreds of hours, not tens or thousands. Analysis and review of existing material has been done on an informal and voluntary basis to provide some preliminary results on the whale sounds. Ljungblad has reviewed many of the recordings from instances when tape logbooks from the ship on which he was working indicate that whales were vocally active. Sections of tape collected during the 1996/97 and 1997/98 recording efforts which were known to contain sounds, were copied and provided to Clark for preliminary analysis. For the 1997/98 effort this did not include material from Area II. For the 1996/97 analysis effort, Clark took the material sent to him and converted it onto CD-ROM, a medium that provided much more efficient access and analysis. Some of these CD-ROM data files were then provided back to Ljungblad. Significant portions of the available recordings have not been fully reviewed or analyzed for whale sounds.

As further recording efforts take place, and more becomes known about regional and subspecies characteristics of blue whale sounds, the value of organization and documentation of the recordings increases. Given the initial, though limited, success at collecting material (i.e., small number of samples of blue whale recordings in the Southern Oceans), and the early indications that sounds from true blue whales recorded in Area II are different from pygmy blue whales off Madagascar, it is important to: (a) properly archive all original recordings; (b) fully analyze all existing recordings in a consistent manner; and (c) properly copy all original recordings onto at least one standard format so that these data are available to IWC Scientific Committee scientists and other researchers worldwide. At the very least, the archival process includes collating all data associated with a recording (e.g., recording parameters, environmental conditions, behavioral observations).

We recommend that an acceptable natural sound library (e.g., BBC, LNS) serve as the repository for the original recordings. Clark offered to discuss this matter with the curator of the Cornell Library of Natural Sounds (LNS), which presently serves as the largest and most active sound library in the world. Clark further offered that the Cornell Bioacoustics Research Program would be willing to convert all appropriate material onto a common digital medium (e.g., CD-ROM readable on Macs, PCs and UNIX), and work with Don Ljungblad (and any others wishing to be involved) to complete the analysis of the acoustic data set in time for next year's meeting. This Bioacoustics effort to convert and analyze the recordings would require some modest support but until a full inventory of material is known, the level of support cannot be determined.

REFERENCES

Ljungblad, D.K., Stafford, K.M., Shimada, H. and Matsuoka, K. 1997. Sounds attributed to blue whales recorded off the southwest coast of Australia in December 1995. *Rep. int. Whal. Commn* 47: 435-439.

Ljungblad, D.K., Clark, C.W. and Shimada, H. 1997. Sounds attributed to pygmy blue whales recorded south of Madagascar, December 1996. Paper SC/49/SH17 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 11pp.

Appendix 3

RIGHT WHALES - REPORT OF THE CAPE TOWN WORKSHOP – CHAIRMAN'S SUMMARY

Last year, the Commission (IWC, 1997a, item 11.8.2) endorsed the Scientific Committee's recommendation (IWC, 1997b, item 10.3) for a special intersessional meeting on right whales, to be held in early 1998 in Cape Town, South Africa. Details of the proposal were formulated in last year's report, annex H, appendix 4.

The last scientific review of right whales was in 1983 (Brownell *et al.*, 1986). Since then, much new material has become available from studies of the northwest Atlantic right whale population, and from at least four Southern Hemisphere populations (Argentina, Australia, New Zealand, South Africa), based on photo-identification programmes, genetic and pollution studies. Information is now also available on previously unreported Southern Hemisphere pelagic catches. Some Southern Hemisphere populations are now increasing, but this has not been apparent for any Northern Hemisphere population. The status of northwest Atlantic right whales, with a population of perhaps only 300 animals, has been one of the most serious recent conservation issues facing any single large whale population. An attempt to explain that contrast was seen as a major focus of the special meeting.

As planned, a two-day public Symposium was followed by a six-day Workshop, in and south of Cape Town on 16-17 March and 19-25 March 1998, respectively. Workshop participants attended by invitation. The forty participants were drawn from eight nations, including national delegates and invited participants, and from the IWC Secretariat; there was equal representation from the Northern and Southern Hemispheres. The Workshop report was presented to the main Scientific Committee as SC/50/Rep4.

The Workshop addressed five main areas of interest:

(1) a detailed worldwide review of current information on right whale systematics, stock identity, historical and modern catches, biological parameters and estimates of abundance and trends, all based on information provided at the meeting, and leading to a population modelling exercise for the southern hemisphere;
(2) a worldwide comparison of population status;
(3) a detailed review of factors potentially affecting recovery;
(4) consideration of issues relating to whalewatching;
(5) conclusions on the implications of all the above for management, and on future research.

1. Worldwide review of current information (SC/50/Rep4, items 6-10)

Systematics (item 6)

The current classification of right whales is based, uniquely for large whales, on a taxonomic distinction between Northern and Southern Hemispheres (the northern right whale, *Eubalaena glacialis*, and the southern right whale, *E. australis*), and depends upon a single skull character. No study to date has examined other characters (morphological or molecular) to assess the validity of the traditional, morphological, classification. There is a lack of sampling from throughout the species' range, with little or no information on North Pacific *E. glacialis*, and genetic information on *E. australis* only from one or two populations or geographic regions. North Pacific right whales have either been classified as a subspecies of their North Atlantic counterpart, or described as full species; both North Atlantic and North Pacific right whales have been considered taxonomically distinct from Southern Hemisphere animals.

An examination of mitochondrial DNA material from three ocean basin forms of right whales (North Atlantic, North Pacific, Southern Oceans) gave results inconsistent with current taxonomy, supporting independent taxonomic status for all three forms (Rosenbaum *et al.*, 1998). The Workshop **recommended** that additional samples from those areas and some available from the South Pacific, plus additional historic and current North Pacific material, should be used in further analyses, and that the question of right whale taxonomic status be reconsidered by the Scientific Committee following publication of the results. In the meantime, assessments could continue on the basis of the results available at the meeting.

Stock identity: distribution and population separation (item 7)

The Workshop agreed it would attempt to identify present and past breeding (i.e. mating) and calving grounds as the basic 'management unit', together with associated feeding areas.

For each of five main regions (North Atlantic; North Pacific; South Atlantic and Indian Ocean coast of South Africa; Australia/New Zealand and Indian Ocean; Southern Hemisphere – general), the Workshop reviewed information on a series of topics, including distribution and seasonality on calving and feeding grounds, movements and genetic information. For some regions, information was included on historic catches, morphology and parasites. The results were synthesised for each region independently. Those relating to seasonal abundance were tabulated in detail for each of four regions (SC/50/Rep4, annex D, tables 1-4) in terms of both relative and absolute abundance.

The results for each region, as contained in the specific Synthesis section for each, can be summarised as follows.

A. NORTH ATLANTIC (ITEM 7.1.5)

Only animals found in the western North Atlantic can be considered a functioning extant unit. For practical purposes, that area can be considered a single 'management unit', from genetic evidence probably corresponding to a true biological population. Animals in the eastern North Atlantic may be considered as a 'relict' population or populations.

B. NORTH PACIFIC (ITEM 7.2.4)

Whether two or more stocks exist is still problematical. Only animals in the western area can be considered a functional extant unit. From their different catch and recovery histories it seems there were once at least two stocks, at least on the feeding grounds. Right whales summering in the Okhotsk Sea have been considered to be a separate population, wintering in the Sea of Japan and possibly the East China Sea, although it seems unlikely that animals found in such close proximity, notably in the Kuril Islands and Okhotsk Sea, would belong to separate stocks.

C. SOUTH ATLANTIC AND INDIAN OCEAN COAST OF SOUTH AFRICA (ITEM 7.3.6)

Three calving grounds in the South Atlantic (Brazil, Argentina, South Africa) from up to a possible six in the past, are now substantially populated. From genetic,

morphological and possibly parasite data, calving grounds off Brazil and Argentina should be considered as separate management units, but with a small amount of movement between them. Of five suggested South Atlantic feeding grounds, links (from photo-identification) have only been established between Argentina and the South Georgia area, and between South Africa and 'south of 50°S'.

D. AUSTRALIA/NEW ZEALAND AND INDIAN OCEAN EXCLUDING EAST AFRICA (ITEM 7.4.5)

Animals wintering on the Australian coast are considered a single management unit, probably comprising a true biological population. There is now evidence for more extensive movements into colder waters (as far as 65°S) than previously believed. Around New Zealand, the great majority are found in the Auckland-Campbell Islands area, and should be referred to as the New Zealand sub-Antarctic population, separate both from a New Zealand-Kermadec management unit and the Australian unit.

In the Indian Ocean, records of 19th century catching positions (Townsend, 1935) suggest a separate Central Indian Ocean management unit, with the possibility of another unit further to the west, near the Crozet Islands, although there is little evidence of animals there currently.

A number of specific recommendations arose out of the stock identity review, i.e. on collection and analysis of biopsy samples, the number, timing and localities for additional samples (see item 7.5 and table 1), and on analysis of stable isotopes from baleen, as well as recommendations relating to population structure, choice of genetic markers, genetic data analysis and reporting (item 7.6).

Historical and modern catches (item 8)

Pre-modern data (i.e. pre-1900) were reviewed for the North Atlantic, North Pacific and Southern Hemisphere, with sub-division by ocean in the latter. Given the lack of actual catch data, the kill has had largely to be obtained from oil or baleen production statistics; it is therefore estimated rather than known. Different assumptions and procedures have been used in past estimates. The same is true for adjustment for hunting loss; depending on the fishery the adjustment ranges from 1.2 to 1.5 times the landed catch.

In the North Atlantic (item 8.1.1), catching occurred from at least the 11th Century, in Basque coastal and pelagic whaling. While dozens of whales were taken in the Bay of Biscay each year until 1650, the pelagic catch elsewhere has, for example, been estimated at between some 25,000 to 40,000 right whales off Labrador in the 80-year period 1530-1610. The stocks had been severely reduced before Yankee whaling began in the mid 18th Century. Shore whaling along the US east coast began in the mid 17th Century, peaking in around 1680-1730, but continuing with variable effort and total known catches only in the hundreds, until as recently as 1924. In the period 1855-1897, Yankee whalers in the North Atlantic took about 186 animals.

In the North Pacific (item 8.1.2), the Japanese net fishery took right whales from the late 17th Century. Before 1850, no more than about 100 animals were taken per year, with a decline thereafter. Few animals were taken from shore off the North American coast. Right whale pelagic whaling began in the Sea of Japan in the 1820s, on the central and eastern North Pacific 'Northwest' (Kodiak) grounds in 1835 and in the Okhotsk Sea in 1845. About 14,500 were taken as a total by American pelagic whalers in the North Pacific in 1835-1904, with 90% taken in 1840-59, although they cannot be allocated to grounds. No allowance can be made in North Pacific catches for hunting loss, nor for catches by other nationalities.

For the Southern Hemisphere (item 8.1.3), while shore-based catches can be allocated by management unit, based mainly on winter calving grounds, pelagic catches cannot be allocated as easily. Annex L details available information by decade and area. For shore-based whaling, catches are grouped by coastal wintering area; for those offshore, allocations are made to coastal wintering areas where possible ('bay whaling') or otherwise to ocean basin.

Pelagic catches in the South Atlantic (annex L, table 1) began in the 1770s, peaked in the 1840s, and continued at reduced levels until the early 1900s. A kill of 48,034 is recorded for the South Atlantic up to 1900. In the South Pacific, the pattern was similar (annex L, table 2), but began later (at Australian shore stations from 1805 and from American pelagic vessels from about 1815), peaking in the 1830s and dwindling thereafter. Data on a kill of 37,196 whales up to 1900 are given in annex L, table 2. In the Indian Ocean (annex L, table 3), a total of 12,605 kills up to 1900 is recorded, from the 1830s; they peaked within only a few years, in about 1835-44, and dwindled thereafter.

Details of the relatively small numbers taken in the 'modern' whaling era (post-1900) were provided (item 8.2). In the North Atlantic, a kill of some 100 animals in 1906-10 off the western British Isles seems to have had a catastrophic effect on the eastern North Atlantic population. In the North Pacific there was commercial whaling between 1911 and 1946, and catches for scientific research from the 1950s to the 1970s. Illegal Soviet catches in 1958-64 took some 200 animals, and there is some evidence of 'hundreds' being taken illegally in the Okhotsk Sea and of additional unreported takes near the Kuril Islands.

For the Southern Hemisphere, relatively few catches were reported from 1900 (item 8.2.3), but particularly significant are large unreported illegal Soviet catches from 1951/52-1971/72, totalling at least 3,349. The largest documented catches were off Patagonia (1,335), the southeast Atlantic (704), the southwest Pacific (372) and near the Crozet Islands in the south west Indian Ocean (309). Tables 1-3 in annex L record a total kill of 4,892 animals post-1900 in the Southern Hemisphere, with 3,397 in the South Atlantic, 943 in the South Pacific and 552 in the Indian Ocean.

The total Southern Hemisphere kill reported in annex L is 88,727 animals: 37,341 in the South Atlantic; 38,139 in the South Pacific; and 13,157 in the Indian Ocean (but see below for adjustments to allow for some catches being subsumed within other estimates for another area).

Biological parameters (item 9)

While agreeing that it was important to try to standardise data collection and data field types to permit comparisons within and between datasets, the Workshop did not attempt a Comprehensive Assessment of methodology and techniques but addressed three particularly important categories: photo-identification; biopsy; and necropsy.

Item 9.1.1 focused on coding the quality/detail of photographed sightings for quantitative comparison of matches within and between catalogues. Five assessment categories were agreed. A set (10 or so photographs) should be made available for comparison between research groups. The Workshop recognised the value of long-term photo-identification studies (Hammond *et al.*, 1990) in providing essential data for assessing and monitoring the

status of right whale populations. It **recommended** the continuation of existing programmes and the establishment of new programmes where appropriate.

Given the value of the historical information contained in the various photo-identification catalogues, it also **recommended** that the images in the catalogues be digitised and archived in a secure way (and see IWC, 1990, pp.9-10).

A range of biopsy sampling topics relevant for both genetic and organochemical/biochemical analyses was reviewed (item 9.1.2). Methodology, numbers and locations of samples from different geographical areas were summarised (annex E). Technical matters addressed included: sterilisation of biopsy tips; the reaction of animals to biopsy; and the potential of alternative methods, e.g. use of sloughed skin, scrub scrapers and hand scrapes. It was noted that none of the latter would provide blubber samples, and their small size might restrict some DNA analyses. Calves typically show less reaction to the darting than the mother, and it was agreed that there is considerable scientific merit in obtaining samples from calves. The Workshop **recommended** that where possible such samples should be obtained from calves.

Researchers were reminded to ensure adequate time for obtaining the necessary permits for acquisition, import and export of samples. The Workshop **recommended** that IWC member nations should be asked to facilitate transfer of skin/blubber biopsy samples between research institutions in different countries to assist collaborative analyses, and that the IWC Secretariat approach the CITES Secretariat to determine the best way to facilitate the exchange of such material.

The Workshop **recommended** that where possible, necropsies should be conducted to determine the cause of death (Best *et al.*, 1998; Knowlton and Kraus, 1998) and to provide biological samples relevant to studies of the recovery of right whale populations. Protocols and minimum collection needs were detailed (item 9.1.3). The Workshop recognised a number of important ongoing studies that could be addressed further through necropsy data (annex F).

Data and methodologies for obtaining estimates of biological parameters were examined in the context of the underlying assumptions in the models used, and their likely reliability. Several points applicable to all the analyses used in the Workshop were noted. The underlying assumptions in the estimation methods presented, their biological significance, and the effects of their violation, were tabulated in detail (table 2). **Recommendations** and conclusions were presented (item 9.2). Attention was drawn to Caswell *et al.* (1998), a study of declining probability of survival in North Atlantic right whales, where of all the potential biases arising from possible violation of the tabulated assumptions that related to probable differences in parameter values by sex and age, potentially introduced the most serious bias into the results. A **recommendation** was made for the authors to take account of such factors in continuing to develop their methodology, together with a number of other **recommendations** relevant in this context.

A tabulation was provided of maximum lengths and ranges of calf size (table 3). Available information on longevity, age structure and growth rates, as well as for mortality rates and survivorship, was summarised for each major region (items 9.2.1, 9.2.2). The longest active reproductive life span identified so far is of a North Atlantic animal fortuitously identified in 1935 and rephotographed over 60 years later. A female photographed with a calf in 1967 was also seen with a calf 29 years later.

Given the possibility that survival rates have declined in recent years in the western North Atlantic population, the Workshop **recommended** that the results of the additional recommended work related to the methodology in Caswell *et al.* (1998) be presented to the Committee as soon as possible.

Information was also presented on reproductive parameters, i.e. age at sexual maturity, pregnancy rate and calf production and reproductive cycle/seasonality (item 9.2.3). The mean calving interval in the western North Atlantic was estimated as 3.67 (SE 0.11), but the Workshop noted an increase over time in recent years (Kraus *et al.*, 1998), with a significant increase ($p<0.001$) in 1985-97 from 3.33 to 5.36 years. Kenney (1998) reported that calving rate changes could be correlated statistically with the Southern Oscillation Index; with an intense El Niño in 1998, a low calving rate could be expected in 1999.

Southern Hemisphere mean calving interval estimates included 3.35 years (SE 0.05) for Argentina, 3.12 years (95% CI 3.05, 3.17) for South Africa, and 3.64 years (SE 0.13) for Australia. Differences in the probability distribution of calving interval in Argentina and South Africa, with more three year intervals and fewer five year intervals in the former, could not be explained.

Estimates of abundance and trends (item 10)

For the western North Atlantic, one Workshop participant commented that population simulations suggest some recovery following protection in 1935, and that this slow recovery seemed to have continued at least until the 1980s (Reeves *et al.*, 1992).

Population size estimates based on a six-year running total of catalogued animals (see item 9.2) had been used to obtain an annual rate of increase (range –0.039 to +0.031) for each year 1987-1996 (Kraus, 1997). A regression estimate of 0.01 (SE 0.0232), using all the data, was probably negatively biased.

Three alternative methodologies to obtain estimates of the rate of increase were summarised (annex G). The first gave an estimate of 0.0159 (CI –0.0246, 0.0564) with the caveat that it is likely to underestimate the increase rate for the 1980s because the calving interval has increased significantly in recent years. The second used data from parous females, giving an increase between 1985 and 1997 (0.035, 95%CI 0.024–0.045) but with an apparent long-term oscillation in recruitment. The third (based on the approach of Caswell *et al.*, 1998) suggested an upper bound of 0.043. Although actual growth rates are likely to be considerably less than that, the figure illustrates that the growth rate of this stock is both low and substantially less than that of southern right whale populations, reported below.

Given the methodological concerns already expressed (item 9.2), the Workshop believed it could not reach any firm conclusions on recent population trends for the western North Atlantic stock. Given concerns over its status (see item 11, below) the Workshop **recommended** that as a matter of urgency further work should be carried out to provide quantitative information on population trends. For example, more complex models (which allow for parameters such as calving rate to vary with time) should be explored to test for any possible changes in trend. In addition, the use of stochastic models should be explored: stochasticity is particularly important in considering small populations. The Workshop also noted indications of a recent decrease in growth rates, as suggested by a statistically significant calving interval increase and three years' poor calf production (Kraus *et al.*, 1998). There were further concerns

over a possible major change in the feeding grounds, as well as over recent increases in reported ship strikes and potentially fatal entanglements.

No information was available for the North Pacific. The workshop **recommended** that given its concerns over status (item 11), studies to assess population trends be implemented as a matter of urgency.

For the Southern Hemisphere, both in relation to population trends and abundance (item 11), the 11 management units already agreed (item 7) were used, i.e. sub-Antarctic New Zealand, Australia, Central Indian Ocean, Mozambique, South Africa, Namibia, Tristan da Cunha, Brazil, Argentina, Chile/Peru and mainland New Zealand/Kermadec. Current best estimates of certain demographic parameters and population sizes for each of these regions were summarised (table 4). Major results accepted by the meeting included:

(a) Argentina - increase rate 0.071(SE 0.8%), 1971-90; population size (reproductive females) 330 (95% CI 274-386), 1990;
(b) Australia - increase rate 0.0825 (95% CI 0.510-0.1140), 1983-97; population size (reproductive females) 73, 1995;
(c) South Africa - 0.072, 1969-87; population size (reproductive females) 613, 1996.

Detailed comments on these and other estimates, and the rationale for their acceptance, were given in items 10.1 and 10.2.

The Workshop agreed that it would be possible to attempt to obtain estimates of initial abundance for the Southern Hemisphere only if the whole hemisphere was combined. It could be attempted for specific breeding populations but that would need assignment of historical catches to each population - an extremely difficult task, not achievable at the meeting. A modelling approach was used (item 10.3.1), as in the *Catch Limit Algorithm* of the RMP; in conventional Committee stock assessment terms the approach was one of 'Hitting with fixed MSYR'. An average population increase rate of $r = 0.075$ was adopted; for comparative purposes rates of $r = 0$ (equivalent to estimating K by simply summing all historical catches plus the current population size estimate) and $r = 0.04$ were also used. In that way the extent to which the population's surplus production had been able to compensate for the effect of reductions through whaling could be assessed. Other parameter values adopted, to calculate the juvenile/adult ratio, were the annual average survival rate, s, = 0.98 p.a., and average age at first parturition, t_m, = 9 years.

Current population size was set at year 1997, with adjustments where necessary to the adult female population estimates available, using the assumed annual growth rate of 0.075. The estimate obtained, 1,607 adult females, was both negatively and positively biased, for reasons detailed (item 10.3.2). The calf/juvenile: adult ratio was estimated to be relatively high, at 1.4:1 - a consequence of the relatively high population growth rate (in the western North Atlantic, calves and juveniles account for only 26-31% of the population).

The 1997 total population size estimates for each area were then summed, giving a total of 7,571 whales for use in the population model. Noting the coarseness of many of the assumptions used to arrive at this figure, the Workshop emphasised that the current best estimate of the total number of right whales in the Southern Hemisphere is preferably expressed as 'about 7,000'.

Historical catch data used in the model were revised from those already considered (item 8) to account for some indicated catches being subsumed within estimates for another area. They were also modified to allow for struck and lost animals (at rates of 1.2-1.5 times the landed catch, depending on the fishery; IWC, 1986, p.31). Three catch histories were developed (table 6) - 'base case' (using an average loss rate of 1.35), and 'high' and 'low' cases (using the two extremes of struck and lost rates, and assumptions of 'none' and 'all' for instances of catch duplication). The catch per decade data (annex L) were converted to annual estimates assuming an even catch distribution per ten-year period.

The modelling results (fig. 5) gave an initial population size of about 160,000 for $r = 0$, but about 60,000 for $r = 0.075$. Estimated population trajectories for $r = 0.075$ for each of the three catch scenarios (fig. 6) showed marked changes only in the early part, suggesting a possible range for initial population size of 55,000-70,000 whales. An expanded version of the 'base case' trajectory (fig. 7) from 1880 illustrated: (i) the rapid depletion of the stock following the substantial catches of the early-mid 1800s; (ii) the almost complete lack of any sign of a recovery after 1850, for almost 100 years, followed by a gradual recovery after protection in 1935; and (iii) the effect of the illegal Soviet catches of the 1960s in delaying further recovery by about 20 years.

The trajectory also indicated that the entire Southern Hemisphere population reached a low point of about 300 animals in 1920, corresponding to an adult female population of about only 60 individuals. However, if there had been depensation effects (not allowed for in the current model), the minimum number in 1920 would have been higher than 300. The Workshop noted continuing uncertainties over both the historical catch series and the current projection and that the aggregation of different breeding populations might have distorted impressions of lowest sizes; the exact numbers generated by the model should thus be treated with caution.

In summary, the modelling exercise confirmed that the Southern Hemisphere population of right whales is still heavily depleted, perhaps at about 10% of its initial size. The model used suggested that the current growth rate should continue for some time before onset of any marked density dependent reduction, implying that the population as a whole should continue to grow with a doubling time of about 10 years for at least the next decade.

The Workshop recognised that the above exercise was merely an initial attempt to determine the population trajectories and initial population sizes for southern right whales. It **recommended** that at least three modifications of the analysis should be attempted in the future, as listed in item 10.3.4.

2. Worldwide comparison of population status (item 11)

The workshop noted that several Southern Hemisphere populations (those off Argentina, Australia and South Africa) are increasing at annual rates of *ca* 7-8%. The New Zealand sub-Antarctic population has increased (at least at the Auckland Islands) since the 1940s, but systematic research has not been undertaken for long enough to estimate whether it is currently increasing. Other areas where major whaling operations were conducted show no sign of recovery although recent information is either absent or

incomplete. The Workshop **recommended** that research be undertaken to determine the current status of right whales there.

For the three best known Southern Hemisphere areas, the current estimated total abundance was about 7,000 (item 10). Should those populations continue to grow at 7-8% they would double in ten years. There have been no catches in the Southern Hemisphere since the early 1970s and there is no evidence that human-related mortality is affecting population recovery.

In the North Pacific, the situation differs greatly between the western and eastern populations. Sightings survey estimates for the summer feeding ground indicated an abundance of around 900 (95% CI 404; 2,108) in the Sea of Okhotsk. However, for the situation in the eastern North Pacific, there was considerable concern. Over the past forty years, most sightings have been of single whales; there have been encouraging sightings of small groups recently, but no confirmed sightings of calves this century and there were large illegal Soviet catches in the early 1960s. The workshop **recommended** that research effort to improve understanding of population status and possible human-related problems should be greatly expanded as a matter of urgency.

The situation in the North Atlantic gave the Workshop great cause for concern. The eastern North Atlantic population probably numbers only in the low tens of animals; its future remains questionable. For the western North Atlantic population, the Workshop expressed considerable concern. Whereas it may have increased since protection in 1935 (e.g. see Reeves *et al.*, 1992) and may have been still increasing at a modest rate (about 2.5%) in the 1980s (Knowlton *et al.*, 1994), more recent data (near-failure of calf production from 1993-95, increased calving interval, and a relatively large number of human-induced mortalities) suggest that this modest recovery rate (by comparison with the Southern Hemisphere) may not have continued in the 1990s. North Atlantic parous females show an increase between 1985 and 1997 but with an apparent long-term oscillation in recruitment (annex G). These features, together with the lack of significant increase in calving rates, support the need for age-structured models to account for the complexity of this population's dynamics. It was unclear whether the population is now declining, stationary or increasing, and the best estimate of current population size is only 300 animals (see item 10). The Workshop **recommended** that, as a matter of urgency, increased efforts be undertaken to determine the recent trajectory of this population.

The Workshop noted the high rate of known entanglement and ship strikes in the western North Atlantic; not all dead whales are recorded especially when they die, or are killed, offshore. The western north Atlantic population also shows a significantly depressed calving interval and fecundity compared with the Southern hemisphere. The Workshop agreed that inbreeding, organic chemical exposure and nutritional factors need further study (see item 12). It **recommended** that comparative studies should be undertaken to try to determine factors that may explain the difference between Northern and Southern hemisphere reproductive parameters.

The Workshop concluded that any human related mortality could be detrimental to the long-term survival of the western North Atlantic population. Efforts to reduce human-induced mortality are of the greatest urgency if the chances of the western North Atlantic population recovering are to be maximised. The Workshop drew the Commission's attention to its recommendations on Management Implications under item 14.

3. Factors potentially affecting recovery (item 12)

The workshop discussed a number of aspects in this context in detail: genetic diversity and genetic problems in small populations (inbreeding depression) (item 12.1); trophic relationships and body condition (item 12.2); anthropogenic factors (item 12.3); and health and pathology (item 12.4). Detailed **recommendations** were provided for each and those of greatest significance for management were reviewed for appropriate priority under item 14.

4. Whalewatching (item 13, annex J)

A Working Group established by the Workshop considered relevant issues, i.e. positive and negative aspects; legislation; regulations and guidelines; and management regulations. Its recommendations were discussed under item 14.

5a. Management implications (item 14)

The Workshop discussions resulted in a number of recommendations requiring management action to attempt to reduce or eliminate non-natural mortality of right whales and habitat disturbance. These are particularly important for those stocks for which the Workshop expressed concern over status.

Mortality

The Workshop identified ship strikes and incidental entanglements in fishing gear as the most significant cause of human-induced mortality of right whales (item 12)

With respect to ship strikes (item 12.3.3), given the serious concern over the status of western North Atlantic right whales (item 11), the Workshop **strongly recommended** that the Committee urges the Commission to make every effort to encourage the adoption by relevant governments of the specific recommendations in annex I.

More generally, the Workshop (item 12.3.2) **recommended** that the Committee requests the Commission to:

(1) urge its member nations to;
   (a) initiate or expand preventative measures including Notices to Mariners, notifications on charts and informational brochures to other areas where right whales and high levels of shipping overlap; and
   (b) develop mitigating options, areas to be avoided, early warning systems, sonar detection of whales, acoustic deterrents, and the shifting of shipping lanes and reductions in ship speed;
(2) seek cooperation from the International Maritime Organisation to provide protection for right whales, including but not limited to mandatory ship reporting and ship routing, especially where commercial vessels are entering calving, breeding or feeding areas.

With respect to entanglements (item 12.3.2), the workshop **recommended** that the Committee requests the Commission to urge member governments to ensure that:

(1) research continues on methods to reduce right whale entanglements in fishing gear;
(2) entanglement rates and the success of steps to reduce entanglement are determined and monitored (e.g. through periodic analysis of scarring rates and levels of severe entanglement in photo-identification databases);

(3) if the above monitoring indicates that protective measures are insufficient, they are upgraded as appropriate;
(4) disentanglement programmes (including training from experienced persons) are established where appropriate;
(5) consideration is given to the prohibition of any gear that might entangle right whales in high use habitats, and especially in calving, breeding or feeding areas and sanctuaries.

Disturbance and habitat
The Workshop **recommended** that the Committee requests the Commission to urge local, regional and national authorities responsible for right whale habitats to develop contingency plans for oil and chemical spills, where these do not exist (item 12.3.1).

It also made specific recommendations on habitat-related issues requiring management action by individual governments (item 12.3.5). It **recommended** that the Committee requests the Commission to ask the relevant governments to take the necessary action.

Facilitation of research
The Workshop **recommended** that the Committee requests the Commission to urge member governments to provide funding for the identified research items (item 15). In addition it draws attention to the following **recommendations** requiring action but not funding:

SAMPLE COLLECTION
The Workshop made a number of research recommendations concerning collection of biopsy samples. It **recommended** that the Scientific Committee requests the Commission to urge member governments to facilitate the issue of national permits to collect sufficient biopsy samples from adult and calf right whales to address the research recommendations identified in its report (items 7 and 9).

NECROPSIES
The Workshop noted the need for detailed necropsies of right whales, particularly for those populations for which there is concern over status. It **recommended** that the Committee urges the Commission to request that member governments ensure that appropriate programmes are initiated and, where necessary, permits granted to enable the work to take place (item 9.1.3).

SURVEYS IN TERRITORIAL WATERS
The Workshop identified the need for a further research cruise to assess the abundance of right whales in the western North Pacific. It **recommended** that the Committee requests the Commission to urge relevant member nations to cooperate in this exercise and in particular that the Russian Federation is urged to grant permission for vessels to survey within 12 n.miles of Okhotsk Sea coast (see item 10.2).

WHALEWATCHING
The Workshop endorsed the Commission's general principles for whalewatching (IWC, 1997b, p.105) and recommended that they be applied to all whalewatching activities involving right whales. It was agreed that it was critical to: (1) manage the development of new and fledgling whalewatching operations to minimise the risk of adverse affects; and (2) take appropriate regulatory measures in areas where directed research demonstrates negative impacts on whales from established whalewatching activities.

The Workshop agreed that special protected areas provide a framework for the implementation of site-specific regulations for whalewatching and that such areas are important in conserving coastal habitats. It therefore **recommended** that studies be undertaken to assess the establishment of special protected areas in areas of known right whale concentration (e.g. the Central-South Coast of Santa Catarina, Brazil).

5b. Future research (item 15)
During its discussions of the various agenda items, the workshop made a number of recommendations for future research (table 9). It re-iterated the value it attaches to all those recommendations. However, as at previous IWC workshops, it recognised the need to assign some priority to research items in the context of IWC interest. In particular, this applies to questions associated with the 'trend and condition of whale stocks' and 'measures for the[ir] conservation' (Article IV of the Convention). This was reaffirmed in the terms of reference for the meeting (item 1.2).

Trends and status
The Workshop confirmed the view already expressed by the Committee on several previous occasions (IWC, 1990) of the extreme importance of maintaining research effort when investigating trends in both abundance and in biological parameters. It therefore stressed that high priority should be given to the continuation of both demographic photo-identification studies (item 9) and surveys designed to improve knowledge of absolute abundance and current trends (item 10). Similarly, high priority should be given to the processing and analysis of such data. This is particularly important for the western North Atlantic where there are serious concerns over the status of the stock (item 11).

It also noted the need to initiate and improve such studies in areas of identified concentrations where they are either absent or in their infancy. High priority should be given to those areas where it is believed there is most chance of success.

To interpret data on trends and abundance it is important to determine appropriate management units. In this context, high priority should be given to stock identification studies that will answer questions believed to be hindering the ability to address important conservation questions (see item 7). Genetic sampling programmes should be initiated where needed, and maintained in areas where increased sample sizes are needed for statistical validity.

Conservation measures (item 15.2)
The workshop agreed that **high priority** should be given to research that will lead directly to improved methods of reducing anthropogenic mortality (e.g. reducing ship strikes and fishing gear entanglements) for stocks for which there is concern over survival (see item 11).

Priority should also be given to research into environmental factors that affect the fecundity and mortality rates of right whale populations (e.g. food limitation, pollution, item 12). Such research should ultimately lead to improved recommendations for appropriate and effective management action. Comparative studies between stocks that are recovering and stocks that do not appear to be (item 10) may be particularly valuable in this context. Studies that improve information on feeding grounds in the Southern Hemisphere will facilitate such comparisons.

From the genetic standpoint, two questions are of high priority:

(1) what are the implications of the low haplotype diversity detected in certain populations; and
(2) is the effective population size of right whales significantly lower than the abundance estimates?

Other items

Under 'Other Business' (item 17) the Workshop agreed that a proposal for the creation of a global right whale catalogue should be included in the context of a broader proposal for a Southern Hemisphere right whale consortium (annex K). Some concerns were expressed over the scientific rationale behind the project. The Workshop recognised that creation of a framework for collaborative research, similar to that in the North Atlantic Right Whale Consortium, could provide similar benefits, as well as serving as a vehicle for identifying and seeking support for right whale research worldwide. Its objectives were detailed in item 17.

The Workshop **agreed** that there was merit in the proposal and **recommended** that the Scientific Committee approves the principle of establishing a Southern Hemisphere Right Whale Consortium, for recommendation to the Commission. Subject to such approval, a Steering Committee, comprising representatives of each Southern Hemisphere nation currently involved in right whale research, should be established to develop the details of the proposal. Funding should be sought from, *inter alia*, the Commission, national governments and other sponsors to convene a meeting of interested parties, with appropriate terms of reference, to formally establish the Consortium.

In conclusion, the Workshop particularly wished to record its appreciation to the local convenor, Dr P. Best, and his associates; to the meeting sponsors - MTN Cape Whale Route, and The Two Oceans Aquarium, Cape Town; and to Mondi (SA), Price Forbes and The Monkey Valley Beach Resort.

REFERENCES

Best, P.B., Peddemors, V.M., Cockcroft, V.G. and Rice, N. 1998. Mortalities of right whales and related anthropogenic factors in South African waters, 1963-1997. Paper SC/M98/RW25 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

Brownell, R.L., Best, P.B. and Prescott, J.H. (eds.). 1986. *Right Whales:Past and Present Status.* International Whaling Commission, Cambridge. vi+289pp.

Caswell, H., Fujiwara, M. and Brault, S. 1998. Declining survival probability and its implications for the North Atlantic right whale. Paper SC/M98/RW3 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

Hammond, P.S., Mizroch, S.A. and Donovan, G.P. (eds.). 1990. *Individual Recognition of Cetaceans: Use of Photo-Identification and Other Techniques to Estimate Population Parameters.* Reports of the International Whaling Commission, Special Issue 12. IWC, Cambridge, UK. [vi]+440pp.

International Whaling Commission. 1986. Report of the Workshop on the Status of Right Whales. *Rep. int. Whal. Commn* (special issue) 10:1-33.

International Whaling Commission. 1990. Report of the Workshop on Individual Recognition and the Estimation of Cetacean Population Parameters, La Jolla, 1-4 May 1988. *Rep. int. Whal. Commn* (special issue) 12:3-40.

International Whaling Commission. 1997a. Chairman's Report of the Forty-Eighth Annual Meeting, Appendix 1. IWC Resolution 1996-1. Resolution to resolve the distress of the Japanese small-type coastal whaling as community-based whaling. *Rep. int. Whal. Commn* 47:48.

International Whaling Commission. 1997b. Report of the Scientific Committee. *Rep. int. Whal. Commn* 47:59-257.

Kenney, R.D. 1998. Global climate change and whales: Western North Atlantic right whale calving rate correlates with the Southern Oscillation Index. Paper SC/M98/RW29 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

Knowlton, A.R. and Kraus, S.D. 1998. Mortality and serious injury in North Atlantic right whales. Paper SC/M98/RW8 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

Knowlton, A.R., Kraus, S.D. and Kenney, R.D. 1994. Reproduction in North Atlantic right whales (*Eubalaena glacialis*). *Can. J. Zool.* 72(7):1297-305.

Kraus, S.D. 1997. North Atlantic right whales: can we stop extinction? *Eur. Res. Cetaceans* [Abstracts] 10:9.

Kraus, S.D., Hamilton, P.K., Knowlton, A. and Slay, C.K. 1998. Status and trends in reproduction of the North Atlantic right whale. Paper SC/M98/RW1 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

Reeves, R.R., Breiwick, J.M. and Mitchell, E. 1992. Pre-exploitation abundance of right whales off the eastern United States. *In:* The Right Whale in the Western North Atlantic: a Science and Management Workshop, 14-15 April 1992, Silver Spring, Maryland. NOAA/National Marine Fisheries Service, Northeast Fisheries Science Center Reference Document 92-05.

Rosenbaum, H., Brownell Jr, R.L., Brown, M., Schaeff, C., Portway, V., White, B., Malik, S., Pastene, L., Best, P.B., Clapham, P.J., Hamilton, P.K., Moore, M., Payne, R., Rowntree, V. and Desalle, R. 1998. A genetic review of inter-relationships between right whales in different ocean areas. Paper SC/M98/RW23 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. *Zoologica (N.Y.)* 19(1-2):1-50+6maps.

Appendix 4

CURATION OF INDIVIDUAL IDENTIFICATION PHOTOGRAPHS FOR HUMPBACK WHALES FROM THE ANTARCTIC: A RESEARCH PROPOSAL TO THE SCIENTIFIC COMMITTEE, INTERNATIONAL WHALING COMMISSION

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Description of project

College of the Atlantic (COA) has maintained a collection of humpback whale identification photographs from the Antarctic since 1987. This proposal seeks support from the IWC for: (1) expansion of this collaborative effort in the form of submission of identification photographs from members of the Commission and other researchers working in the Antarctic, and (2) resources for curation of these images.

Background

Personnel at College of the Atlantic have coordinated the development and testing of the photographic identification method for humpback whales, and pioneered development of the collaborative network throughout the North Atlantic region for compiling fluke photographs from different regions into a catalogue and master database. Two substantial collections of photographically identified humpback whales from the North Atlantic are housed at COA: the North Atlantic Humpback Whale Catalog (NAHWC) and the Years of the North Atlantic Humpback Whale (YoNAH) collection. The NAHWC contains approximately 16,000 photographs of over 5,000 individuals primarily collected since 1976. Project YoNAH, a three-year international collaborative project, was initiated to collect photographs from individual humpback whales using protocols designed to eliminate biases inherent in opportunistically collected photographs, and to expand sample size to improve precision of population estimates. COA has conducted all photographic analysis and cataloguing for the project. The YoNAH collection includes approximately 5,000 images of 3,000 individuals. In addition, COA is developing and housing the completed YoNAH database used for analysis and the YoNAH archive.

Current status of Antarctic Catalog

The Antarctic Humpback Whale Catalog maintained by COA was created in 1987. It currently contains fluke photographs of 270 humpback whales from the Antarctic collected between 1981 and 1997, primarily from the region of the Antarctic Peninsula. In addition, the collection contains photographs from breeding and calving grounds in Brazil, Colombia, Ecuador, New Zealand and Australia. The effort is highly collaborative. Photographs have been contributed by 80 individuals or research groups.

Plan of research

The catalogue currently relies primarily on photographs of the tail flukes, with dorsal fin photographs included where available as part of the same catalogue and database. This proposal calls for expanded use of dorsal fin and flank photographs. This would require the creation of two additional collections of photographs, one for left dorsals, the other for right dorsals. These collections could be used independently or jointly depending on the analytical requirements.

Relational databases will be used to store all associated field data and to coordinate data from the three collections. All images will be scanned and archived digitally, and linked to the database for ease of access and retrieval. The database will allow each image to be tracked to the appropriate field sighting data.

Reports will be issued to contributors when comparison of their submissions is completed. Reports will include the data for each photograph as it is contained in the database to allow for error checking, and the associated catalogue numbers assigned to each photograph. Reports will also include a sighting history for each individual previously sighted. A summary of catalogue activity will be issued annually to the Scientific Committee prior to the annual meeting.

Budget 1998/1999

This proposal seeks funds for comparing photographs and preparing and managing the resulting data (see Table 1). The infrastructure (computers, software, etc.) is in place to support the analysis and skilled personnel are available to undertake the analysis.

Table 1

Budget required. All costs in US$.

	COA	IFAW	Requested from IWC
Photographic comparison 400 hrs @ $10/hr	3,000		1,000
Project and database management			
Catalogue and database set-up, 80 hrs @ $15/hr			
Maintenance and reporting, 120 hrs @ $12/hr			1,200
Administration, 80 hrs @ $15/hr	1,200		1,440
External supervision, 80 hrs @ $15/hr		1,200	
Darkroom, photographic processing			500
Phone, fax supplies			200
Fringe (26% of project and database management salary)			686
Total	4,200	1,200	5,026

REPORT FROM WORKING GROUP ON SOUTHERN HEMISPHERE CENTRALISED DIRECTORY FOR HUMPBACK WHALE PHOTOGRAPHS AND ANTARCTIC HUMPBACK WHALE CATALOGUE

Best, Carlson, Gambell, Pastene

Centralised directory

Once information on photographic material is received, the Secretariat could, this year, establish a centralised directory for Southern Hemisphere humpback whale photographs as outlined last year in IWC (1998). The directory would take at least two weeks of the computing staffs' time and therefore would be prioritised accordingly with other work recommended.

Progress on the Antarctic Catalog

Photographs of Antarctic humpback whales taken during the JARPA/SOWER surveys between 1989/90 and 1995/96 have been evaluated and scored for 'matchability'. Photographs of Antarctic humpback whales from IDCR cruises have been evaluated and 100 were printed for the catalogue. Photographs of 40-50 individual humpback whales from the Peninsula region will be submitted to the catalogue this year by a Brazilian Antarctic survey team. It will continue to submit photographs each year. Photographs of Antarctic humpback whales from other sources (i.e. Chile; previous IDCR/SOWER cruise participants) should be solicited for the catalogue by the IWC Secretariat. The College of the Atlantic has agreed to curate the catalogue with agreement from the Committee. The proposal for curation, establishment of two additional catalogues for left and right dorsal fins and relational databases is presented above. The Working Group puts forward these items to the sub-committee for consideration.

REFERENCES

International Whaling Commission. 1998. Report of the Scientific Committee. Annex G. Report of the Sub-Committee on the Comprehensive Assessment of Southern Hemisphere Humpback whales. *Rep. int. Whal. Commn* 48: 170-182.

Appendix 5

COARSE EXTRAPOLATION OF IWC/IDCR-SOWER ESTIMATES OF ABUNDANCE FOR HUMPBACK AND SPERM WHALES TO COMPARABLE AREAS

D.S. Butterworth

SC/50/CAWS37 provides the following estimates (Table 1) of abundance (with CVs in parenthesis) for Southern Hemisphere humpback and sperm whales, following standard IWC methodology.

Table 1

Abundance estimates from SC/50/CAWS37.

	Humpback	Sperm
1st circumpolar	5,300 (0.39)	5,500 (0.44)
2nd circumpolar	9,700 (0.27)	11,400 (0.18)
3rd (incomplete) circumpolar	8,600 (0.26)	7,900 (0.19)

The difficulty with using these estimates to draw inferences about possible trends in abundance is that they do not correspond to identical survey areas. Approximately, the coverage of the area of open ocean south of 60°S is 63%, 79% and 55% respectively for the three sets of surveys.

This paper attempts some crude extrapolations to render the estimates all pertinent to the full area south of 60°S and therefore comparable. For the 1st and 2nd circumpolar surveys, this has been done by taking the effort-weighted average sighting rate (n/L) in the northernmost strata of each Management Area, and assuming that this applies also in the unsurveyed 'T' strata (see SC/50/CAWS37, table 2) between these northernmost strata and 60°S. Appropriate subtractive corrections are made in the few cases where existing strata extend slightly north of 60°S.

For the 3rd circumpolar surveys, lack of coverage is predominantly longitudinal. Very roughly speaking, this set of surveys (as far as analysed in SC/50/CAWS37) have covered Areas I, III, V and VI, with II and IV (constituting about 29% of the total open ocean area south of 60°S) still to be surveyed. The proportions of total abundances estimated in the earlier circumpolar surveys that correspond to Areas II and IV are given in Table 2.

These are not too dissimilar (on average) from the corresponding areal proportion of 29%. Thus it seems reasonable, as a crude first approximation, to effectively

Table 2

Proportion of total abundances estimated in earlier circumpolar surveys that correspond to Areas II and IV.

	Humpback	Sperm
1st circumpolar	0.18	0.29
2nd circumpolar	0.39	0.41

assume that densities of these two species are invariant over the whole area south of 60°S, and hence simply to scale the pertinent abundance estimates of SC/50/CAWS37 upwards to account for the 45% of the area south of 60°S yet to be covered.

The net effect of these adjustments is to provide the 'comparable' estimates given in Table 3.

CVs for the above would be straightforward, though messy to calculate, if the extrapolation uncertainties are ignored. Results for the first two circumpolar cruises would be similar to those of SC/50/CAWS37 quoted above as these abundance estimates are dominated by the contributions from the northernmost strata, whereas those given for the 3rd circumpolar formally remain unchanged in terms of the crude assumption made for extrapolation in that case.

Table 3

Comparable estimates following adjustments.

	Humpback	Sperm	Mid-period year
1st circumpolar	7,500	7,900	1981
2nd circumpolar	11,800	13,000	1988
3rd (incomplete) circumpolar	15,700	14,300	1993/94

Appendix 6

UPDATE ON THE STATUS OF INFORMATION ON THE NORTH ATLANTIC HUMPBACK WHALE

T.D. Smith, P.S. Hammond, N. Friday and P.J. Clapham

Information being developed on the North Atlantic humpback whale is described, updating Smith *et al.* (1998) to assist the Scientific Committee in determining if it should undertake a Comprehensive Assessment in 1999 or in 2000. We conclude that while an assessment could be done in 1999, there would probably be substantially more information still under development at that time. Therefore, we suggest that the assessment be conducted in 2000.

In 1997, the Scientific Committee reviewed the status of information on the North Atlantic humpback whale (*Megaptera novaeangliae*) and agreed to conduct a Comprehensive Assessment in 1999 or 2000. The Committee considered both existing information and planned analyses of data relevant to such an assessment (Smith *et al.*, 1998). Here, we update the status of information on this population, to determine if the information required for such an assessment is likely to be available in 1999, or if the assessment should instead be conducted in 2000.

Papers published and in press

Over the last year, one paper has been published and another has been accepted for publication. Stevick *et al.* (1998a) documented the migration of whales from Norwegian waters to the West Indies breeding grounds.

Smith *et al.* (In press) described major results from the Years of the North Atlantic Humpback (YoNAH) project, including sampling methodology and results especially relative to abundance. Sex ratios on the feeding grounds were near parity, while significantly fewer females than males were sampled on the breeding grounds. Different proportions of groups sighted on the breeding grounds were sampled by photography and by biopsy, and these proportions varied with behaviour. Three sets of photographic and biopsy based estimates of total abundance were compared; those based on samples only from the feeding areas, those only from the breeding areas, and those from both breeding and feeding areas. Feeding-only and breeding-only estimates were strongly biased downward. Estimates based on both breeding and feeding ground estimates appeared to be unbiased, and the inverse-variance weighted average of photographic and biopsy-based estimates were 10,600 (CV = 0.067) and 10,400 (CV = 0.138), respectively.

Sex-specific estimates of abundance using biopsy samples only from feeding grounds were biased downward for both sexes. Corresponding estimates using samples only from breeding grounds were biased downward for females, but not for males, as suggested by Palsbøll *et al.* (1997). Possible causes of such biases were discussed, and the authors concluded that in the North Atlantic it is not possible at this time to obtain reliable abundance estimates using photographs collected solely on the breeding grounds.

Conference presentations

Several additional results from the YoNAH project were presented during the World Marine Mammal Science Conference in Monaco. Mattila *et al.* (1998) described the sexual composition of humpbacks on their breeding grounds, noting that the date of first sighting of animals seen in successive years was highly correlated for females but uncorrelated for males. They suggested that this may be an explanation of the apparent bias in abundance estimates of females using only breeding ground samples.

Friday *et al.* (1998) described a method for evaluating the effects of photographic quality and distinctiveness (see SC/49/O19 for an earlier version of this work). The authors demonstrated the degree of upward bias that differences in photographic quality could introduce into abundance estimates based on the YoNAH data, and provided criteria for balancing bias and precision in such cases. They also demonstrated that individual animal distinctiveness does not bias photographic-based estimates using the YoNAH data.

Stevick *et al.* (1998b) compared photographic and genetic identifications to estimate the rate of errors in matching individuals in the YoNAH data. They found no false positives using either method. Further, they showed that for photographic identification using both techniques, false negatives occurred much more frequently with poorer quality photographs and less distinct individuals, and that biopsy identification errors tended to occur with animals that

matched on all but one of the six microsatellite loci used. Despite these results, the overall rate of error in the project was found to be very low.

Palsbøll *et al.* (1998) evaluated the implications of glaciation for explaining the relatively low levels of divergence among populations of North Atlantic cetaceans, drawing in part on YoNAH data. They suggest that post-glacial range expansions must be considered when interpreting the genetic structure of many North Atlantic cetacean populations.

Papers in preparation

The results presented to the 1998 World Marine Mammal Science Conference are being finalised by Mattila, Palsbøll *et al.*, Stevick *et al.* and Friday *et al.*

Abundance: Hammond is conducting a joint analysis of the YoNAH photographic and biopsy mark-recapture data to develop a combined abundance estimate. He will draw on the error rates noted by Stevick *et al.* (1998b), as well as upon a study simulating the effects on abundance estimation of sampling by different behavioural classes on the breeding ground (Friday, 1997), and other aspects of humpback behaviour (see Annex V).

Trends: In light of findings from the YoNAH project (notably those relating to effects of photo quality), Stevick is conducting a reanalysis of previously published abundance estimates based upon data from the North Atlantic Humpback Whale Catalogue. When complete, these estimates will represent the basis for estimating trends in abundance from 1979 through 1993. Larsen and Hammond are conducting an analysis of photographic data from Greenland to estimate trends in abundance on that feeding ground.

Ocean-Basin-Wide Population Structure: Reviews of the population structure in the North Atlantic are in preparation based on genetic data (Mattila and Palsbøll *et al.*) and on photographic information (Stevick *et al.*). Additional analyses of mitochondrial DNA in the western North Atlantic and of microsatellite data from all regions will be used to expand upon previously published results.

Regional Population Structure: Palsbøll and Mattila are beginning a study of the family tree of humpback whales using the Gulf of Maine (pers. comm.). Clapham *et al.* are analysing photographic data from the Gulf of Maine to identify possible regional preferences within that feeding area. Sponer *et al.* are reviewing the genetic structure of animals that summer off West Greenland. Stevick (pers. comm.) is also examining the YoNAH data within Canada to better determine the definition of that feeding ground.

Migration and Breeding Grounds: In addition to the breeding grounds sampled by YoNAH, there are several other areas in the southwestern and southeastern North Atlantic where humpback whales are known to occur in the winter. The need for additional information about the whales using Windward Islands locations is described in Clapham *et al.* (1998). There is also a need for additional information concerning animals using the Cape Verde Islands (Reiner *et al.*, 1996). Reeves is reviewing log book data from the Windward Islands and from the Cape Verdes to better determine the temporal and spatial distribution of humpback catches. Also, further light may be shed by analysis of seasonal and area patterns of vocalising whales recorded using the United States SOSUS system (Chris Clark, pers. comm.).

Catch Data: Complete catch data will not be available as much of the whaling was poorly documented, especially in the north-eastern North Atlantic. Information has already been summarised for the western North Atlantic, including the West Indies (Mitchell and Reeves, 1983). Information for catches in the eastern North Atlantic in the 20th Century can be synthesised from several publications (e.g. Thompson, 1928; Brown, 1976). Additional information on years of harvesting may be forthcoming from logbook studies by Reeves for the Windward Islands and the Cape Verdes (see above), but information on total removals is likely to remain substantially incomplete.

Conclusions

Substantial information is available on the North Atlantic humpback whale. A large number of additional analyses drawing on the North Atlantic Humpback Whale Catalogue and on YoNAH data, as well as several other regional sets of data, are underway. The additional information that has been, and continues to be, obtained from genetic analyses of the biopsy samples, has revealed a complex population structure, the full extent of which is not yet apparent. Several of the ongoing studies are addressing aspects of the temporal-spatial behaviour on both ecological, historical, and evolutionary time scales. A thorough understanding of this aspect of North Atlantic humpback whale biology may be essential for a complete assessment of population status in this area.

The most important papers from the YoNAH project are expected to be available by the end of 1998. Although many of the other analyses mentioned above are substantially developed, the likely time frame for their availability is unclear. Critical areas include the analyses of trends in abundance, and clarification of population structure, notably as it relates to specific breeding grounds. Thus, while there could be sufficient information available to conduct the Comprehensive Assessment in 1999, there would probably be substantially more information still under development at that time. In the interest of allowing a complete assessment to be conducted, and given that there does not appear to be a pressing time frame associated with this, we suggest that the assessment be conducted in 2000.

REFERENCES

Brown, S.G. 1976. Modern whaling in Britain and the NE Atlantic. *Mammal Rev.* 6(1):25-36.

Clapham, P.J., Smith, T.D., Reeves, R.R. and Swartz, S.L. 1998. Status and stock origin of humpback whales in the Windward Islands. Paper SC/50/CAWS11 presented to the IWC Scientific Committee, April 1998 (unpublished). 4pp.

Friday, N. 1997. Evaluating photographic capture-recapture estimates of abundance of North Atlantic humpback whales. Ph.D. Thesis, Graduate School of Oceanography, University of Rhode Island. 173pp.

Friday, N., Stevick, T., Fernald, T., Allen, J. and Smith, T.D. 1998. Evaluating the effects of photographic quality and whale distinctiveness on mark-recapture estimates of humpback whales. Paper presented to the Biennial Meeting of the Marine Mammal Society, 20-24 January 1998, Monaco.

Mattila, D.K., Palsbøll, P.J., Bérubé, M., Bowman, R.S., Carlson, C.A., Clapham, P.J., Mignucci, A., Robbins, J., Stevick, P. and Vasquez, O. 1998. Sexual composition of the North Atlantic population of humpback whales on their principal mating and calving grounds: are some females missing? Paper presented to the Biennial Meeting of the Marine Mammal Society, 20-24 January 1998, Monaco.

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.

Palsbøll, P.J., Allen, J., Bérubé, M., Clapham, P.J., Feddersen, T.P., Hammond, P.S., Hudson, R.R., Jørgensen, H., Katona, S., Larsen, A.H., Larsen, F., Lien, J., Mattila, D.K., Sigurjónsson, J., Sears, R., Smith, T., Sponer, R., Stevick, P. and Øien, N. 1997. Genetic tagging of humpback whales. *Nature, Lond.* 388:767-9.

Palsbøll, P.J., Bérubé, M., Clapham, P.J., Dendanto, D., Diwtz, D., Feddersen, T.P., Heiberg, A.-C., Heide-Jorgensen, M.-P., Heide-Jorgensen, H., Larsen, A.H., Larsen, F., Lien, J., Mattila, D.K., Notarbartolo di Sciara, G., Sigurjónsson, J., Sears, R., Sponer, R. and Øien, N. 1998. Post-glacial origin and expansion of arctic and temperate cetacean populations in the North Atlantic. Paper presented to the Biennial Meeting of the Marine Mammal Society, 20-24 January 1998, Monaco.

Reiner, F., Dos Santos, M.E. and Wenzel, F.W. 1996. Cetaceans of the Cape Verde archipelago. *Mar. Mammal Sci.* 12(3):434-43.

Smith, T.D., Allen, J., Friday, N. and Clapham. 1998. Status of information on the North Atlantic humpback whale. Annex H, Appendix 7. *Rep. int. Whal. Commn* 48: 200-202.

Smith, T.D., Allen, J., Clapham, P.J., Hammond, P.S., Katona, S., Larsen, F., Lien, J., Mattila, D., Palsbøll, P.J., Sigurjónsson, J., Stevick, P.T. and Øien, N. In press. An ocean-basin-wide mark-recpture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). *Mar. Mammal Sci.* 15(1).

Stevick, P.T., Øien, N. and Mattila, D.K. 1998a. Migration of a humpback whale (*Megaptera novaeangliae*) between Norway and the West Indies. *Mar. Mammal Sci.* 14(1):162-6.

Stevick, P.T., Palsbøll, P.J. and Allen, J.M. 1998b. Comparison of capture-recapture results using photographic and genetic identification: relative rates and sources of errors. Paper presented to the Biennial Meeting of the Marine Mammal Society, 20-24 January 1998, Monaco.

Thompson, D.W. 1928. On whales landed at the Scottish whaling stations during the years 1908-1914 and 1920-1927. *Fish. Board Scotl. Sci. Invest.* 3:3-39.

Appendix 7

REPORT OF THE *AD HOC* INTERSESSIONAL SPERM WHALE GROUP MEETING

R.L. Brownell, Jr., T. Kasuya, H. Kato and S. Ohsumi

The *Ad hoc* Group met at the Institute of Cetacean Research, Tokyo, Japan on 2 February 1998. The meeting participants were Brownell (Convenor), Kasuya, Kato and Ohsumi.

Introduction

During the 49th meeting of the Scientific Committee, an intersessional e-mail sperm whale group was established to review plans for a Comprehensive Assessment. Our discussions in Tokyo were specifically related to sperm whales in the North Pacific.

Population studies

The following types of studies were identified for population studies: review of mark-recapture data and joint US – Japan genetic studies. A proposal by Brownell to pool US and Japanese genetic samples was discussed. Other possible sources of genetic material to be investigated are teeth from past Soviet whaling operations.

Abundance estimates

Kato and Miyashita will prepare preliminary abundance estimates for western North Pacific sperm whales. Some of the major problems associated with abundance estimates include $g(0)$, group size and acoustic corrections.

Review of past abundance estimates

It was agreed that past abundance estimates and models need to be reviewed.

Review of historical catch data

Problems in catch records relating to both numbers and sex were identified as an area of concern. Brownell noted that official Soviet pelagic whaling data were grossly under-reported. It was also noted that Japanese pelagic catch numbers are correct but that some problems exist with determination of sex and that Japanese coastal sperm whale catch data are unreliable. It was agreed that Ohsumi would review the history of sperm whale regulation in the North Pacific. Additional sources of sperm whale catch records include at least: past scientific reviews, IWC records, national records, industry records and records kept by old whalers.

Other items

Other important items that need to be discussed for a sperm whale Comprehensive Assessment include: life history, social behavior, ecosystem information, and current human-related mortality.

The *Ad hoc* Group agreed that it would recommend that the Comprehensive Assessment for sperm whales start with a focus on North Pacific sperm whales.

Appendix 8

PROGRESS REPORT ON THE WORK TO ADDRESS OUTSTANDING ISSUES OF JARPA

Government of Japan

1. Introduction

In May 1997 a meeting was held,to review the data and samples derived from the JARPA surveys (JARPA Review Meeting). The report of this meeting was adopted at the 49th Annual Meeting of the IWC Scientific Committtee held in September 1997. The Committee adopted the JARPA review report and listed several tasks to address unresolved problems, discussed the usefulness of past commercial samples and identified the plan to address the problem of sampling biases (IWC, 1998a, pp. 95-106). Progress made on each of these tasks is given in SC/50/O1.

The aim of this Appendix is to brief Committee members further as to progress on the tasks on JARPA identified last year. It should be noted that the period between the 49th and 50th meetings was shorter than normal. Thus, for some of the tasks identified there is, as yet, no substantial progress.

2. Future work of JARPA

The Committee listed the tasks below at last year's meeting (IWC, 1998a, p.103).

(1) Development of methods to correct bias of abundance estimate.
(2) Stock definition.
(3) Statistical analysis of mtDNA data considering the inclusion of school sizes as a covariate.
(4) Pilot study on nuclear DNA analysis on JARPA minke samples.
(5) Effort to obtain biological materials for genetic analysis from low latitude areas of the Southern Hemisphere.
(6) External morphology/morphometry analysis for stock structure.
(7) Examination of possible stock boundaries (geographical and temporal) in Areas IV and V.
(8) Segregation study.
(9) Recalculation of biological parameters by biological stocks.
(10) Mesoscale survey plan on marine ecosystem and environmental change.

The Committee also discussed two additional items: (1) on the availability and existence of commercial samples for stock-ID analyses; and (2) the problem of representativeness of samples. On the latter item, Japanese scientists presented their plans to address the problem of sampling biases as follows:

(i) the size of the biases will be evaluated using a resampling simulation model;
(ii) post (cruise) modelling methods will be applied to determine whether it is possible to resolve or reduce biases;
(iii) if this is not effective, modification of the sampling scheme will be considered, and the effectiveness and practicality of such a modification will be evaluated; while
(iv) simultaneously, the comparability between the current and any new scheme will be carefully evaluated.

3. Progress on the ten main items

3.1 Development of methods to correct bias of abundance estimate

With respect to item 1, a study was already in progress by Borchers and his colleagues. Some details of this work had already been submitted to last year's meeting (Clarke and Borchers, 1997), and further progress presented this year in SC/50/CAWS34.

3.2 Stock definition

On item 2, the Committee agreed last year that the lack of a working definition of stocks and sub-stocks is a general problem, not only for JARPA, and therefore needs to be addressed by the Committee (SC/49/Rep1). Japanese calculations of the sample sizes necessary to obtain adequate statistical power in identifying separate stocks in the JARPA program, have been based on the assumption that the extent of genetic variation found between the 'Western' and the 'Core' stocks is typical of that which distinguishes different breeding stocks. We hope the Committee will take the initiative for establishing stock definition and Japanese scientists are willing to cooperate in such work.

3.3 Statistical analysis of mtDNA data considering the inclusion of school sizes as a covariate

Japanese scientists will establish a group to include scientists in genetics and mathematics for this item. Work will start in the near future.

3.4 Pilot study on nuclear DNA analysis on JARPA minke samples

On item 4, Abe, Goto and Pastene have begun a preliminary microsatellite analysis in the Southern ordinary form minke whale. They used historical samples from Brazil, and JARPA samples from Area IV obtained in the 1989/90 survey. Samples from Area IV were grouped in a similar way as in the mtDNA analysis: Area IVW-early, Area IVW-late and Area IVE-early and late. Five microsatellites were used in the analysis: GT23, GATA98, EV1Pm, EV94Mn and EV104Mn. Given the preliminary character of this analysis, no document will be presented at this meeting. However, some preliminary results are shown in the progress report of the Institute of Cetacean Research (SC/50/O3).

3.5 Effort to obtain biological materials for genetic analysis from low latitude areas of the Southern Hemisphere

With respect to sampling in the breeding grounds, Japanese scientists also recognise that samples from the low-latitudinal areas (i.e. breeding grounds) are important. The results of a survey of biological material among researchers and institutions of the Southern Hemisphere was presented in draft at the 45th meeting. No comprehensive samples have been made available to date. Analyses of individual samples caught in the area off Brazil by commercial whaling are currently underway. Samples from minke whales, which were collected off Durban in the mid-1970s by Best, are available. We need to check whether these samples are useful for DNA analysis.

3.6 External morphology/morphometry analysis for stock structure

There has been no progress on the analysis of the morphology of minke whales, the problem of individual variations in measurement among researchers is not yet resolved.

3.7 Examination of possible stock boundaries (geographical and temporal) in Area IV

3.8 Segregation study

3.9 Recalculation of biological parameters by biological stocks

These items are closely linked to the context of the results of the Committee discussion on stock definition. After resolving this matter and sampling biases, Japanese scientists will recalculate biological parameters.

3.10 Mesoscale survey plan on marine ecosystem and environmental change

This item is under consideration. Under the present scale of the JARPA survey there is no time to incorporate the mesoscale survey. Restructuring of the research scale or use of another research vessel would be necessary before this item could be considered further.

4. Progress on the additional two items

4.1 Availability of existing samples for genetic analysis

Taylor (1997) suggested a method to incorporate commercial samples into the genetic analyses. Although JARPA is not a research only for genetic analyses, the

suggestion contains interesting elements. As a first step, researchers in Japan sought to re-establish a comprehensive inventory of usable commercial samples. This list was made available to this meeting in Yoshida *et al.* (SC/50/RMP6).

On the second task of this issue in IWC (1998, annex U1), i.e. a test for usefulness of commercial samples for genetic analysis, a preliminary examination has been conducted using the JARPA samples by Goto *et al.* (1998). From this analysis, the Western Stock was only detected through comparison of offshore and ice-edge samples collected in JARPA surveys from Area IV. This suggests that commercial samples, usually collected in waters close to ice-edge, are not sufficient for stock distribution identification.

4.2 On sampling biases

Examination on item (i), i.e. simulation model, has already started. The original plan of the JARPA program was to incorporate both the abundance estimate in each school size and biological data for individual whales because the sampling rate differed by school size (Kishino *et al.*, 1991). As a first step, Japanese scientists are going to calculate the revised abundance estimates by school size incorporating the method of Burt and Borchers (1997). After this calculation, the work will be done, in order, from items (ii) to (iv).

At the last meeting, one approach was proposed for a possible modification of the current sampling scheme (IWC, 1998, annex U2). To respond to this suggestion, the next JARPA survey will be planned to include a limited scale, feasibility study on whether the modified method suggested is workable or not. Tentatively, the preliminary results of this feasibility study will be reported during the 1999 Scientific Committee meeting.

REFERENCES

Burt, M.L. and Borchers, D.L. 1997. Minke whale abundance estimation from the 1995-96 IWC survey in Area VI. Paper SC/49/SH8 presented to the IWC Scientific Committee, September 1997 (unpublished). 14pp.

Clarke, E.D. and Borchers, D.L. 1997. Proposal for the development of unbiased abundance estimators for JARPA sightings survey data. Paper SC/49/SH30 presented to the IWC Scientific Committee, September 1997 (unpublished). 10pp.

International Whaling Commission. 1998a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48: 53-127.

International Whaling Commission. 1998b. Report of the Scientific Committee. Annex U. 1. Report of the Working Group on JARPA stocks. 2. A proposed modification for the JARPN sighting and sampling protocol. *Rep. int. Whal. Commn.* 48: 297-298.

Kishino, H., Kato, H., Kasamatsu, F. and Fujise, Y. 1991. Detection of heterogeneity and estimation of population characteristics from the field survey data: 1987/88 Japanese feasibility study of the Southern Hemisphere minke whales. *Ann. Inst. Statist. Math.* 43: 435-53.

Taylor, B.L. 1997. Using JARPA data to investigate use of historical Japanese Antarctic minke whale samples to examine the temporal changes in stock distribution. Paper SC/49/SH28 presented to the IWC Scientific Committee, September 1997 (unpublished). 5pp.

Appendix 9

SOME COMMENTS ON VPA ASSESSMENTS OF SOUTHERN HEMISPHERE MINKE WHALES IN RESPONSE TO SC/50/CAWS32 BY POLACHECK

D.S. Butterworth and A.E. Punt

A key misunderstanding

SC/50/CAWS32 examines some aspects of earlier VPA assessments by ourselves and co-authors reported in Butterworth *et al.* (1999), which was considered by the 1997 meeting of the Scientific Committee. In particular, SC/50/CAWS32 argues that,

> estimated increasing recruitment trends prior to exploitation in Butterworth *et al.* (1999) are critically dependent upon their selectivity assumptions for the commercial catches

and that the results of SC/50/CAWS32,

> indicate that the issue of the pre-exploitation trends in recruitment remains unresolved.

Unfortunately, it seems that the author of SC/50/CAWS32 has missed/misunderstood the implications of certain sensitivity tests reported in Butterworth *et al.* (1999), which address his otherwise legitimate concerns, and negate his conclusions stated above.

To understand this, it is necessary first to explain the meaning of the parameter S^c_{26} introduced in Butterworth *et al.* (1997). That analysis allows for the possibility for a slope, either up or down, in the selectivity of the commercial catch over ages 21-30. A value $S^c_{26} < 1$ reflects a positive slope (i.e. selectivity increasing with age), while $S^c_{26} > 1$ indicates the reverse.

The 'base case' estimator of Butterworth *et al.* (1999) indeed set $S^c_{26} = 1$, i.e. it fixed the commercial selectivity to be flat over ages 21-30. This was motivated on the grounds that S^c_{26} was likely < 1 for reasons related to biological and operational information, which are detailed in that paper (and in regard to which SC/50/CAWS32 raises some legitimate questions concerning which comments are made below). The choice of $S^c_{26} = 1$ was made to ensure, in the context of this motivation, that the resultant estimate of an historic recruitment trend would be negatively biased. Indeed, this point and the sensitivity of this trend estimate for Area IV to the value of S^c_{26} was illustrated in fig. 4 of Butterworth *et al.* (1999).

But, though this approach was followed as it was considered the best defensible, other results in Butterworth *et al.* (1997) show that it is actually not necessary to impose this constraint on S^c_{26} externally, and that the conclusions of

the paper re. historic recruitment trends follow from the VPA input data and the assumption of flat selectivity at large ages for the (intended random) JARPA catches alone.

Table 7 and fig. 4 of Butterworth *et al.* (1999) show results when S^c_{26} is treated as an estimable parameter. The consequent estimate for S^c_{26} is slightly above 1, though not significantly different therefrom. The associated historic recruitment trend is positive when S^c_{26} is estimated without constraints. Furthermore, the bootstrap 90% confidence interval for this trend estimate is entirely positive (see table 9 of Butterworth *et al.*, 1999), i.e. in this context the possibility of a flat or negative historic recruitment trend is statistically incompatible with the data.

This then negates the key conclusion of SC/50/CAWS32, the analysis in which is unable to address this point because it omits a contribution from the commercial catches-at-age in the likelihood.

Other aspects

Older ages and associated selectivities

SC/50/CAWS32 states that results in Butterworth *et al.* (1999) imply that commercial selectivities decrease for whales above age 30. Given the estimability (and estimate) of S^c_{26} as explained above, this does not negate any of the conclusions of the latter paper. Nevertheless, the following points should also be kept in mind:

(1) the decision to restrict the ages considered in the base case analysis of Butterworth *et al.* (1997) to 30 and below, was made on the basis of the formal recommendation of the highly regarded ICES Working Group on Methods of Fish Stock Assessment, that data for VPA assessments be truncated in this manner – this is because of the poor precision associated with introducing low sample sizes into the analysis, greater possibilities of bias arising from the greater difficulties of reading larger ages accurately, the possibility of senescence – with its associated increase in M at large age, and so on;
(2) tests and alternative choices for the oldest age in the VPA computations do not indicate great sensitivity of results (see table 8 of Butterworth *et al.* (1999), tests 'm = 26' and 'm = 32');
(3) SC/50/CAWS32 reports only point estimates of commercial selectivities for ages above 30 – these estimates will not be very precise because of the low sample sizes involved, so that inferences about trends therefrom may not be statistically reliable.

Unequal sex ratio in the catches

SC/50/CAWS32 implies that failure to take the female preponderance in historic catches into account may have biased results. However, variants of the model of Butterworth *et al.* (1999) that did take account of this indicated no great sensitivity of final results (see table 8, tests 'Males only' and 'Females only').

Form of the term added to likelihood in SC/50/CAWS32

The form of the contribution of the recruitments for the years 1994-1971 (1950-1971 for Area V) to the negative of the log-likelihood function leads directly to the result that the estimates of recruitment for these years are equal to the mean recruitment. This is because the likelihood is minimised if the extent of process error (the deviations in recruitment from the average recruitment) is set **equal to zero irrespective of the fit to any other data**. This is because setting these deviations to zero leads to the negative log-likelihood being equal to $-\infty$. Punt *et al.* (1997) estimate the extent of 'additional variance' for Southern Hemisphere minke whales and show that account needs to be taken of the estimation of the nuisance parameters when constructing the likelihood function. It would seem that a similar approach would be needed in this case to obtain unbiased estimates of recruitment. However, owing to the complexity of the underlying model, it seems unlikely that construction of the reduced information matrix will be straightforward. Another way to deal with this problem would be to pre-specify rather than estimate the extent of variation in recruitment.

It is unclear whether it is appropriate to estimate the recruitments for 1944-1956 (1950-1956 for Area V) even if the likelihood function had accounted for the estimation of the nuisance parameters. This is because none of the data used in the analysis have any influence on the size of these recruitments. The model estimates of the IWC/IDCR abundance estimates for 1980 and 1989 (1980 and 1986 for Area V) do depend on the sizes of these recruitments, but this dependence is very weak, and certainly not sufficient to allow reliable estimation of these recruitments. Therefore, the estimates of these recruitments would be set equal to the average recruitment, seemlingy supporting the assumption of constant recruitment. In contrast to this, the age-data from the period of commercial whaling allow Butterworth *et al.* (1999) to estimate these recruitments.

Spatial/Temporal analyses of the age structure of JARPA samples

The author of SC/50/CAWS32 states that he is unaware of any such analyses. Cooke *et al.* (1997) as reported to the 1997 JARPA Review Meeting, found no significant evidence for heterogeneities in those respects for ages above 10 (though the power of such analyses is obviously somewhat limited given the sample sizes).

Are older minke whales less likely to be caught?

SC/50/CAWS32 raises a number of interesting considerations in this regard, such as older animals having a refuge from whalers in the pack ice. Indeed the analysis of Butterworth *et al.* (1999), which yields a 90% confidence interval for S^c_{26} of [0.94, 1.16], does not exclude this possibility.

Best (pers. comm.) also raises some interesting points on this matter. He observes that though minke length is difficult to estimate in absolute terms, it would nevertheless be relatively easy for the whalers to select the largest animal in a group, which points towards commercial selectivity increasing with age. He also draws attention to the fact that USSR vessels (being ice-strengthened) operated farther into the pack ice than did the Japanese vessels. Quick inspection of the length frequency distributions from the commercial catches in Area IV show the modal lengths of the USSR minke catches to be about 0.5m larger than for those by the Japanese, which could suggest a decreasing selectivity at large ages for the Japanese component of the overall catch. However, for larger lengths, there is little correlation between length and age for minke whales, so that this observation may merely reflect that bigger, and not necessarily older whales go farther into the pack ice. Also, if the Japanese commercial catches do show a declining selectivity at age for large ages for this reason, the JARPA catches would be expected to show the same feature, suggesting that the estimate of the extent of the change in the recruitment trend in Butterworth *et al.* (1999) would not be much affected.

REFERENCES

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). [In press].

Cooke, J., Fujise, Y., Leaper, R., Ohsumi, S. and Tanaka, S. 1997. An exploratory analysis of the age distribution of minke whales collected during JARPA expeditions 1987/88 through 1995/96. Paper SC/M97/21 presented to the IWC Scientific Commitee Intersessional Working Group to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic.

Punt, A.E., Cooke, J.G., Borchers, D.L. and Strindberg, S. 1997. Estimating the extent of additional variance for Southern Hemisphere minke whales from the results of the IWC/IDCR cruises. *Rep. int. Whal. Commn* 47:431-4.

Appendix 10

COMMENTS ON APPENDIX 9

Tom Polacheck

This Appendix is divided into two main sections. The first is a short overview of the 'key misunderstanding' cited in Appendix 9 and the second, longer section, is a more detailed discussion of the technical issues raised in Appendix 9.

An overview of the misunderstanding

In Appendix 9, Butterworth and Punt suggest that I (the author of SC/50/CAW32) had 'a key misunderstanding' of the implications of certain sensitivity test reported in Butterworth *et al.* (1999). Unfortunately, the issues raised in SC/50/CAW32 do not stem from a simple (or complex) misunderstanding of the implications of the sensitivity tests discussed in Appendix 9. However, there definitely appears to be some misunderstanding and what is being misunderstood needs to be resolved.

Being fully aware of the sensitivity tests in Butterworth *et al.* (1999) and their implications, it was acknowledged in SC/50/CAW32 that the authors of Butterworth *et al.* (1999) had conducted extensive sensitivity tests of their results. However, the robustness of a set of sensitivity tests depends on the specification of those tests. As stated in SC/50/CAW32, its purpose was to provide some further evaluation of the robustness of the conclusions in Butterworth *et al.* (1999).

A key conclusion in Butterworth *et al.* (1999) is that there was an increasing trend in recruitments prior to exploitation. A common way to test the robustness of a conclusion is to assume it is false and then examine the implications. If one assumes that the conclusion is false while in fact it is 'true', then the expectation is that one should obtain a basic inconsistency. This is the approach taken in SC/50/CAW32. Given the assertion in Butterworth *et al.* (1999) that recruitment prior to exploitation was increasing, the expectation was that a basic inconsistency would be seen when it was assumed that pre-exploitation recruitments were constant. However, this did not occur. In fact, the only substantive differences in terms of what is being fit in the models were the resulting selectivities for the commercial catches (i.e. the fit to the survey abundance indices and the age structure of the JARPA catches were very similar). Thus, within this modelling framework, only if the selectivity curves obtained in SC/50/CAW32 are considered implausible can one consider the hypothesis that pre-exploitation recruitments were constant to be implausible.

The differences in the selectivity pattern obtained compared to those in Butterworth *et al.* (1999) are displayed in figs 3-6 of SC/50/CAWS32. The selectivity patterns in both cases are dome shaped with the main difference being the age at which the peaks occur. Within the basic VPA model framework being used in both Butterworth *et al.* (1999) and SC/50/CAW32, the general selectivity pattern in SC/50/CAWS32, figs 3 and 5 will yield constant recruitment trends. On the other hand, the general selectivity patterns in SC/50/CAWS32, figs 4 and 6 (i.e. those for the base case in Butterworth *et al.*,1999), will result in increasing recruitment trends. For either selectivity pattern, the fit to the input data and the selectivity/separability assumptions for the JARPA catches are essentially equivalent. It is this equivalence in the fit that led to the conclusion that 'the estimated increasing recruitment trends prior to exploitation in Butterworth *et al.* (1999) are critically dependent upon their selectivity assumptions for the commercial catch'. Moreover, given all the factors that can affect the actual selectivity in commercial harvesting, the differences between the two sets of selectivity curve do not provide a sufficient basis for making definitive conclusions about pre-exploitation recruitment.

Elaboration and technical comments on Appendix 9

Sensitivity tests in Butterworth et al. (1999)

As Appendix 9 pointed out, Butterworth *et al.* (1999) provides some sensitivity tests to the commercial selectivity assumption of their approach. A careful look at this sensitivity analyses is quite informative. Butterworth *et al.* (1999) provides a set of sensitivity analyses for their selectivity assumptions by considering the hypothesis that selectivity between the three age groups, 23, 26 and 29 was a linear function and constant in time. For Area IV, results for values of the slope of this assumed relationship are provided (expressed in terms of the selectivity at age 26 compared to age 29). It is clear from the sensitivity tests, that if S^c_{26} were set to about 1.4 then the estimated slope of the pre-exploitation recruitment trend would go to zero. Thus, the sensitivity tests in Butterworth *et al.* (1999) demonstrate that an increasing pre-exploitation trend is dependent upon the specific selectivity/separable assumptions used[1].

[1] While a value of 1.4 is outside of the 90% confidence limit given for S^c_{26} in Appendix 9 and thus not statistically likely within the Butterworth *et al.* (1999) formulation, the range of selectivity models tested in Butterworth *et al.* (1999) was quite limited (see below) and these confidence intervals are dependent upon their selectivity and separable assumptions. With a value of 1.4, the model estimates a set of realised selectivity. Butterworth *et al.* (1999) results indicate that these realised selectivities are not highly likely in the context of the assumption of a constant linear selectivity relationship. However, for different assumptions about the selectivity patterns, they would be. Thus, the question is whether the formulation in Butterworth *et al.* (1999) encompasses the full range of plausible selectivity patterns for the commercial catches.

Appendix 9 provides two types of arguments why one would reject S^c_{26} being greater than one. One is based on their estimated likelihood and the other is based on biological and operational information. Since their estimated likelihood function in this case can only be derived from their selectivity and separable assumptions, it becomes circular to argue that the resulting estimated value for the likelihood provides support for those assumptions[2]. It is the second type of argument (i.e. those based on biological and operational information) that is relevant. The Discussion section of SC/50/CAW32 elaborates a number of observations, issues and concerns with respect to the interpretation of possible selectivity patterns in commercial catch from biological and operational information. SC/50/CAW32 notes the difficulty in attempting to infer selectivity patterns from such data. However, it suggests that a useful step forward would be to undertake more comprehensive analyses of the age and locational information from the commercial and JARPA catches.

Table 9 from Butterworth *et al.* (1999) notes that the 90% confidence intervals for the slope of the trend estimates in this table are entirely positive. It is worth noting that the lower limit for two of the eight confidence intervals in this table is zero (at least to three significant figures) and 0.002 for two others. Presumably, if one considered the more standard 95% intervals, the confidence intervals would encompass negative values. Also, the set of bootstrap results in Table 9 includes only one or two dimensional variants of the base-case estimator. The intervals would be wider if a fuller dimensional consideration of the uncertainties had been undertaken.

Older ages and associated selectivities

Appendix 9 states that decreasing selectivity for whales past age 30 does not negate any of the conclusions of the latter paper. In a formal sense, this is true since selectivity assumptions for whales past age 30 are not used in the likelihood formulation. Thus, whatever the selectivities are for these older animals, they have no effects on the recruitment estimates. However, the implicit selectivities for these older animals do have important significance for evaluating the relevance of the selectivity assumption for the commercial catch underlying the specific model formulation in Butterworth *et al.* (1999).

Butterworth *et al.* (1999) conclude, based on its consideration of biological and operational information, that selectivities should be non-decreasing up to age 29. Their rationale and arguments would seem equally applicable to animals past 30. Thus, the fact that the selectivities decrease past 30 in their model results would seem to be inconsistent with the basis for the selectivity assumption underlying their model formulation. Moreover, if selectivities decrease with age past 30, then the implication is that they are 'dome' shape. In this case, it is not clear why one should necessarily assume that the peak in the dome should be flat between ages 22-30, as is assumed in their base-case or that it is constrained to lie at either age 23 or 29, as is assumed in their sensitivity analyses. In fact, the maximum likelihood estimate for the slope parameter for the commercial selectivities between ages 22-30 in their sensitivity test results is negative. This indicates that the best estimate, even within their formulation, is that selectivities are 'dome' shaped below the terminal age of 28-30 and that the peak of the dome occurs at age 22. The results in Butterworth *et al.* (1999) do not allow for the possibility that the peak could occur below this age.

With respect to the three specific points that Appendix 9 list in this regard:

(1) It was never suggested (nor would I ever suggest) that one should not use a plus group in a VPA analysis of this type. However, one should not ignore the information contained in the age data for the plus group catches - particularly if direct ageing methods have been used. It should also be pointed out that if M was increasing within the plus group, that this would tend to require larger recruitments from the pre-exploitation cohorts. This is required in order for them to make the same contribution to the estimates of total population sizes when fitting to the IDCR and JARPA abundance estimates. This could reduce or eliminate the increasing recruitment trend in Butterworth *et al.* (1999).
(2) The sensitivity tests for choice of terminal ages does not free up the constraint that selectivities must be decreasing below age 22.
(3) The sample sizes for the plus group commercial catches in most years are quite substantial (i.e. >200) and if selectivity were flat the expected numbers would have been substantially greater.

Spatial/temporal analyses of the age structure data

In SC/50/CAW32 it was noted that I was not aware of any comprehensive analyses of the spatial/temporal patterns of the age structure of either the commercial catches or of the more recent JARPA samples. Appendix 9 points to Cooke *et al.* (1997) as such a study for the JARPA data. Having not been at the JARPA Review Meeting, I was not aware of the details of this paper. I thank the authors of Appendix 9 for directing me to it. I see no value and have no interest in getting into a debate as to what constitutes a comprehensive analysis. However, in making my original comment I had envisioned a more detailed examination of the spatial/temporal pattern of the age compositional data than is contained in Cooke *et al.* (1997) (e.g. latitude in this paper is only considered in terms of N/S of 65 and no longitudinal effects are considered). My comment was motivated by the analyses of portions of the JARPA data that are contained in a variety of papers which display latitudinal, longitudinal, and seasonal differences (some of them clearly significant) (e.g. Kato *et al.*, 1990; Fujise *et al.*, 1994).

Are older animals less likely to be caught?

Best's pers. comm. in Appendix 9, combined with the possible difference in lengths between the Japanese and Russian catches, does suggest that the declining selectivity for the Japanese commercial catch can not simply be dismissed as being outside of the range of plausible hypotheses. The suggestion that the selectivity in the JARPA catches may also have a decreasing selectivity with age because of whales within the pack ice needs to be further explored. However, it is not clear if this effect did exist in

[2] For example, in my formulation, I could turn the estimation problem around and assume that the underlying selectivity patterns during the commercial harvested were those pictured in figs 3 and 5 of SC/50/RMP32. In such a formulation, no assumptions about recruitment trends would need to be made. A likelihood component could then be derived for the catch-at-age data based on these assumed selectivity patterns. If I did this, I would get the same recruitment estimates and the likelihood component for the commercial catch component would equal 1. Of course, it would be totally inappropriate to then argue that the likelihood estimates can be used to justify the assumed selectivities.

both the JARPA and the commercial catches, what the combined effect would be on the recruitment trends in Butterworth *et al.* (1999).

Form of term added to the likelihood and the information for estimating pre-exploitation recruitments

Appendix 9 points out a problem with the formulation of the added term in the likelihood in SC/50/CAW32. The authors are correct that as formulated the negative of log-likelihood will go to negative infinity. While not intentional, it turns out that there was an error in the program that calculated the likelihood function that ensured that the nuisance parameter (i.e. the variance in the pre-exploitation recruitments) did not go to zero.

It should be noted that the results will not be very sensitive to whatever value is used for the nuisance parameter. The reason for this relates directly to the second paragraph of Appendix 9 on this topic. As pointed out in Appendix 9, there is only a weak link or dependence between each of the individual early recruitment estimates and the other data used in the analyses. The dependence comes from the contribution of these cohorts to the estimated total population size in years when there were abundance surveys. This dependence is sufficient to determine the general magnitude or 'average' recruitment levels during this period so that the total contribution from these cohorts to the estimated population numbers is of the appropriate magnitude in those years when there are survey abundance estimates for the total population. However, the dependence is not sufficient to provide much information for estimating the year specific recruitment estimates (and this is the reason that SC/50/CAW32 ends up with essentially no variation around the estimated constant mean levels in these early years). It is also for this reason that one could replace the constant recruitment assumption in SC/50/CAW32 with either an increasing or decreasing trend and still get essentially the same fit in terms of the other components of the likelihood function. The model is informative about the overall level of recruitment that must have occurred in these early years, but not about its pattern.

The question can be asked how does Butterworth *et al.* (1999) get around this problem so as to provide 'informative' estimates of the individual recruitment estimates for these early years? It uses no additional external data than that used in SC/50/CAW32. The answer is that Butterworth *et al.* (1999) gets around this problem through the use of selectivity and separability assumptions for the commercial catches. These assumptions allow one to construct a likelihood term for these catches based on the relative proportions by age in the catches within a year. However, the form of this likelihood term is dependent upon the assumptions made about the selectivities during the commercial catch; change the selectivity assumptions and one will get different recruitment estimates (also see above and footnote 1). Thus, Appendix 9 is correct in stating that 'age-data from the period of the commercial whaling allow Butterworth *et al.* (1999) to estimate these recruitments', but this is only true because of the selectivity assumptions made in that paper[3]. There is no external data (such as survey abundance estimates) used to estimate these trends. This is the basis for SC/50/CAW32 concluding that the 'estimated increasing recruitment trends prior to exploitation in Butterworth *et al.* (1999) are critically dependent upon their selectivity assumptions for the commercial catches'.

Is there a way forward?

SC/50/CAW32 suggests one way forward; to undertake more comprehensive analyses of the commercial and JARPA age compositional data. This might provide a firmer basis for developing a range of plausible hypotheses for the selectivities during the commercial harvest. In conjunction with this, it may be worthwhile considering within the context of Butterworth *et al.* (1999) a broader range of functional forms for the expected selectivities in the commercial catch (e.g. quadratic over the 10 plus age range with allowance for a temporal component). This would at least provide an assessment of whether there is some statistical basis in terms of likelihoods and number of parameters (e.g. AIC) for excluding particular selectivity patterns - although one needs to be cautious about the potential power to distinguish between different selectivity patterns solely on statistical grounds. In this regard, it would be valuable to know how the likelihood for a functional representation (based on a small number of parameters) of the selectivity patterns that yielded constant recruitment in SC/50/CAW32 compares with those in Butterworth *et al.* (1999).

REFERENCES

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). [In press].

Cooke, J., Fujise, Y., Leaper, R., Ohsumi, S. and Tanaka, S. 1997. An exploratory analysis of the age distribution of minke whales collected during JARPA expeditions 1987/88 through 1995/96. Paper SC/M97/21 presented to the IWC Scientific Commitee Intersessional Working Group to Review Data and Results from Special Permit Research on Minke Whales in the Antarctic.

Fujise, Y., Zenitani, R., Kato, H. and Kishino, H. 1994. Age distributions of minke whales in the Antarctic Areas IV and V in 1991/92 and 1992/93 seasons. Paper SC/46/SH20 presented to the IWC Scientific Committee, May 1994 (unpublished). 22pp.

Kato, H., Kishino, H. and Fujise, Y. 1990. Some analyses on age composition and segregation of southern minke whales using samples obtained from the Japanese feasibility study in 1987/88. *Rep. int. Whal. Commn* 40:249-56.

[3] It should be noted that the JARPA catch data have little or no influence on the individual estimate of recruitment for these early recruitments and that it is these early recruitment estimates which determine if an increasing trend existed. Appendix 9 does not appear to be consistent about this. On the one hand it states that the 'age-data from the period of the commercial whaling allow Butterworth *et al.* (1999) to estimate these recruitments', which makes sense based on the above discussion. On the other hand, earlier in the paper it is assertes 'that the conclusions of the paper re. historic trends follow from the VPA input data and the assumption of flat selectivity at large ages for the (intended random) JARPA alone'.

Appendix 11

ON QUERIES RAISED IN SC/50/CAWS32 CONCERNING INFERENCES ABOUT THE HISTORIC RECRUITMENT TREND FOR SOUTHERN HEMIPSHERE MINKE WHALES BASED UPON VPA ASSESSMENTS

D.S. Butterworth

The selectivity assumptions for the commercial catch in Butterworth *et al.* (1999) which are queried by Polacheck in SC/50/CAWS32, were motivated on two independent grounds, 'biological' and 'statistical'. The following responses are offered to his criticisms.

Biological grounds

(i) An increasing selectivity-at-age was suggested by the combination of the whalers' desire to take larger animals, coupled to the fact that whaling took place close to the ice edge, and a larger proportion of bigger animals are indicated to be there by IDCR percent takeable data, commercial whaling data and JARPA data (see table 4 of Butterworth *et al.* (1999), which indicates an increasing trend in the age of animals caught in Area IV by degree latitude strip from 61º 10°S to 66+° 10°S).

(ii) Suggestions in SC/50/CAWS32 that results are confounded by differential male/female availability spatially are refuted by sensitivity tests in Butterworth *et al.* (1999), table 8, which shows historic recruitment trend estimates to be essentially unchanged when the analyses were conducted on a sex-disaggregated basis.

(iii) The commercial selectivity curves reported in SC/50/CAWS32 to correspond to an assumption of a flat historic recruitment trend, reflect an unavailability of some 25% of otherwise takeable minke whales. Of the explanations offered by Polacheck for this:
   (a) a reflection of local depletion caused by the concentration of whaling close to the boundaries of Management Areas – this is refuted by calculations of additional variance reported in Punt *et al.* (1997) which indicate substantial inter-annual movements of minke whales on a greater longitudinal scale than this;
   (b) presence of these older animals in lower latitudinal waters – this is refuted by analyses using Japanese Scouting Vessel data to extrapolate minke whale abundances north of the IDCR survey area to 30°S (Borchers *et al.*, 1990) which show there to be a relatively small proportion of the population in this area in mid-summer, much of which must comprise younger animals given IDCR estimates of proportion takeable and relatively low abundances of the youngest age classes in JARPA survey samples; and
   (c) animals in the pack-ice unavailable to whalers – an average value of some 25% over time seems large, but even if this is the case, it would indicate that the JARPA selectivity-at-age also decreases at large age; since the conclusion of an historic increasing recruitment trend is a reflection of *changes* over time in the catch-curve slope (Butterworth and Punt, 1990, see equation 5 and following), similar changes to the selectivity assumptions for both the commercial and JARPA catches would not likely change conclusions regarding recruitment trends (though it would also be desirable to check this computationally in this particular case).

Statistical grounds

(i) Butterworth *et al.* (1999) shows (table 9) that when the slope of the commercial selectivity-at-age from ages 22-30 is treated as an estimable parameter rather than fixed to be flat ('2-parameter approach'), the conclusion of a historic increase in recruitment significant at the 5% level remains.

(ii) Polacheck has correctly pointed out that the calculation in (i) is conditional on any maximum in the commercial selectivity-at-age occurring at ages above 21; however, the text of Butterworth *et al.* (1999) indicates that other runs of the model considered there, which allowed a fully flexible shape of this selectivity function ('4 parameter' approach) as sought by Polacheck, were rejected in favour of the simpler parameterisation for which results were reported ('1 parameter' approach) on the basis of likelihood ratio tests (though since such other results are not reported in detail in Butterworth *et al.* (1999), I would wish to recheck the outputs in question before being absolutely definitive on this point); furthermore, rough calculations based on the base-case ('1 parameter') commercial selectivity-at-age estimate for ages 16-21 (0.86 compared to 1 for ages 22-30), coupled with the best estimate of the age 22-30 selectivity slope when treated as an estimable parameter (a decrease of some 0.08 to 0.10 over this age range), suggest that the constraint of a selectivity maximum at an age above 21 is not impinging on the results corresponding to the latter ('2-parameter') approach which limited the selectivity on ages 16-21 to a maximum of 1.

(iii) The general formulation considered in Butterworth *et al.* (1999) does not impose any selectivity pattern on the commercial catches-at-age at ages less than 16 in the light of results in Sakuramoto and Tanaka (1985) which suggested high variability in commercial selectivity for such younger ages, and makes only the weak assumption of temporal invariance in expectation (i.e. not deterministic invariance) for the selectivity pattern above that age. In contrast, the likelihood in SC/50/CAWS32 gives infinite weight (in principle – though reportedly only very large in practice) to the contribution seeking constancy in the recruitment prior to the onset of commercial whaling, while omitting any contribution from the commercial catches-at-age entirely, thus allowing no possibility for at least some selectivity pattern in such data (as is conventionally allowed in VPA assessment of fish stocks) to influence results.

(iv) Inferences SC/50/CAWS32 about selectivity at age above 30 derived from the results in Butterworth *et al.* (1999) are of questionable reliability because of the small sample sizes available, the absence of variance

estimates accompanying the results reported and plausible alternative interpretations of increasing natural mortality with age or ageing error at such relatively large ages.

REFERENCES

Borchers, D.L., Butterworth, D.S. and Kasamatsu, F. 1990. Southern Hemisphere whale abundance estimates south of 30°S derived from IWC/IDCR survey and Japanese scouting vessel data. Paper SC/42/SHMi18 presented to the IWC Scientific Committee, June 1990 (unpublished). 42pp.

Butterworth, D.S. and Punt, A.E. 1990. Some preliminary examinations of the potential information content of age-structure data from Antarctic minke whale research catches. *Rep. int. Whal. Commn* 40:301-15.

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). [In press].

Punt, A.E., Cooke, J.G., Borchers, D.L. and Strindberg, S. 1997. Estimating the extent of additional variance for Southern Hemisphere minke whales from the results of the IWC/IDCR cruises. *Rep. int. Whal. Commn* 47:431-4.

Sakuramoto, K. and Tanaka, S. 1985. A new multi-cohort method for estimating Southern Hemisphere minke whale populations. *Rep. int. Whal. Commn* 35:261-71.

Annex F
Report of the Standing Working Group (SWG) on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP)

Members: Donovan (Chair), Albert, Allison, Born, Borodin, Breiwick, Buckland, Butterworth, Cooke, DeMaster, George, Givens, Goto, Hakamada, Hester, Innes, Magnússon, Melnikov, Moronuki, Okamoto, Okamura, Ohsumi, Poole, Punt, Raftery, Rooney, Schweder, Senn, Skaug, Slooten, Tanaka, E., Tanaka, S., Wade, Walløe, Witting, Zeh, Zhu.

1. INTRODUCTORY ITEMS

1.1 Convenor's opening remarks
Bannister welcomed the participants.

1.2 Election of Chair
Donovan was elected Chair. He recalled that at last year's meeting he had expressed some concern at the limited membership of the SWG. The SWG had agreed that a number of factors were important for it to be efficient and effective. These included: (a) some continuity of membership; (b) several 'groups' of developers; (c) experts in the management procedures field who are not developers; and (d) broad areas of expertise.

He was pleased to note the progress in this. In particular the composition of the present group was broader, including additional experts who, at present, were not developers. He especially welcomed Magnússon who had been specifically invited to attend this sub-committee and reiterated that the contribution of invited participants would be greatly enhanced if they can be invited on a longer-term basis

The short intersessional period had meant that it had been difficult for developers to produce many results for the SWG to examine at this meeting. He therefore believed that considerable attention should be devoted to developing a timetable for ensuring that as rapid progress as possible is made towards producing an AWMP that satisfactorily meets the Commission's objectives.

1.3 Appointment of rapporteurs
Punt acted as rapporteur, 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/50/AWMP1–7 and relevant extracts from the Chairman's Report of the 49th meeting of the Commission. Punt and Givens agreed to revise the glossary of terminology (Appendix 2) and full details of the latest trial scenarios, statistics and assumptions (Appendix 3) as necessary. The SWG had agreed last year that these would be living documents whose contents may change to reflect the AWMP development process.

For ease of reading, unless another reference is given, 'Last year' refers to IWC (1998, annex I), the report of this SWG from 1997.

1.6 Commission comments from the Monaco meeting
Last year, the Committee had agreed that it was appropriate for the Chair of the Standing SWG to present its work to the Commission. At last year's Commission meeting he presented the relevant sections of the Scientific Committee's report to the Aboriginal Subsistence Whaling Committee. In addition, he presented a less technical working paper to that Committee highlighting the questions to the Commission raised by the SWG during its 1997 meeting and had informal discussions with some Commissioners. The SWG appreciated the Commission's efforts to answer its questions (IWC, 1998), noting that some of these questions were complex (e.g. the issue of multi-species fisheries) and would be considered further by the Commission.

1.7 Report of the e-mail correspondence group
An e-mail correspondence group (awmp-grp) chaired by DeMaster operated intersessionally. Although the number of messages sent via the group was relatively low (20–25), the SWG agreed that it had been useful and had facilitated technical discussions and distribution of software. The SWG also thanked Givens for setting up the AWMP web page[1] which contains information about the AWMP development process, an archive of awmp-grp e-mail messages, and copies of software used to evaluate candidate *SLA*s and to plot the results of the simulations. Givens recalled that some issues surrounding the distribution of some of the software raised last year remained to be addressed. It was **agreed** that Allison needs to discuss this further with the Secretariat and provide advice to Givens.

2. INITIAL EXPLORATION TRIALS – GENERAL ISSUES

2.1 Common Control Program
The Common Control Program is the computer code used by developers to run the *Initial Exploration Trials* for scenarios that involve a single[2] stock (IWC, 1998). This program also calculates the performance statistics and the information

[1] http://www.stat.colostate.edu/~geof/iwcawmp.html
[2] This remains the case until the Secretariat validates the multi-stock code presented by Punt and used in SC/50/AWMP3

needed to compare the performance of candidate *SLA*s using the graphical format developed by Zeh (see Item 2.2.2). The only portion of code which an AWMP developer needs to supply is that implementing their candidate *SLA*. Allison reported that she had completed the changes to the Common Control Program specified at last year's meeting, but due to the short intersessional period, it had not been possible to complete it in time for the developers to use in papers for this year's meeting. The SWG thanked Allison for completing this task. Punt noted that the specifications agreed last year had been changed slightly to reflect the fact that the gestation time for baleen whales is considered to be one year, rather than the two years that had been inherent in last year's specification (Section A, Appendix 3). The SWG **approved** this change.

2.2 Statistics and performance plots

2.2.1 Statistics

SC/50/AWMP6 reported two problematic features of need statistic N1, Total Need Satisfaction. The first arises because N1 (which defines need satisfaction as the ratio of the total catch over the management period to the total need over this period) is not a monotonically increasing function of need satisfaction, so that an increase in N1 does not necessarily imply an increase in the satisfaction of need. The author proposed a variant of the N1 statistic, that defines need satisfaction as the average of the ratio of the catch to the level of need (constrained to be less than 1). The SWG **agreed** that this variant (henceforth referred to as the N9 statistic – the average need satisfaction) contained useful information not summarised by the N1 statistic; it avoids giving greater weight to satisfying need when need is large. It **recommends** that N9 should become one of the mandatory statistics and that the current N1 statistic should become optional. It further **agreed** that for future *Initial Exploration Trials*, the catch would be constrained to be no larger than the level of need.

The second problem identified in SC/50/AWMP6 arises because there is a trade-off between the satisfaction of current and future need. The author suggested that hunters would be more interested in current rather than long-term need satisfaction. This view was echoed by several members of the SWG. Neither N1 nor N9 differentiate between the two need components. Instead, they measure need satisfaction for the entire simulation period. As this period is usually 100 years, current need satisfaction is represented only marginally in N1 and N9. Hence, *SLA* optimisation with respect to N1 and N9 does not guarantee the satisfaction of current need. However, it was also noted that the values for the performance statistics are calculated for 20, 50 and 100 year management periods. Use of statistics based on a 20-year management period should allow an evaluation of how well need is satisfied in the short term.

During last year's meeting, the SWG refined the set of statistics used to summarise the performance of candidate *SLA*s and divided them into those that are 'mandatory' and those that are 'optional'. It was noted that despite this, there are still a large number of mandatory statistics. In fact, none of the papers presented to this meeting had reported all of the mandatory statistics but that this had not prevented a useful discussion of the results (see Item 5). The SWG agreed that it was not necessary to report all the 'mandatory' statistics when presenting papers. Instead it agreed that developers must at least include the 5% and median values for the D1 (final depletion - both mature and 1+ component of the population) and the N9 (average need satisfaction) statistics. However, developers must bring encoded versions of all of the statistics to meetings so that these can be discussed if the SWG so wishes.

The SWG noted that the present performance statistics to compare candidate *SLA*s do not include any that directly assess performance in terms of the variation over time in strike limits. It was agreed that such statistics could be developed after consideration of Commission comments this year (see Item 7).

Table 1 summarises the SWG's consideration of performance statistics thus far in the development process.

2.2.2 Performance plots

Last year, the SWG had agreed that the task of summarising and interpreting the vast array of results from different developers would be greatly facilitated if the format used for presentation of statistics was standardised. Zeh reported that the *S-Plus* software that she had developed last year for this purpose is available through the web site. She intends to make some changes to this software (including addition of the new N9 statistic) and provide a revised version to Givens for inclusion on the web site (the e-mail group will be notified when the revised software is available). Zeh and Allison agreed to discuss this further to ensure that the statistical output from the Common Control Program can easily be integrated with plotting software.

2.3 Review of simulation framework

During the development of the current set of *Initial Exploration Trials* (IWC, 1996; 1997), a number of modelling issues were identified that would require investigation in the future. The SWG agreed to review the issues considered at last year's meeting to determine whether progress had been made on any of these (and whether any new issues had been identified).

2.3.1 Density dependent survival rate

At present the Common Control Program assumes that density dependence acts on fecundity and the calf survival rate. In principle, this can lead to oscillatory population trajectories although the results examined to date do not indicate that this is a severe problem. Such problems would be avoided by allowing density dependence to act on the non-calf survival rate. Punt indicated that intersessionally, he would attempt to incorporate density dependence on the survival rate for juveniles into the Common Control Program and present the resultant population trajectories for consideration at the 1999 meeting.

2.3.2 Component to which MSYL applies

The SWG considered this issue in considerable detail at its 1997 meeting (IWC, 1998). The Committee had agreed that to progress its work in the short term, developers should carry out the *Initial Exploration Trials* using only the 1+ component (the component which, on balance, appeared scientifically preferable to the SWG). Trials using the mature component would be postponed until further in the development process when candidate *SLA*s were more fully specified and comparison with the RMP more appropriate and rewarding. This has the advantage of not increasing the number of trials, but provides no early information on the consequence of this choice (IWC, 1998). Givens noted that SC/50/AWMP1 showed that if density dependence acted on the mature component of the population (assuming that $MSYL = 0.6$ applied to the mature component), this implied a peculiarly high value for $MSYL_{1+}$ (greater than K in some instances).

Table 1

Performance statistics for use in the *Initial Exploration Trials*.

ID	Mandatory	Optional	Can be shown using Zeh graph program	Used to explain performance to layperson	Used to evaluate performance for Scientific Committee	Name	Comment
D1	1+, mature		Yes	Yes	Yes	Final Depletion	1996
D2	1+, mature		Yes	Yes	Yes	Lowest Depletion	1996
~~D3~~						~~Lowest Stock Level under Exploitation~~	DELETE: misleading (1997)
~~D4~~						~~Lowest Depletion under Exploitation~~	DELETE: misleading (1997)
~~D5~~						~~Relative Survival Probability~~	DELETE: not useful (1997)
D6	1+	Mature	Yes	Yes	No	Trajectories 1 and 2	1996
D7	1+	Mature	Yes	Yes	No	Pointwise Quantile Trajectories	1996
N1		Yes	Yes	Yes	Yes	Total Need Satisfaction	1996
N2	Yes		Yes	Yes, after conversion	Yes	Longest Shortfall	Rescale to 0-1; must convert to years for interpretation by Commission - 1996
N3		Yes	No	Yes	No	Severe Shortfall Frequency	Demote to optional (1997)
N4		Yes	No	Yes	Yes	Shortfall Frequency	1996
N5	Yes		Yes	Yes	Yes	Block Need Satisfaction	1996
~~N6~~						~~Adapted Utility~~	DELETE: undesirable properties (1997)
N7		Yes	Yes	No	Yes	Percent Need Satisfaction Pointwise Quantile Trajectory Plot	1996
N8		Yes	Yes	No	Yes	Percent Need Satisfaction Trajectory Plot	1996
N9	Yes		Will be	Yes	Yes	Average need satisfaction	See Item 2.2.1
R1	1+, mature		Yes	Yes	Yes	Relative Recovery	To be redefined
R2		1+, mature	No	No	Yes	Relative Probability of Recovery	1996
R3		1+, mature	No	Yes	Yes	Time Frequency in Recovered State after Recovery	1996
R4		1+, mature	No	Yes	Yes	Relative Time to Recovery	1996

2.3.3 Density dependence on the mature rather than 1+ component

Last year, the SWG agreed that density dependence would act on the mature female rather than the 1+ component. This year, Punt reported that this choice had some undesirable features. These include negative values for the resilience parameter (and hence f_{max}) and reducing the recovery times for populations currently at very low levels. The SWG **encouraged** Punt to present additional information on this at next year's meeting.

2.3.4 Protocol for generating other sources of data

No proposals for new simulated data were presented. It was recognised that should any such proposals be made in the future, the inevitable uncertainty that use of such data would entail should be fully represented.

2.3.5 Time trends in MSYR and K

These issues had been considered during the development of the RMP (e.g. IWC, 1992). *Inter alia*, these can be used to model the effects of changing environment (e.g. habitat degradation). It was **agreed** that these trials are too complex to be considered at this stage of the development process.

2.3.6 Age- and length-structured population dynamics model

It was **agreed** that this did not require attention at present.

2.3.7 Block quotas and carryover

Last year, the Commission had been asked to indicate how much emphasis it should place on developing an AWMP that incorporates block quotas and a mechanism for carryovers. At the Commission, Denmark, Norway and the USA all stated that they believed that such provisions were extremely important and should be incorporated as design features (IWC, 1998). It was noted that some previous papers (Butterworth and Punt, 1994; Givens and Thomas, 1997) had considered the issue of block quotas/carryover in simulation trials. The SWG **acknowledged** the importance of incorporating this feature into the final *SLA*s. In terms of the present development process, however, it was **agreed** that considering strike limits on an annual basis will provide sufficient information.

2.3.8 Allowing for temporal auto-correlation among survey estimates

Initial Exploration Trials condition on past survey data and temporal auto-correlation can, if desired, be readily taken into account for such data. However, there are several sources of potential correlation between future surveys, and the SWG reiterated that this issue merits eventual consideration.

2.3.9 Multi-species issues

When Greenland presented its need request to the Commission, it expressed this as a number of tons of whale meat, with need not assigned to species. At present, Greenlanders take minke and fin whales; humpback whales

were taken up to 1985. At last year's meeting, the SWG requested that the Commission provide it with an estimate of the maximum proportion of total need that minke whales might be expected to supply for the harvest off West Greenland. This clarification should lead to a better balance between need satisfaction, risk and recovery being achieved. At that Commission meeting, Denmark was strongly of the view that a multi-species model should be considered and developed as a priority; it could not agree to the initial development of a single species model without simultaneous multi-species consideration (IWC, 1998). The SWG reiterated that it **recognised** the importance of this issue. It is discussed further under Item 4.3.

2.3.10 Confounding of bias factor and K

At last year's meeting, the SWG agreed to continue to use the current protocol to allow for bias in the *Initial Exploration Trials* and encouraged development of alternatives. No papers dealing with this issue were presented during the meeting and the SWG **agreed** to retain this item on its agenda.

2.3.11 100 year time horizon

At last year's meeting, the SWG agreed that, although need may be difficult to specify over time horizons exceeding 20 years, preliminary trial results indicated that a full 100 years was necessary for the stock to recover in some cases, even with zero catch. It had agreed, therefore, to retain the 100-year management period as mandatory.

2.3.12 Survey frequency

The SWG agreed that the frequency of future surveys required or used by an AWMP was an important issue, both for AWMP development and testing, and also as part of a broader aboriginal subsistence management scheme which would include certain data requirements. For the present, it **agreed** to consider survey frequency on a stock-specific basis. Details of present assumptions used in the trials are given in Appendix 3.

2.4 Facilitating AWMP comparison and tuning

Each candidate *SLA* is likely to achieve a different balance among the objectives specified by the Commission for an AWMP. This makes it difficult to compare candidate *SLA*s. Tuning, or rather more specifically *equivalence tuning*, is a way to provide *SLA* developers with the opportunity to adjust their *SLA*s to strive towards a pre-specified balance of risk, catch and recovery.

SC/49/AS10 had suggested a new approach to tuning candidate *SLAs* that would consider need and recovery as well as final depletion. This approach, denoted *H-tuning*, involved selecting the values for the parameters of the *SLA*s to match as adequately as possible the strike limits set by a pre-specified *SLA* which is based on perfect information about stock dynamics and operating model parameter values. The target *SLA* is not intended to represent ideal *SLA* performance, rather it is meant to illustrate a particular balance between need satisfaction, population depletion and recovery to which candidate *SLAs* may all be tuned. The SWG had agreed that this was a promising approach.

SC/50/AWMP4 described methods for *equivalence tuning* AWMP *SLAs*. It compared the relative merits of *depletion tuning*, as was used for RMP *CLA* candidates, and *H-tuning*. *Depletion tuning* aims to achieve a pre-specified median final depletion on a trial, whereas *H-tuning* aims to match a pre-specified set of strike limit trajectories for a collection of trials. *Depletion tuning* is familiar (it was used during the RMP development process) and conceptually simpler. However, it focuses on stock depletion only and places the management simulation within an optimisation loop, which can be computationally very slow. Examples presented in SC/50/AWMP4 show that care should be taken when choosing a target depletion for *depletion tuning*. *H-tuning* considers need satisfaction and stock recovery objectives more explicitly, and is computationally much faster because it places simulation outside the optimisation loop. However, it was agreed that the speed of *H-tuning* is achieved at the expense of some accuracy and, unlike *depletion tuning*, *H-tuning* does not yield an exact equivalence. During the development of the RMP, tuning had been used to ensure that the range of variants for each candidate *CLA* spanned a range so that is was possible to compare them to assess the trade-offs among the management objectives that they achieve. SC/50/AWMP4 also suggested ways for evaluating and comparing the degree to which *SLA*s are equivalenced if *H-tuning* is used.

Theoretically, the selection of the best *SLA* among several candidates can depend on how the candidates are equivalence tuned; requiring an exact *depletion tuning* target could result in an inferior candidate being selected. However, if *SLA* strike limits are likely to change smoothly with tuning parameter values, and if *MSYR* is not high, then the two tuning methods should provide similar results.

SC/50/AWMP4 also identified several problems with the specifications of *H-tuning* drafted last year (IWC, 1998, annex I). In particular it suggested that they should include a clear specification of how the catch limits to be compared to those corresponding to *H* are calculated.

The SWG reiterated that it found *H-tuning* a promising idea. It **agreed** with the authors of SC/50/AWMP4 that their recommended method for implementing *H-tuning* was appropriate. Revised specifications are included in Appendix 3. The SWG further considered the relative merits of *H-tuning* and *depletion-tuning*. A question was raised as to whether the performance of an *H-tuned SLA* might be inferior in terms of actual performance (as measured by the values for performance statistics). However, it was noted that *H-tuning* is merely a method for equivalencing and that eventual comparisons would be based on the full set of performance statistics. A potential advantage of *H-tuning* is that it is possible, although not mandatory, for more than one trial to be used. However, it was noted that it would be difficult to select weights if more than one trial was used as part of the tuning.

The SWG **agreed** that at present, results should be presented for both *depletion tuning* and *H-tuning*. It was noted that current implementation of *H-tuning* gives additional weight to trials in which the catches under *H* are high. It was requested to select an objective function that did not have this property. The SWG **agreed** that the approach presented in Appendix 3 should be adopted. A small group chaired by Magnússon was established to specify the technical details of how this can be achieved.

3. DESCRIPTION OF FISHERY TYPE 3

During last year's meeting, the SWG agreed that it would be valuable to begin consideration of an additional type of fishery in the development of an AWMP. This arose out of its discussions of multi-species fisheries. It was further agreed that this new type of fishery would refer to populations to be harvested that were small, although the question of how small was left to be discussed. DeMaster

and Breiwick undertook to examine this matter intersessionally. DeMaster reported that in an effort to develop objective criteria for determining a minimum population size to be used in the *Initial Exploration Trials* for type 3 fisheries, he had carried out exploratory simulations to determine the minimum population size that could sustain an annual take of one or more animals while not increasing the 95%-ile time to recovery by more than 10%. The population model used was similar to that described by Wade (1998) with the additional feature that the underlying maximum rate of growth of the population was also allowed to vary annually. Using CVs between 0.2-0.3 for the maximum rate of growth, estimates of abundance and the number of animals harvested annually, and assuming an initial population status of 0.1 relative to carrying capacity, DeMaster reported that a minimum population of 1,000 animals was required to meet the objective of not increasing the 95%-ile time to recovery by more than 10%. However, he noted that the 95%-ile of the time to recovery was only increased by 7% for a population of 500 animals, where an average of one animal was removed every four years. Finally, he noted that the results of such simulations used to estimate the distribution of recovery times were quite sensitive to assumptions regarding the initial status of the population. The SWG thanked DeMaster for conducting this work. It noted that the analysis had been conducted in a scale-invariant manner, and that alternative models of variability needed consideration to fully reflect the implications of small population size.

The SWG **agreed** that, for exploratory purposes, it will initially examine fishery type 3 as a case in which the current population size is small (~ 300) and where demographic and environmental variability may have an impact on recovery times. Although the number 300 was largely arbitrary and intended to allow an exploratory investigation of the problem, it was loosely based on considerations of the size of the West Greenland humpback whale feeding aggregation, the lower confidence interval of the abundance estimate for fin whales in the West Greenland area and possible sizes of some Canadian stocks of bowhead whales. Initial trials for fishery type 3 would need to consider cases in which the population is depleted to a small fraction of its pre-exploitation size and ones where it is close to this size. The SWG's initial attempts to address this problem are detailed in Appendix 3.

4. DESCRIPTION OF POTENTIAL PROCEDURES

4.1 Fishery type 1

No new approaches were presented.

4.2 Fishery type 2

SC/50/AWMP5 introduced a new *SLA* for fishery type 2 based on likelihood methods. This approach was an improvement on an *SLA* introduced in Givens (1997a), in that the new variant used the entire historical catch record, 1848-present, and required fewer parameters for model fitting.

4.3 Other

SC/50/AWMP6 compared the management procedures of commercial and subsistence whaling by assuming that subsistence catches are more fundamental than commercial catches. This leads to a unified whaling procedure that primarily allocates catches into the satisfaction of need, but also allows for commercial catches when need is smaller than the catch limit set under the RMP.

Past work on AWMPs have focussed mainly on single species systems, but SC/50/AWMP7 considered the multi-species situation where need is given in tons of whale meat, not assigned to specific species. The paper develops multi-species *SLA*s that satisfy need by converting the total need into catch limits of the different species considered. The multi-species *SLA*s are simple algorithms that are superimposed on top of the upper catch limits of the underlying single species *SLA*s. The multi-species *SLA*s can fulfil larger needs than single species *SLA*s, and they can optimise the recovery rates of the multiple species when need is satisfied. Four different algorithms were proposed based on principles of respectively species ranking, even catch, even exploitation and even recovery. The multi-species algorithms require no estimates beyond those of the underlying single species AWMPs and, thus, they can be applied to any combination of species given that each species has a single species AWMP.

The SWG appreciated this contribution to the consideration of the multi-species issue. Additional suggestions for allocation schemes suggested include relative productivity of the populations and an 'even risk of extinction' approach. This is discussed briefly under Item 7.1.

5. INITIAL EXPLORATION TRIALS

In discussing this Item, it was agreed that a small working group, convened by Magnússon, should develop revised trial specifications based on the general discussion in the full SWG. It was **agreed** that the principles of the revisions should be agreed by the SWG but that the details of the trials could be completed by the small group after the closure of the sub-committee. These are included in Appendix 3.

5.1 Fishery type 1

At its 1996 meeting, the Committee defined fishery type 1 as a case where there is relatively little available information and stock identity problems (e.g. West Greenland minke whales) and where the Committee has had considerable problems in providing advice under Para.13(a) of the Schedule.

5.1.1 Review progress with existing trial structure

Punt reported that he had developed a control program to implement the multi-stock trials for fishery type 1 that had been specified at last year's meeting. SC/50/AWMP3 presented results for the application of a Small Areas variant of the *SLA* developed by Punt and Butterworth (1997). Performance for these trials was relatively poor and depended primarily on the value for the *MSY* rate.

5.1.2 Modifications to trials

The SWG **agreed** to combine the single stock and multi-stock trials for fishery type 1 to be able to distinguish the impact of *MSYR* from that of stock identity uncertainty. A unified set of trials for this type of fishery was agreed upon (Table 2). In addition to the eight trials agreed last year (IWC, 1998, annex I, table 7) a further four were specified such that a 1% and a 7% MSYR trial was carried out for all combinations. These trials are to be carried out with and

Table 2
The set of trials agreed for fishery type 1.

Trial	$MSYR_{1+}$	Initial population	Catch in Area 1	Need	Survey interval	Stock structure
MM1	0.01	High	0	Const.	10yrs	Boundary between middle and 2
MM1a	0.07	High	0	Const.	10yrs	Boundary between middle and 2
MM2	0.01	High	0	Const.	10yrs	Boundary between 1 and middle
MM2a	0.07	High	0	Const.	10yrs	Boundary between 1 and middle
MM3	0.07	High	0	Const.	10yrs	Mixing in middle cell
MM4	0.07	High	Yes[1]	Const.	10yrs	Mixing in middle cell
MM5	0.01	Low	0	Const.	10yrs	Boundary between middle and 2
MM5a	0.07	Low	0	Const.	10yrs	Boundary between middle and 2
MM6	0.01	Low	0	Const.	10yrs	Boundary between 1 and middle
MM6a	0.07	Low	0	Const.	10yrs	Boundary between 1 and middle
MM7	0.01	Low	0	Const.	10yrs	Mixing in middle cell
MM8	0.01	Low	Yes[1]	Const.	10yrs	Mixing in middle cell
MM9	0.01	High	0	Inc.	10yrs	Boundary between middle and 2
MM10	0.07	High	0	Inc.	10yrs	Mixing in middle cell
MM11	0.01	Low	0	Inc.	10yrs	Mixing in middle cell
MM12	0.01	High	0	Const.	2-10yrs[2]	Boundary between middle and 2
MM13	0.07	High	0	Const.	2-10yrs[2]	Boundary between 1 and middle

[1] Catches set using RMP. [2] Surveys every 2 years until year 10, and every 10 years thereafter.

without information about stock identity. Need is taken to be constant in all these cases and a further three trials consider increasing need (Appendix 3).

Present *SLA*s do not perform well in cases of low stock size combined with high MSYR. It is possible that the poor performance is due to the rather long interval between surveys. In order to investigate whether this performance could be improved by more frequent surveys, it was **agreed** that two trials should be carried out when surveys were carried out every second year for the first ten years (six surveys in all) followed by surveys every ten years thereafter.

These two trials consist of the combinations low stock size/low MSYR and high stock size/high MSYR. These trials represent the first step at addressing this issue and further robustness trials will be considered in the future.

The issue of data availability and the ability to develop a successful *SLA* for fishery type 1 is discussed in further under Item 10.

5.2 Fishery type 2

At its 1996 meeting, the Committee defined fishery type 2 as a case where there is a relatively large amount of information and Para. 13(a) of the schedule has largely been met (e.g. Bering-Chukchi-Beaufort Seas stock of bowhead whales).

5.2.1 Review progress with existing trial structure

SC/50/AWMP2 contrasted two methods for conditioning the *Initial Exploration Trials* for fishery type 2. The difference between the two methods lies in that one conditions on pre-specified choices for *MSYL*, *MSYR* and P_0 whereas the other does not. The distributions for four biological parameters (age-at-maturity, the survival rate for juveniles, the greatest age at which natural mortality for juveniles applies and the survival rate for adults) were found to be sensitive to the method chosen. Not conditioning on the pre-specified values for *MSYR*, *MSYL* and P_0 leads to values for the maximum pregnancy rate which have previously been considered to be unrealistic by the Scientific Committee and notably broader distributions for the number of mature females. It was shown that even if the suggested method for conditioning the trials was adopted, an inconsistency would remain between the population trajectories underlying the trials and the actual data for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Suggestions were made for re-designing the trials for fishery type 2 to avoid this lack of consistency.

Givens introduced Appendix 4 which agreed that the solution proposed in SC/50/AWMP2 solved the conditioning problem, but noted that it also reduced considerably the amount of variation in future population trajectories in any trial, while simultaneously making the extreme trials (B3 and B7) even more extreme. This was considered further by the trials group and an agreed revised method for conditioning the trials is given in Appendix 3.

The SWG considered the question of introducing stochasticity into fishery type 2 trials as noted in Appendix 4. It **agreed** that a move to a stochastic model was desirable but was unsure whether the parameter choices in Appendix 3 would introduce sufficient additional variation in population trajectories. It **agreed** that the operating model for the fishery type 2 trials should be made stochastic. The specifications for the stochastic model are given in Appendix 3.

Cooke noted that a low level of variation in the biological parameters within each trial was only a concern if this meant that it was possible for an *SLA* to 'identify' the trial and hence perform unrealistically well. Givens considered that *SLA* performance could be examined on a broad spectrum of trials and it would not be unreasonable for an *SLA* to select among a small number of stock status scenarios and set the strike limit accordingly. He noted that the 'tri-level reluctant shift' *SLA* of SC/49/AS10 had adopted such a strategy.

Further discussion in the SWG related to whether uncertainty should be expressed using a large number of trials with little within-trial variation or a small number of trials with greater within-trial variation. Some members preferred the latter, more integrative, approach (except with respect to *MSYR*) because a small number of trials would simplify *SLA* comparison and would discourage 'worst-case' reasoning when examining *SLA* performance. Other members agreed with the merits of using a small number of trials with greater within-trial variation, but also saw merit to spanning the range of uncertainty with separate specific trials to isolate problematic scenarios. The SWG **agreed** that this matter required further consideration.

5.2.2 Modifications to trials

The SWG noted that the introduction of stochasticity will require some exploratory work. It was **agreed** that the assumptions in the trials agreed last year should remain unchanged (except that as a result of the new conditioning approach, the initial population ($=P_{1993}$) is no longer fixed). The **agreed** trials are summarised in Table 3.

Table 3

Initial Exploration Trials for fishery type 2.

			Need		Data Quality				
Trial no.	$MSYR_{1+}$	Initial population P_0	Initial level	Final level	CV_{est}	$\gamma_{12.9}$	$\lambda_{12.9}$	Bias B_A	Comments
B1	0.025	8,200	68	68	0.25	0	1	1	1996
B2	0.025	8,200	68	68	0.125	4	2	1.5	Replace (7a)
B3	0.04	9,400	100	200	0.25	0	1	1	Deleted 1997
B4	0.04	9,400	68	68	0.25	0	1	1	Deleted 1997
B5	0.01	9,400	100	200	0.25	0	1	1	1996
B6	0.01	9,400	68	68	0.25	0	1	1	1996
B7	0.01	7,200	100	200	0.25	0	1	1	1996
B8	0.01	7,200	68	68	0.25	0	1	1	Deleted 1997
B9	0.04	7,200	100	200	0.25	0	1	1	Deleted 1997
B10	0.04	7,200	68	68	0.25	0	1	1	1996

5.2.3 Fishery type 3

The SWG agreed that the trials for fishery type 3 (limited information, small stock size of 300) should be based on stochastic population dynamics models that allow for variation in the birth-death process and possibly depensation. It was agreed to focus on stochastic population dynamics and to consider three kinds of models (see Appendix 3):

(i) simple demographic stochasticity (on survival and birth rate);
(ii) demographic stochasticity plus environmental stochasticity without auto-correlation;
(iii) same as (ii) but with auto-correlation.

Some initial simulations and explorations are needed are needed to determine feasible and reasonable combinations and ranges of parameter values but the focus is on low population size (~ 300 whales) and a K value either close to the population size or much higher. MSYR values of 1%, 4% and 7% will be considered for each of the three types of stock model. The SWG's initial attempts to address this problem are detailed in Appendix 3.

6. PLANNING FOR FUTURE SELECTION OF *SLA*s

6.1 Clarification of management and performance objectives

The SWG recalled the (summarised) objectives given by the Commission:

(1) ensure that the risks of extinction to individual stocks are not seriously increased by subsistence whaling;
(2) enable aboriginal people to harvest whales in perpetuity at levels appropriate to their cultural and nutritional requirements, subject to the other objectives: and
(3) maintain the status of stocks at or above the level giving the highest net recruitment and to ensure that stocks below that level are moved towards it, so far as the environment permits.

Highest priority shall be accorded to the objective of ensuring that the risks of extinction to individual stocks are not seriously increased by subsistence whaling.

6.2 Specification of performance measures

The SWG **agreed** that the performance measures, as amended in this report (see Item 2.2.1), were satisfactory for the purposes of *SLA* evaluation at this time.

6.3 Statistical design of performance evaluation trials

At last year's meeting, the SWG agreed to a staged process of *SLA* evaluation and selection. No work on the optimal experimental design of simulation trials was carried out during the intersessional period.

6.4 Quantitative strategies for ranking, optimising and merging *SLA*s.

No methods for ranking *SLA*s were considered at this time.

At last year's meeting, the SWG encouraged further work on methods for optimising *SLA*s, noting that the ideas in Givens (1997b) appeared highly promising. Givens presented SC/50/AWMP5 wherein several potential AWMP *SLA*s were reviewed and enhanced, including the likelihood approach referred to under Item 4.2 and the Punt and Butterworth (1997) *SLA*. The focus was on an optimisation method for improving the performance of existing *SLA*s and for creating enhanced, merged *SLA*s from existing candidates. This approach has several appealing statistical optimality properties. Optimisation of existing *SLA*s was very effective. For example, by applying this approach to the Punt and Butterworth (1997) *SLA*, a new variant was created which was superior on the B3 *Initial Exploration Trial* and which provided 50% more need satisfaction on the B7 *Initial Exploration Trial* while reducing the final stock size by only 0.01K below that achieved by the original *SLA*, based on 5th percentile performance. Results for merging two *SLA*s were dependent on the quality and correlation of the candidates to be merged, as well as the fitting model and loss function. A key feature of the optimisation method is that it isolates *Initial Exploration Trial* simulation outside the optimisation loop to enable fast computation. In the SC/50/AWMP5 examples, the method used an objective function that was within 4% of the one used in a standard approach, but to obtain the exact answer the standard approach would have required up to 600,000% more computing time. The optimisation method in SC/50/AWMP5 therefore allows preliminary research effort to be concentrated on a wide-ranging and intensive search for optimal *SLA* performance.

The approach in SC/50/AWMP5 does not explicitly consider variation over time in strike limits. This could be dealt with by including an extra term in the function minimised, and some members considered that this would, in due course, be an essential refinement. However, while agreeing that this could theoretically be a concern, Givens argued that any such problem would be identified during the *SLA* evaluation phase – his method was intended for

creating, not evaluating, candidate *SLA*s. Using a different loss function would also be an alternative for *SLA* developers. The SWG **agreed** that strike limit trajectories are usually smooth functions of time, and therefore the application of the approach in SC/50/AWMP5 (which is a function of existing *SLA*s) would not be likely to cause excessive catch limit variation.

It was noted that one *SLA* examined at this meeting had been tuned so that the strike limit was a polynomial function of its nominal strike limit and the calendar year. Concerns were raised as to whether this constituted an inappropriate management strategy since: (1) aboriginal need is a linear function of time in most *Initial Exploration Trials*; (2) whale stocks exist independent of the human calendar; and (3) some such strategies can lead to dangerous time extrapolation if continued indefinitely. However, given that the primary objective is good simulation performance, regardless of the intricacies of the *SLA*, and more importantly that several RMP candidates had successfully used the time variable with various degrees of explicitness, it was **agreed** that no restriction regarding the use of the time variable should be adopted at this stage.

7. DIALOGUE WITH COMMISSION AND HUNTERS

The SWG reiterated the importance it attached to continuing dialogue with the Commission and hunters throughout the development process (IWC, 1998, annex I). It agreed that the procedure adopted last year, i.e (1) a presentation by the Chairman of the SWG of its report and a less technical Chairman's discussion paper, and (2) informal discussions with interested Commissioners, had proved successful. It **recommends** that this procedure be repeated this year.

7.1 Approach for Oman

The SWG noted the questions posed to the Commission during last year's meeting (IWC, 1988, annex I) and discussed which were the questions which most urgently required further comment from the Commission.

7.1.1 Multi-species considerations

The SWG noted the importance which some delegations placed on developing a multi-species operating model. It reiterated that it recognised this and is starting to develop a multi-species operating model. As a first step in this process, trials are being constructed for fishery type 3. In addition, it is examining options involving multi-species *SLA*s superimposed on top of the upper catch limits of underlying single species *SLA*s. The multi species *SLA*s can fulfil larger needs than single species *SLA*s, and they can optimise the recovery rates of the multiple species when need is satisfied. A number of features of this approach will require input from the Commission and hunters, as can be seen in the discussion under Item 4.3.

7.1.2 Need satisfaction

At present, need satisfaction is considered over 20, 50 and 100 year periods. The SWG requests the Committee to ask the Commission to comment on whether greater emphasis should be placed on satisfying current rather than projected future need.

7.1.3 Catch variability considerations

At last year's meeting, the SWG requested that the Committee ask the Commission to provide it with a general indication of the importance of variability in catches. For example, would it prefer an AWMP that achieves a slightly higher level of total need satisfaction averaged over a longer time period at the expense of greater variability in strike limits or would it prefer to sacrifice some satisfaction of total need to ensure less variability in catches? The Commission had agreed to give consideration to this during the year. The SWG agreed that resolution of this issue was important for its work. The SWG agreed that the Chairman should request information on catch variability by presenting the Commission with a series of time trajectories of strike limits which reflect the trade-off between need satisfaction and variation in strike limits and ask the Commission to select among the alternatives.

8. WORKPLAN (INCLUDING COMPUTING NEEDS AND FINANCIAL IMPLICATIONS)

As noted under Item 1, the Chair indicated that he believed that it was important that the SWG began to consider how best to ensure that it could progress as efficiently as possible to being able to present the Commission with an AWMP that satisfied the Commission's objectives. In this context he wished to thank Givens for producing an extremely useful discussion paper on this subject.

In order to enable progress to be made he believed that it was important to have a general discussion on the likely form the SWG believed the AWMP might take, before considering more detailed aspects of the workplan.

At its 1996 meeting, the SWG had agreed that the *Initial Exploration Trials* should be case-specific rather than generic because there are a limited number of cases for which aboriginal subsistence harvesting is likely (IWC, 1997). However, it did not reach consensus on whether the AWMP should include a generic *SLA* or case-specific *SLA*s.

At this meeting, the SWG agreed that there were three alternatives:

(1) an *SLA* which is completely generic;
(2) a generic core *SLA* with case-specific modifications; and
(3) completely case-specific *SLA*s.

The SWG **agreed** that it in principle it would be preferable to have a single generic *SLA*. However, the primary task of the AWMP is to satisfy the management objectives established by the Commission to the greatest extent possible for the fisheries of concern.

The SWG **agreed** that given the results so far, and the well-documented differences between the fisheries in terms of data availability, stock identity complexity and the nature of the fisheries themselves (e.g. the multi-species nature of the Greenlandic case), it was extremely unlikely that a single *suitable* generic *SLA* could be developed. It is therefore clear that either of the alternatives (2) or (3) are most likely to enable us to satisfy the Commission's objectives. It **draws this to the attention** of the Committee and the Commission. The SWG **agreed** that to the extent possible it would be preferable to follow option (2).

Thus, a likely potential scenario is that the Commission might establish an Aboriginal Whaling Scheme that comprises the scientific and logistical (e.g. inspection/observation,) aspects of the management of all aboriginal fisheries. Within this, the scientific component might comprise some general aspects common to all fisheries (e.g. guidelines and requirements for surveys and for data c.f. the RMP) and an overall AWMP (within which there will be common components and case-specific components).

An important implication of this is that given the different degrees of difficulty, it will be possible to develop *SLAs* for some stocks before others. The SWG **agreed** that it could best fulfil its role of providing the Commission with advice on stocks subject to aboriginal whaling if it presented available components of the AWMP to the Commission as and when they were ready. It **draws this to the attention** of the Committee and the Commission. This is considered further under Item 8.2.

The SWG reaffirmed that its aim was to produce an AWMP that satisfactorily meets the Commission's objectives as quickly as possible. The SWG noted that improvements beyond this point would not be justified in terms of time and cost.

8.1 Short-term (1 year)

The SWG identified a number of tasks that required work during the coming year, including computing tasks for the Secretariat. These are given in Table 4. The SWG **recommends** that the highest priority be accorded to the computing tasks by the Committee. It stressed that the pace of the development process was critically dependent on the appropriate software being available as soon as possible.

The SWG recalled that, last year, it had noted that it would probably require an intersessional meeting between the 1998 and 1999 meetings. In order to give developers as much time as possible and to ensure that adequate time is available for the SWG to consider the results of their work, the SWG **recommends** that its work commences three days immediately prior to the next Scientific Committee meeting. It also **draws the Committee's attention** to its request that invited participants be invited on more than a one off basis.

The SWG noted the importance of continuity to its work. It therefore **recommends** that Donovan act as co-ordinator of its intersessional activities during the coming year.

8.2 Medium-term funding

Last year the SWG had recognised that during the development of the *RMP*, the Committee and the Commission had established a fund to help support the work of some developers and had requested that the Committee and the Commission should consider establishing a similar scheme for AWMP development. This year it **recommends** that such a fund be established. It agreed that the fund should initially be established at a level of £5,000 with a maximum of £1,500 available annually to each developer. It is envisaged that the fund should carry-over from year to year, such that each year it begins with £5,000. Developers wishing to draw on the fund should apply to the Secretariat. The decision to approve the application should be taken by the Chairman of the Standing SWG and the Chairman of the Committee.

8.3 Long-term

The SWG noted the steps it had previously identified in the development of the AWMP (IWC, 1998, annex I):

(1) summarise existing data for stocks harvested by aboriginal whalers (completed);
(2) clarify management and performance objectives of the *AWMP* (may require additional input from the Commission and hunters as work proceeds);
(3) specify performance measures (on-going);
(4) specify simulation trials (on-going);
(5) specify candidate *SLAs* (on-going);
(6) subject candidate *SLAs* to stock-specific simulations trials and compute performance measures under a range of scenarios;
(7) if required, modify candidate *SLAs* in light of simulation results and repeat simulation trials;
(8) recommend *SLAs* to the Commission.

In the light of its discussions above, it reiterates that it believes that it is most appropriate to provide the Commission with recommended *SLAs* for different fisheries at different times.

The SWG **agreed** that it was not in a position to develop a precise timetable for its work. However, it believed it would be in a stronger position to do so at its next meeting. It therefore confined itself to:

(1) an elaboration of the process above by which it would arrive at recommended *SLAs*;
(2) general comments on a timetable on a fishery by fishery basis.

Table 4

Work to be carried out by in the coming year.

Task	Estimated time/to be done by
Secretariat computing	
(1) Revise the program to implement the multi-stock trials for fishery type 1 as detailed in Appendix 3.	1 month
(2) Implement the stochastic dynamics model (including the 3 methods given in Appendix 3) and apply the stochastic backwards method to obtain input parameters for fishery type 2. This may require iteration through the AWMP correspondence group. As a first step, modify the control program to input rather than pre-specify P_0 and apply the deterministic backwards method to obtain input parameters for fishery type 2 that can be used until the task is completed.	2 months
(3) Modify the common control program to implement and run trials to investigate the effects of 3 different methods of incorporating stochasticity into fishery type 3 trials.	
(4) Finalise the plotting program (in collaboration with Zeh).	
Other	
(1) Software distribution questions (Item 1.7).	Secretariat
(2) Incorporate density dependence on the survival rate for juveniles into the common control program and present trajectories (Item 2.3.1).	Punt
(3) Additional information on density dependence on the mature rather than 1+ component (2.3.3).	Punt
(4) Begin work on the gray whales (Item 8.3).	DeMaster

With respect to (1), it identified the following types of trials necessary.

Evaluation Trials. Such trials would be used for formal comparison of candidate *SLA*s. Their number would be limited, compared to the number of *Robustness Trials*. Development of *Evaluation Trials* would commence prior to that of *Robustness Trials*. More than one round of such trials is likely before a favoured *SLA* is identified. Developers would be able to adapt their efforts accordingly.

Robustness Trials. Trials to examine *SLA* performance for a full range of plausible scenarios. These would be applied to the restricted set of *SLA*s found to perform well in *Evaluation Trials*. The number of such trials would be potentially large. Results will be used to fine tune *SLA*(s) for acceptable performance. Again, more than one round may be necessary.

With respect to (2) the following comments were made.

Greenland fisheries

The Chairman of the SWG referred to discussions in the sub-committee on Aboriginal Subsistence Whaling (Annex I). That sub-committee had noted with great concern that it has never been able to provide satisfactory scientific advice on either fin or minke whales off West Greenland. The reason that satisfactory advice cannot be given is the lack of requisite data, particularly on stock structure and abundance. That sub-committee had recognised that the logistical difficulties of obtaining the necessary information are enormous, both in terms of the physical environment (including weather conditions) and the level of resources required.

The Chairman had indicated to that sub-committee that even at this stage in the development process, it was clear that developing an *Strike Limit Algorithm* for the Greenland Fisheries that would fulfil all the Commission's objectives will be an extremely difficult, if not impossible task, given the available data.

The sub-committee on aboriginal subsistence whaling had therefore **recommended** that the Committee establishes a SWG, in collaboration with Greenlandic scientists, to determine a costed research programme that will enable the Committee to provide satisfactory advice to the Commission as soon as possible. At a minimum this programme will address questions of stock identity and abundance. The programme will take into account the work of this SWG, where the important relationship between data requirements and management procedures has already been stressed.

The SWG **agreed** that providing advice on the Greenlandic fisheries was a matter of the highest priority. It concurred that, given our present state of knowledge, developing an *Strike Limit Algorithm* for the Greenland Fisheries that would fulfil all the Commission's objectives will be an extremely difficult, if not impossible task.

It therefore **strongly recommends** that the above SWG be established and that representatives of the AWMP Group should be included. Noting that the Greenlandic scientists are currently designing a research programme it **further recommends** that an Intersessional Correspondence Group be established to assist in this process. Noting the SWG's full workload, and the fact that the sub-committee on Aboriginal Subsistence Whaling does not need to carry out a major reassessment next year, it suggests that the Committee considers giving the Greenlandic research programme high priority status in the work of that sub-committee next year.

In view of the above, the SWG **agreed** that it would be in a stronger position to provide advice on a timetable, for providing the Commission with a recommended *SLA* for this multi-species fishery, when the results of the research programme begin to become available.

Bering-Chukchi-Beaufort Seas stock of bowhead whales

The SWG noted that last year the Commission had established catch limits for this stock until the year 2002. It therefore **agreed** that it would be highly desirable if it could be in a position to recommend an *SLA* for this fishery to the Commission by that year. It hoped to be able to give the Commission more advice on whether this was achievable after its next meeting.

Eastern stock of gray whales

Although the fishery type 2 *Initial Exploration Trials* have been based on the bowhead whale situation, the SWG **agreed** that the eastern stock of gray whales was essentially a fishery type 2 stock. It believed that it was likely that a single *SLA* (or minor variants) would be applicable to both stocks. The SWG **agreed** that consideration of this fishery should begin in the near future. DeMaster indicated that such work may be undertaken within the USA. The SWG noted that last year the Commission had also established catch limits for this stock until the year 2002. It therefore **agreed** that it would be highly desirable if it could also be in a position to provide a recommendation to the Commission for this fishery by that year. It hoped to be able to give the Commission more advice on whether this was achievable after its next meeting.

St. Vincent and The Grenadines humpback whales

The SWG has not yet considered this fishery in any detail. It noted that the Committee was intending a major review of North Atlantic humpback whales at the year 2000 meeting.

9. ANY OTHER BUSINESS

The SWG noted that the Committee has in the past expressed concern over the status of the Baffin Bay-Davis Strait and Hudson Bay-Foxe Basin stocks and that this was re-iterated in Annex G this year. It also noted the kill of one whale in 1996 from the Hudson Bay-Foxe Basin stock and that Canada, a non-member nation, had authorised up to two strikes in 1998 from the Baffin Bay-Davis Strait stock.

DeMaster indicated that he was planning to begin exploratory work on developing a management procedure for these stocks. The SWG **agreed** that, provided that this did not interfere with its priority work to develop *SLA*s for those stocks that the Commission was managing directly, it would be prepared to review and comment on work on other stocks

10. ADOPTION OF REPORT

The report was adopted at 17:00 on 6th May 1998.

REFERENCES

Butterworth, D.S. and Punt, A.E. 1994. RMP Miscellany. Paper SC/46/Mg4 presented to the IWC Scientific Committee, May 1994 (unpublished). 33pp.

Givens, G.H. 1997a. AWMP development and diverse prototypes. Paper SC/49/AS10 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 27pp.

Givens, G.H. 1997b. Separable multicriterion design and performance optimization of AWMPs. Paper SC/49/AS4 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 21pp.

Givens, G.H. and Thomas, D.J. 1997. Bowhead aboriginal management procedure trials and statistics. *Rep. int. Whal. Commn* 47:851-863.
International Whaling Commission. 1992. Report of the Fourth Comprehensive Assessment Workshop on Management Procedures, Annex D. Single stock trials for finalised procedures. *Rep. int. Whal. Commn* 42:317-8.
International Whaling Commission. 1996. Report of the Scientific Committee. *Rep. int. Whal. Commn* 46:49-236.
International Whaling Commission. 1997. Report of the Scientific Committee, Annex P. Report of the working group on aboriginal whaling management procedures. *Rep. int. Whal. Commn* 47:243-9.
International Whaling Commission. 1998. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48:53-302.
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.

Appendix 1

AGENDA

1. Introductory items
   - 1.1 Convenor's opening remarks
   - 1.2 Election of Chair
   - 1.3 Appointment of rapporteurs
   - 1.4 Adoption of agenda
   - 1.5 Review of documents
     - 1.5.1 Update of glossary
     - 1.5.2 Update of 'trials' appendix
   - 1.6 Commission comments from the Monaco meeting
   - 1.7 Report of the e-mail correspondence group
2. *Initial Exploration Trials* - general issues
   - 2.1 Common Control Program
   - 2.2 Statistics and performance plots
   - 2.3 Review of simulation framework
   - 2.3 Facilitating AWMP comparison and tuning
3. Description of fishery type 3
4. Description of potential procedures
   - 4.1 Fishery type 1
   - 4.2 Fishery type 2
   - 4.3 Other
5. *Initial Exploration Trials* - specific
   - 5.1 Fishery type 1
     - 5.1.1 Review progress with existing trial structure esp. multi-stock trials
     - 5.1.2 Modifications to trials
   - 5.2 Fishery type 2
     - 5.2.1 Review progress with existing trial structure incl. conditioning
     - 5.2.2 Modifications to trials
   - 5.3 Fishery type 3
6. Planning for future selection of *SLA*s
   - 6.1 Clarification of management and performance objectives
   - 6.2 Specification of performance measures
   - 6.3 Statistical design of performance evaluation trials
   - 6.4 Quantitative strategies for ranking, optimising and merging *SLA*s
7. Dialogue with Commission and hunters
   - 7.1 Approach for Oman
   - 7.2 Future
8. Workplan (including computing needs and financial implications)
   - 8.1 Short-term (1 year)
   - 8.2 Long-term
9. Any other business
10. Adoption of report

Appendix 2

TERMINOLOGY

Table 1 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 definitions 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.

REFERENCE

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.

(Table 1 on next page)

Table 1

Procedures (schemes, procedures and algorithms)	
AWMP	Aboriginal Subsistence Whaling Management Procedure.
AWS	Aboriginal Subsistence Whaling Scheme.
SLA	*Strike Limit Algorithm*: 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 Para. 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 *Initial Exploration Trials* 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.
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 *SLA*s to strive towards a pre-specified balance of risk, satisfaction of need and recovery.
Evaluation Trials	Trials used for formal comparisons of candidate *SLA*s. Their number would be limited, compared to the number of Robustness Trials. Evaluation Trials would be initiated prior to Robustness Trials.
Generic trial	A trial in which the population size or the other input parameters are not customised to represent a specific application.
H	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 *SLA*s, 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*.
Initial Exploration Trials	Case-specific simulation trials for assessing the merits of performance statistics and to provide a framework for developers in the AWMP.
Merging of *SLA*s	Any method for combining *SLA*s that produces a new *SLA* that provides strike limits depending on the limits given by the component *SLA*s.
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.
Robustness Trials	Trials to examine *SLA* performance for a full range of plausible scenarios. These would be applied to a restricted set of *SLA*s found to perform well in Evaluation Trials. The number of these trials would be potentially large.
Fishery type 1	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).
Fishery type 2	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).
Fishery type 3	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).
Revised Management Procedure (RMP) the RMP is described in detail in IWC (1994, pp.145-52).	
CLA	*Catch Limit Algorithm*, the process described in IWC (1994, pp.147-8) that is used in the RMP to calculate a catch limit for a Management Area.
Implementation/Simulation Trials	Involve identifying the range of plausible hypotheses relevant to recommending an Implementation or Implementation Review for the RMP and formulating simulation models which conform with these hypotheses

Appendix 3

THE INITIAL EXPLORATION TRIALS

This Appendix provides the specifications for the *Initial Exploration Trials*. The trials are based upon the age- and sex-structured population dynamics model used for the evaluation of *Catch Limit Algorithms* for the RMP. The trials model three types of fishery:

(1) a case where there is relatively little available information and stock identity problems (e.g. West Greenland minke whales) and where the Committee has had considerable problems in providing advice under Para. 13(a) of the Schedule. The trials consider both the case when the stock identity is uncertain and the case when the boundaries of the stock being managed are known (which is equivalent to the single stock case);
(2) a case where there is a relatively large amount of information and Para. 13(a) of the Schedule has largely been met and in which it is known that the region managed contains only a single stock (e.g. Bering-Chukchi-Beaufort bowhead whales);
(3) a case where the current population size is small (~ 300) and where demographic and environmental variability may have an impact on recovery times (e.g. West Greenland humpback feeding aggregation, fin whales off West Greenland which are at population levels near the lower confidence limit and some Canadian stocks of bowhead whales).

In order to begin exploration of stock structure a simple 2 stock model has been developed and is specified in section G. This models the problem of setting strike limits based on surveys of an area which include either more than just the stock from which the removals are taken, or only a part of that stock.

A. The population dynamics model

A.1 Basic dynamics

The underlying dynamic model is age- and sex structured and is governed by the equations:

$$\begin{aligned} R^{m/f}_{t+1,a+1} &= (R^{m/f}_{t,a} - C^{m/f}_{t,a})S_a + U^{m/f}_{t,a} S_a \delta_{a+1} \qquad 0 \le a \le x-2 \\ R^{m/f}_{t+1,x} &= (R^{m/f}_{t,x} - C^{m/f}_{t,x})S_x \\ &\quad + (R^{m/f}_{t,x-1} - C^{m/f}_{t,x-1})S_{x-1} \\ U^{m/f}_{t+1,a+1} &= U^{m/f}_{t,a} S_a (1-\delta_{a+1}) \qquad 0 \le a \le x-2 \end{aligned} \tag{1}$$

$R^{m/f}_{t,a}$ is the number of recruited males/females of age a at the start of year t;
$U^{m/f}_{t,a}$ is the number of unrecruited males/females of age a at the start of year t;
δ_a is the fraction of unrecruited animals of age a-1 which recruit at age a (assumed to be independent of sex);
S_a is the annual survival rate of animals of age a, and is equal to exp(-Ma) where Ma is the instantaneous natural mortality rate for animals of age a (assumed to be independent of sex and whether or not an animal is recruited);
$C^{m/f}_{t,a}$ is the catch of males/females of age a during year t (whaling is assumed to take place in a pulse at the start of each year); 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 female component of the mature 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.

$$\begin{aligned} U^{m/f}_{t+1,0} &= 0.5(1-\alpha_0) B_{\text{init}} N^f_{t+1} \{1 + A(1-(D_{t+1} / D_{\text{init}})^z)\} \\ R^{m/f}_{t+1,0} &= 0.5\alpha_0 B_{\text{init}} N^f_{t+1} \{1 + A(1-(D_{t+1} / D_{\text{init}})^z)\} \end{aligned} \tag{2}$$

B_{init} 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;
N^f_t is the number of mature females at the start of year t:

$$N^f_t = \sum_{a=1}^{x} \beta_a (R^f_{t,a} + U^f_{t,a}) \tag{3}$$

D_t is the size of the component of the population in year t upon which the density dependence is assumed to act;
D_{init} is the pristine size of the component of the population in year t upon which the density dependence is assumed to act;
α_0 is the proportion of animals of age 0 which are recruited; and
β_a is the proportion of females of age a that are mature (assumed to be independent of year and whether or not an animal is recruited).

In these trials $D_t = N^f_t$ and $D_{\text{init}} = N^f_{\text{init}}$. The common control program maintains the option to use $D_t = N^{1+}_t$ and $D_{\text{init}} = K^{1+}$ as were specified in a previous definition of these trials, where

N^{1+}_t is the 1+ population size at the start of year t:

$$N^{1+}_t = \sum_{a=1}^{x} (R^f_{t,a} + U^f_{t,a} + R^m_{t,a} + U^m_{t,a}) \tag{4}$$

K^{1+} is the pristine total (1+) population size:

$$K^{1+} = \sum_{a=1}^{x} (R^f_{\text{init},a} + U^f_{\text{init},a} + R^m_{\text{init},a} + U^m_{\text{init},a}) \tag{5}$$

A.3 Catches

The historical ($t<0$) catches are taken to be equal to the reported catches by sex and year. For fishery type 1 these are taken to be the catches from 1930 to 1992 from *Small Areas*

WG, CG, CIP, CIC and CM for North Atlantic minke whales (IWC, 1993, p.194), and those for fishery type 2 are taken to be the catches from 1848-1993 for the Bering-Chukchi-Beaufort bowhead whales (IWC, 1995, p144), apportioned equally between males and females.

Catches are taken uniformly from the recruited component of the population:

$$C_{t,a}^{m/f} = C_t^{m/f} R_{t,a}^{m/f} / \sum_{a'} R_{t,a'}^{m/f} \quad (6)$$

where $C_t^{m/f}$ is the catch of males/females in year t. The total catch in a given year is taken to be the strike limit for that year, $C_t = C_t^m + C_t^f$. Future catches are assumed to be split 50:50 male:female in fishery type 2. Two different options will be considered for fishery type 1: (i) a sex ratio of 35:65 males:females, based loosely on the sex ratio of historical catches off West Greenland and (ii) 65:35 males:females to examine the implications of the reverse sex ratio. The current set of trials considers only option (i).

A.4 Recruitment

The proportion of animals of age a that would be recruited if the population was pristine is either a knife edged function of age or is given by:

$$\alpha_a = \begin{cases} 0 & \text{if } a < a_{r,\min} \\ [1+\exp[-(a-r_{50})/\sigma_r]]^{-1} & \text{if } a_{r,\min} \le a < x-1 \\ 1 & \text{if } a \ge x-1 \end{cases} \quad (7)$$

r_{50} is the age-at-50%-recruitment;
σ_r is a parameter which determines the width of the recruitment ogive; and
$a_{r,\min}$ is the first age at which an animal can be recruited (taken to be age 2 for fishery type 1).

The 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:

$$\delta_{a+1} = \begin{cases} [\alpha_{a+1} - \alpha_a]/[1-\alpha_a] & \text{if } \alpha_a < 1 \\ 1 & \text{otherwise} \end{cases} \quad (8)$$

The current set of trials are based on the knife edge function only, although both options are available in the common control program.

A.5 Maturity

The proportion mature (actually that past the age of first parturition) at each age is either a knife edged function of age or is given by:

$$\beta_a = \begin{cases} 0 & \text{if } a < a_{m,\min} \\ [1+\exp\{-(a-m_{50})/\sigma_m\}]^{-1} & \text{if } a_{m,\min} \le a < x-1 \\ 1 & \text{if } a \ge x-1 \end{cases} \quad (9)$$

m_{50} is the age-at-50%-maturity;
σ_m is a parameter which determines the width of the maturation ogive; and
$a_{m,\min}$ is the first age at which an animal can be mature (taken to be age 2 for fishery type 1).

A.6 Initialising the population vector

The numbers at age in the pristine population are given by:

$$\begin{aligned} R_{\text{init},a}^{m/f} &= 0.5 N_{\text{init},0} \alpha_a \exp[-\sum_{a'=0}^{a-1} M_{a'}] && \text{if } a < x \\ U_{\text{init},a}^{m/f} &= 0.5 N_{\text{init},0} (1-\alpha_a) \exp[-\sum_{a'=0}^{a-1} M_{a'}] && \text{if } a < x \\ R_{\text{init},x}^{m/f} &= 0.5 N_{\text{init},0} \exp[-\sum_{a'=0}^{x-1} M_{a'}]/(1-\exp[-M_x]) && \text{otherwise i.e. when } a = x \end{aligned} \quad (10)$$

$R_{\text{init},a}^{m/f}$ is the number of animals of age a that would be recruited in the pristine population;
$U_{\text{init},a}^{m/f}$ is the number of animals of age a which would be unrecruited in the pristine population; and
$N_{\text{init},0}$ is the total number of animals of age 0 in the pristine population.

The value of $N_{\text{init},0}$ is selected so that the 1+ population size in the first year in which the *SLA* is applied ($t=0$) is equal to a pre-specified value.

A.7 Estimation of A and z

The values of A and z depend on the values specified for *MSYR*, *MSYL* and the parameters which determine the maturity and recruitment ogives. The detailed algorithm for calculating A and z from *MSYR* and *MSYL* is given by Punt (1999). For these trials both *MSYR* and *MSYL* are defined in terms of uniform selectivity harvesting on the 1+ population. For all of the trials *MSYL* = 0.6. In the future it is anticipated that trials for some fishery types may be conducted in which *MSYL* is defined in terms of uniform selectivity harvesting on the mature population.

A.8 Stochastic Dynamics Model

A preliminary stochastic version of the above dynamics model was developed for fishery type 2. This model, detailed in Adjunct 1, allows for stochastic births/calf survival and deaths; additional simple autocorrelative environmental stochasticity can be added to the birth/calf survival process. The appropriate use of such a model in the Initial Exploration Trials will be examined in the future.

B. Data generation

B.1 Absolute abundance estimates

An estimate of absolute abundance together with an estimate of CV is provided to the *SLA* once every F years during the management period (beginning in year (-1+F)). The CV of the abundance estimate (CV_{true}) is generally different from the CV provided to the *SLA*.

For fishery type 1, an estimate of abundance will also be generated for the whole stock in 1992, the year prior to the first year in which the AWMP is applied. The pre-management abundance estimates for fishery type 2 are taken to be the N_4/P_4 values in Zeh *et al.* (1995).

The survey estimate, $\hat{S}$, may be written as:

$$\hat{S} = B_A P\, Yw\ /\mu = B_A P^* \beta^2 Yw \quad (11)$$

B_A is the bias;
P is the current 1+ population size ($= N_t^{1+}$);

Y is a lognormal random variable: $Y = e^{\varepsilon}$ where $\varepsilon \sim N[0;\sigma_\varepsilon^2]$ and $\sigma_\varepsilon^2 = \ell n(1+\alpha^2)$;
w is a Poisson random variable, independent of Y, with $E(w) = \text{var}(w) = \mu = (P/P^*)/\beta^2$;
P^* is the reference population level (the pristine 1+ population, $= K^{1+}$).

Note that under the approximation $CV^2(ab) = CV^2(a) + CV^2(b)$

$$E(\hat{S}) = B_A P_t \text{ and } CV^2_{true}(\hat{S}) = \alpha^2 + \beta^2 P^* / P.$$

The ratio of $\alpha^2 : \beta^2$ is 0.12 : 0.025.

An estimate of the CV, X, is generated for each sightings estimate:

$$X = \sigma\sqrt{(CHISQ / n)} \tag{12}$$

where

$$\sigma^2 = \ell n(1 + CV^2_{est})$$

CHISQ 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); and

$CV^2_{est} = \theta^2(a^2 + b^2 / w\beta^2)$ where a^2 and b^2 are constants and equal to 0.02 and 0.012 respectively.

Note that under the approximation $E(1 / w) \approx 1 / E(w) = 1 / [(P / P^*) / \beta^2] = \beta^2 P^* / P$, this gives:

$$E(CV^2_{est}) = \theta^2(a^2 + b^2 P^* / P) \tag{13}$$

The relationship between CV_{est} and CV_{true} is given by $\eta = [E(CV^2_{true}) - E(cv^2_{est})] / (0.1 + 0.013P^* / P)$ where η is a constant known as the additional variance factor.

The value of θ is set so that required CV_{est} is obtained when $P = 0.6K$, i.e. $\theta^2 = E(CV^2_{est}) / 0.04$.

The values of α and β are computed from a, b, CV_{est} and CV_{true} as:

$$\alpha^2 = \theta^2 a^2 + \eta 0.1 \qquad \beta^2 = \theta^2 b^2 + \eta 0.013. \tag{14}$$

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. n equals 250 for fishery type 2 and 0 for fishery type 1. 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:

$$x / (x + y) = \begin{cases} p(L) & \text{for mature animals} \quad (15a) \\ 1 - p(L) & \text{for calves} \quad (15b) \end{cases}$$

$$xy(n^{-1} + (x + y)^{-1}) / ((x + y + 1)(x + y)) = c \tag{15c}$$

[Equations 15a and 15b set the mean Bernoulli parameters, and 15c 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:

$$p(L) = \sum_{a=0}^{x} p_a(L)(R_a^f + R_a^m + U_a^f + U_a^m) / \sum_{a'=0}^{x} (R_{a'}^f + R_{a'}^m + U_{a'}^f + U_{a'}^m) \tag{16}$$

$p_a(L)$ is the proportion of whales of age a that are assigned as being larger than length L:

$$p_a(L) = \begin{cases} 0 & \text{if } a \leq {}_{\min}(L) \\ (1 + \exp[-(a - a_{50}(L) + \gamma_L) / (\lambda_L \sigma_L)])^{-1} & \text{if } a_{\min}(L) < a < a_{\max}(L) \\ 1 & \text{if } a \geq {}_{\min}(L) \end{cases} \tag{17}$$

$a_{\min}(L)$ is the last age at which no whales may exceed length L;
$a_{\max}(L)$ is 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
λL is a term to account for error in σ_L.

This approach takes account of three sources of error: Bernoulli sampling error, overdispersion 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 1).

Table 1
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

The value 0 for σ_6 reflects the assumption that calves can be indentified 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 Angliss *et al.* (1995).

C. Need

The level of need in each year, Q_t, will be supplied to the *SLA*. The need is given by:

$Q_t = Q_0 + t(Q_{100} - Q_0) / 100$ where Q_0 is the need at the start of the first year in which an AWMP is applied and Q_{100} is the value 100 years later.

The current need for the fishery type 1 trials is computed by assuming the total identified need for edible products from whales (670 tons; Denmark, 1988) is obtained from minke whales (2 tons per minke whale). Trials are performed with $Q_{100} = Q_0$ (i.e. constant need) and with $Q_{100} = 3Q_0$.

D. Trials

The factors considered in trials are chosen from those given in Table 2.

The single stock and stock identity trials for fishery type 1 have been integrated into a common specification, which is detailed in Section D(i). The single stock trials are a special case of this model, in which the SLA is provided with exact information about the stock boundary.

The set of trials for fishery type 2 is given in Section D(i).

Di. Fishery Type 1

Basic concepts and stock structure

The objective of the trials is to begin to address the problems of stock identity for fishery type 1. The trials are an extension of the Type 1 trials that assumed a single stock hypothesis (IWC, 1998). For these trials the area is divided into three cells as shown in Fig. 1, which are labelled 1, Middle and 2. There are two biological stocks and an aboriginal catch will be taken from Cell 2 (i.e. the strike limits will be removed from the population in Cell 2). Three alternative stock structure hypotheses are considered:

(a) Stock 1 feeds in Cells 1 and middle, and Stock 2 feeds in Cell 2 (see Fig. 1a.). There is no mixing between stocks.
(b) Stock 1 feeds in Cell 1, and Stock 2 feeds in Cells middle and 2 (see Fig. 1b.). There is no mixing between stocks.
(c) Stock 1 feeds in Cells 1 and middle, and Stock 2 feeds in Cells middle and 2 (see Fig. 1c). The stocks mix in the middle cell (but do not move permanently from one stock to the other i.e. there is no 'leakage'). The catch mixing matrix (IWC, 1993, p.190) is given in Table 3.

Stock structure hypotheses (a) and (b) are considered to capture: (a) the possibility that the strike limit is based on

Table 2

Factors considered in the trials.

Quantity	Fishery type 1	Fishery type 2	Fishery type 3
$MSYR_{1+}$	0.01; 0.04; 0.07	0.01; 0.025; 0.04	0.01; 0.04; 0.07
$MSYL_{1+}$	0.6	0.6	0.6
[1,2] P_0	25,000; 40,000	See [4] below	~300
[3] CV_{true}	0.3	0.25	
CV_{est}	0.3	0.25; 0.125	
[2] Bias B_A	1; 1.5	1; 1.5	
Inter-survey period F	10 years, 2-10years[6]	5 years	
Age class data: calves	N/A	γ_6=0 λ_6=1	N/A
Age class data: mature	N/A	$\gamma_{12.9}$=0; 4 $\lambda_{12.9}$=1; 2	N/A
Selectivity	Knife-edged - age 1	Knife-edged - age 1	See [7] below
Maturity	m_{50}=7; σ_m=1.2, $a_{m,min}$=2	Knife-edged - age a_m.[4]	See [7] below
Natural mortality	M_a=0.05yr^{-1}	M_J and M_m [4,5]	See [7] below

[1] P_0 is the 1+ population size in year 0, where 0 is the year for which strike limits are first set by the *SLA* (i.e. t=0). Year 0 is 1993 for fishery type 1 and 1994 for fishery type 2.
[2] For the trials in which $B_A \neq 1$, the value of P_0 is taken to be the specified value divided by B_A.
[3] This CV is assumed to apply to a stock which is depleted to 60% of its 1+ pre-exploitation size.
[4] Priors are specified for a_m, a_T, and M_m - see details in Section F.
[5] Natural mortality is M_J from ages 0 to a_T and M_m thereafter.
[6] Surveys every 2 years up to year 10 and every 10 years thereafter.
[7] Parameters typical of those of West Greenland fin and humpback populations will be used.

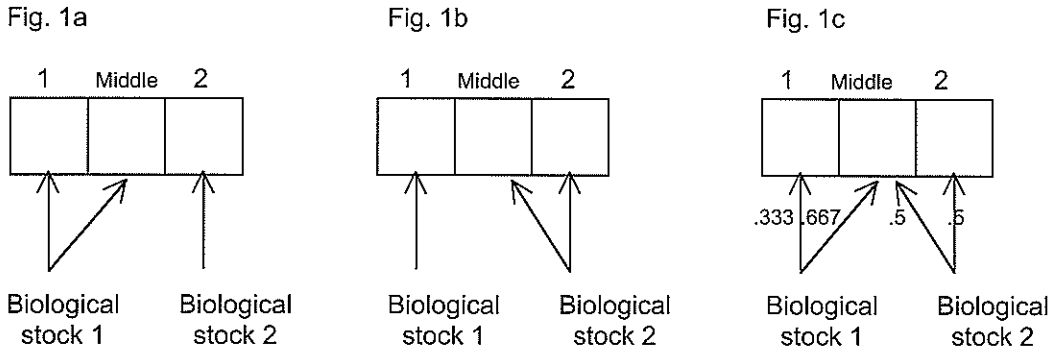


Fig. 1.

Table 3
The catch mixing matrix.

	Cell 1	Middle	Cell 2
Stock 1	0.333	0.667	0.0
Stock 2	0.0	0.5	0.5

surveys that cover more that just the stock being managed; and (b) the opposite case in which the stock being managed is found in an area in which harvesting does not occur.

Initial population sizes
Two sets of initial population sizes are considered and are given in Table 4. (Initial refers to the year for which strike limits are first set by the *SLA* i.e. $t=0$).

Table 4
Initial population sizes.

	Cell 1	Middle	Cell 2
High	10,000	30,000	10,000
Low	5,000	15,000	5,000

The abundances in Cells middle and 2 combined approximately match the values used for the previous fishery type 1 trials.

Future catches in other areas
No catch will be taken in the middle cell. Two options are considered for the level of catch taken in Cell 1. For most trials no catch will be taken from this cell, as this should be the more difficult case. Two sensitivity trials consider the case in which a commercial catch limit will be set in Cell 1 using the RMP. These sensitivity tests are conducted because catches in Cell 1 will affect the trends in 1+ abundance in the middle cell. These may, in turn, affect the overall performance of the SLA used to manage harvesting in Cell 2.

MSY rates
MSY rates (in terms of the 1+ component of the population) of 1% and 7% will be used.

Abundance estimates
Estimates of abundance for each of the three cells will be made available to the *SLA*. They will be calculated using the method described in section B.1.

Other parameters
The historic catches will be taken to be the catches from *Small Areas* CIC for North Atlantic minke whales (Cell 1), CG+CIP+CM (middle cell) and WG (Cell 2).

Trials
The set of trials is given in Table 5. The trials are run with two options: (i) the *SLA* is provided with information about where the stock boundary lies e.g. for trial MM1 it is provided with the fact that the stock being managed is found in Cell 2 only; and (ii) it has no information about the stock boundary.

The following parameters are used in all trials: future catch ratio of 35:65 male:female; bias in absolute abundance estimates = 1.

For comparison Table 6 lists the previous fishery type 1 single stock trials together with the number of the new equivalent (if there is one).

Model details
The equations for the basic dynamics and births are the same as those for single stock trials. This section describes how catches are allocated to biological stocks, and how the expected value of a survey in an area is calculated.

The pristine sizes of the biological stocks are chosen so that if these are projected forwards from unexploited equilibrium to year $t=0$, the population size in each area at the start of year 0 is equal to the initial population sizes for the trial.

Table 5
The set of trials for fishery type 1.

Trial	$MSYR_{1+}$	Initial population	Catch in Area 1	Need	Survey interval	Stock structure
MM1	0.01	High	0	Constant	10yrs	Boundary between middle and 2
MM1a	0.07	High	0	Constant	10yrs	Boundary between middle and 2
MM2	0.01	High	0	Constant	10yrs	Boundary between 1 and middle
MM2a	0.07	High	0	Constant	10yrs	Boundary between 1 and middle
MM3	0.07	High	0	Constant	10yrs	Mixing in middle Cell
MM4	0.07	High	Yes[1]	Constant	10yrs	Mixing in middle Cell
MM5	0.01	Low	0	Constant	10yrs	Boundary between middle and 2
MM5a	0.07	Low	0	Constant	10yrs	Boundary between middle and 2
MM6	0.01	Low	0	Constant	10yrs	Boundary between 1 and middle
MM6a	0.07	Low	0	Constant	10yrs	Boundary between 1 and middle
MM7	0.01	Low	0	Constant	10yrs	Mixing in middle Cell
MM8	0.01	Low	Yes[1]	Constant	10yrs	Mixing in middle Cell
MM9	0.01	High	0	Increasing	10yrs	Boundary between middle and 2
MM10	0.07	High	0	Increasing	10yrs	Mixing in middle Cell
MM11	0.01	Low	0	Increasing	10yrs	Mixing in middle Cell
MM12	0.01	High	0	Constant	2-10yrs[2]	Boundary between middle and 2
MM13	0.07	High	0	Constant	2-10yrs[2]	Boundary between 1 and middle

[1] Catches set using the RMP.
[2] Surveys every 2 years until year 10, and every 10 years thereafter.

Table 6
The previous set of trials for fishery type 1 (for comparison).

Trial	$MSYR_{1+}$	$MSYL$	Initial population P_0	Need		Data quality bias B_A	Future catch ratio M:F	New equivalent trial
				Initial level	Final level			
M1	0.04	$MSYL_{1+}$=0.6	40,000	335	335	1	35:65	
M1a	0.04	$MSYL_{1+}$=0.6	40,000	335	335	1	65:35	
M2	0.04	$MSYL_{1+}$=0.6	40,000	335	1,005	1.5	35:65	
M3	0.04	$MSYL_{1+}$=0.6	25,000	335	335	1.5	35:65	
M6	0.07	$MSYL_{1+}$=0.6	40,000	335	1,005	1.5	35:65	
M8	0.07	$MSYL_{1+}$=0.6	25,000	335	1,005	1	35:65	
M9	0.01	$MSYL_{1+}$=0.6	40,000	335	335	1	35:65	MM1
M10	0.01	$MSYL_{1+}$=0.6	40,000	335	1,005	1.5	35:65	MM9
M11	0.01	$MSYL_{1+}$=0.6	25,000	335	335	1.5	35:65	

Catches
Catches from an area are taken uniformly from the recruited population in that area:

$$C_t^s = \sum_k \tilde{C}_t^k \left\{ V^{s,k} R_t^s \Big/ \sum_{s'} (V^{s',k} R_t^{s'}) \right\} \qquad (20)$$

where C_t^s is the catch (both sexes combined) during year t from biological stock s;
$\tilde{C}_t^k$ is the catch from area k (Cell 1, Cell 2 or middle) during year t;
R_t^s is the total number of exploitable animals in biological stock s at the start of year t:

$$R_t^s = \sum_{a=0}^{x} (R_{t,a}^{s,m} + R_{t,a}^{s,f}) \qquad (21)$$

$R_{t,a}^{s,m/f}$ is number of recruited males/females in biological stock s of age a at the start of year t; and
$V^{s,k}$ is the fraction of whales from biological stock s which feed (and hence may be caught) in area k (the catch mixing matrix).

The catch from a biological stock is allocated to sexes and ages according to Equation (6).

Sightings
The expected value of a survey conducted in area k at the start of year t (P - see Equation 11) is given by:

$$P_t^k = \sum_s V^{s,k} \sum_{a=1}^{x} (R_{t,a}^{s,f} + U_{t,a}^{s,f} + R_{t,a}^{s,m} + U_{t,a}^{s,m}) \qquad (22)$$

The reference population level for area k is given by:

$$P^* = \sum_s V^{s,k} \sum_{a=1}^{x} (R_{\text{init},a}^{s,f} + U_{\text{init},a}^{s,f} + R_{\text{init},a}^{s,m} + U_{\text{init},a}^{s,m}) \qquad (23)$$

Future trials
Future trials should include an option in which the catch mixing matrix is density dependent. Further robustness trials will also be needed for the case in which there is a positive survey bias and the survey bias increases with time.

Suggestion
It is suggested that developers consider adding a condition such that the initial annual catch is at least 150 whales; this condition is loosely based on the current aboriginal catch quota in West Greenland.

Dii. Fishery Type 2
The new method for conditioning the trials (i.e. selecting the values for the parameters for a_m, M_J, a_T M_m and P_0 for fishery type 2). This new scheme reduces or eliminates the possibility of trials using unrealistic combinations of MSYR and the biological parameters. Further trials need to be added to examine sensitivity to a wider range of uncertainties e.g. changing the likelihood for P_0 and the proportions of calves and mature animals. The trials will be conditioned using the following scheme.

(1) The priors specified during the 1994 meeting of the Scientific Committee (IWC, 1995) for a_m, M_J, a_T *and* M_m and that specified during the 1998 meeting (IWC, 1998) for $P_0 = P_{1993}$ are used together with the (fixed) values for $MSYR_{1+}$ and $MSYL_{1+}$
(2) A 'backwards' Bayesian analysis is conducted to provide a set of 100 combinations for a_m, M_J, a_T , M_m and P_0 that are conditioned on the pre-specified values for $MSYR_{1+}$ and $MSYL_{1+}$ (and the data used for the B-C-B assessment). This involves generating N sets of parameters and the associated likelihoods from the priors for a_m, M_J, a_T , M_m and P_0, calculating the values for K which deterministically 'hit' the generated values for P_0, projecting the populations from K to year 0 using the model and calculating the likelihood. The 100 sets of parameters for use in the trials are those with the 100 highest likelihoods.

The initial set of calculations will be based on the deterministic model; an attempt will be made to extend this approach to the stochastic model described in Adjunct 1.

The set of trials for fishery type 2 is given in Table 7. Note that for reasons of consistency the trial numbers have not been altered. Hence there are gaps in the numbers where earlier trials have been deleted.

Diii. Fishery Type 3
Fishery type 3 considers the case where the population to be harvested is small. Trials will be conducted to investigate how small small should be. The trials will consider uncertainty in the trajectory due to individual variability in survival and reproduction (demographic uncertainty) and environmental uncertainty. Three kinds of models are considered:

Table 7
The set of trials for fishery type 2.

			Need		Data Quality			
Trial	$MSYR_{1+}$	MSYL	Initial level	Final level	CV_{est}	$\gamma_{12,9}$	$\lambda_{12,9}$	B_A
B1	0.025	$MSYL_{1+}$=0.6	68	68	0.25	0	1	1
B3	0.04	$MSYL_{1+}$=0.6	68	204	0.25	0	1	1
B6	0.01	$MSYL_{1+}$=0.6	68	68	0.25	0	1	1
B7	0.01	$MSYL_{1+}$=0.6	68	204	0.25	0	1	1
B7a	0.01	$MSYL_{1+}$=0.6	68	204	0.125	4	2	1.5
B10	0.04	$MSYL_{1+}$=0.6	68	68	0.25	0	1	1

(i) simple demographic stochasticity (on survival and birth rate) only;
(ii) demographic stochasticity plus environmental variability without auto-correlation;
(iii) same as (ii) but with auto-correlation.

The models are the same as those described in Adjunct 1.

Some initial simulations and explorations are needed to determine feasible and reasonable combinations and ranges of parameters but the focus is on low population size (~300 animals) and either a K value close to the current population size or much higher. *MSYR* values of 1%, 4% and 7% will be considered for each of the three types of model. The trajectories will be investigated for a range of different initial population sizes and the effects over a 1,000 year time span will be examined. Nine graphs will be produced showing the change in extinction probability with K for all of the different models with the different MSY rates.

The parameters used will be those typical of the West Greenland fin and humpback populations. No catch will be taken.

E. Tuning

Results should be presented for both *H-tuning* and *depletion tuning*.

E.1 Equivalence Tuning

H is defined as the 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 for comparison with candidate *SLA*s so that their parameter values may be selected to match H as adequately as possible. The target *SLA* is not intended to represent ideal *SLA* performance but rather it is meant to illustrate a particular balance between need satisfaction, risk and recovery to which candidate *SLA*s may all be tuned. This process is known as *equivalence tuning*.

For a given trial i and replicate j, $H_t^{i,j}$ is defined as:

$$H_t^{i,j} = \min\left(Q_t, \begin{cases} 0 & \text{if } N_t^{1+} < 2000 \\ 0.8\,RY_t & \text{if } 2000 \le N_t^{1+} < MSYL^{1+} \\ 0.9\,MSY & \text{if } N_t^{1+} > MSYL^{1+} \end{cases}\right) \quad (18)$$

where RY_t is the replacement yield for year t; and
MSY is defined in terms of uniform selectivity harvesting on the 1+ component of the population.

The statistic by which tuning success is to be evaluated for trial i is:

$$Z_i = \frac{\sum_{j=1}^{100}\sum_{t=0}^{99}\left\{H_t^{i,j}(H) - C_t^{i,j}(C)\right\}^2}{\sum_{j=1}^{100}\sum_{t=0}^{99}\left\{H_t^{i,j}(H)\right\}^2} \quad (19)$$

where $H_t^{i,j}(H)$ is the strike limit for replicate j of trial i in year t for a trial in which a catch equal to $H_t^{i,j}$ is removed each year; and $C_t^{i,j}(C)$ 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*.

This approach is to be used for *equivalence tuning* on two trials for each fishery type, one that should allow need to be satisfied, and another in which need cannot be satisfied without severe depletion of the stock. The selected trials (i = 1, 2 for each fishery) are MM1 and MM9 for fishery type 1 and B3 and B7 for fishery type 2. Z is the quantity minimised where $z = z_1 + z_2$.

The Secretariat will modify the Common Control Program to output the values of Z_i (Equation 19).

E.2 Depletion Tuning

The trials for *depletion tuning* are MM1 and B7 for fishery types 1 and 2 respectively. Tuning should be achieved to match the median final depletion achieved by H for these trials to within 0.02. It is recommended that developers also consider tuning to the lower 5%ile of the final depletion for these trials.

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 median final depletions for trials MM1 and B7 include the values 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 mature female component of 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≥ 0.

The *Initial Exploration Trials* are based on a 100-year time horizon, but a final decision regarding the time horizon for simulation trials 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, 50 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 for reasons of consistency the statistic identification numbers have not been altered. Hence there are gaps in the numbers where former statistics have been deleted.

F.1 Risk

D1. Final depletion: P_T/K.

D2. Lowest depletion: $\min(P_t / K)$:$t = 0.1,...,T$.

D6. Plots for simulations 1 and 2 of $\{P_t : t = 0,1,..,T\}$ and $\{P_t^* : t = 0,1,..,T\}$.

D7. Plots of $\{P_{t[x]} : t = 0,1,..,T\}$ and $\{P^*_{t[x]} : t = 0,1,..,T\}$ where $P_{t[x]}$ is the xth percentile of the distribution of P_t. Results are presented for $x = 5$ and $x = 50$.

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.

N3. Fraction of years in which $C_t \geq 0.5Q_t$.

N4. Fraction of years in which $C_t \geq Q_t$.

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 or exceeds the total need; h is 5 for these trials.

N7. Plot of $V_{t[x]}$:$t = 0,1,T - 1\}$ where $V_{t[x]}$ is the xth percentile of the distribution of $V_t = C_t / Q_t$.

N8. Plots of V_t for simulations 1 and 2.

N9. Average need satisfaction: $\frac{1}{T}\sum_{t=0}^{T-1} f_t$ where $f_t = C_t / Q_t$ if $C_t < Q_t$ and 1 otherwise.

F.3 Recovery

R1. Relative recovery: $P_{t_r^*} / P^*_{t_r^*}$ where t_r^* is the first year in which P_t^* passes through *MSYL*. If P_t^* never reaches *MSYL*, the statistic is P_T / P_T^*. If $P_0 > MSYL$ the statistic is min (1, $P_T / MSYL$).

R2. Final recovery: prob($P_T \geq MSYL$ / prob($P_T^* \geq MSYL$); 0/0 is defined as 1.

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:

$$RTR = \begin{cases} 1 & \text{if } P_0 \geq MSYL \\ (T - t_r) / T & \text{if } P_0 < MSYL \text{ and } P_T \geq MSYL \\ \min_t(t \mid P_t^* \geq P_T) / T & \text{if } P_0 < MSYL \text{ and } P_T < MSYL \end{cases}$$

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.

Denmark. 1988. Aboriginal subsistence needs for Greenland – Danish statement. Paper TC/40/AS3 presented to the IWC Sub-Committee on Aboriginal Subsistence Whaling, 26-27 May 1988, Auckland, New Zealand. (unpublished). 1p.

Givens, G.H., Zeh, J.E. and Raftery, A.E. 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. 1993. Report of the Scientific Committee, Annex I. Report of the working group on implementation trials, Appendix 4. Specifications of the North Atlantic minke whaling trials. *Rep. int. Whal. Commn* 43:189-95.

International Whaling Commission. 1995. Report of the Scientific Committee, Annex F. Report of the sub-committee on aboriginal subsistence whaling. *Rep. int. Whal. Commn* 45:142-64.

International Whaling Commission. 1998. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48:53-302.

Punt, A.E. 1999. A full description of the standard Baleen II model and some variants thereof. *J. Cetacean Res. Manage.* 1(1). [In press]

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). 28pp.

Adjunct 1. Model for Stochastic Trials

Compiled by G. Givens, A. Raftery and L. Witting.

Except as detailed below, the stochastic dynamics model will rely on the same assumptions as the model given in Appendix 3.

Mortality

Define $M_{t,a}^{R/U,m/f}$ as the number of recruited/unrecruited whales of age a and sex m/f in year t which are eligible to survive and be counted in $R_{t+1,a+1}^{m/f}$ or $U_{t+1,a+1}^{m/f}$.

Replace equations (1) of Appendix 3 with:

$$R_{t+1,a+1}^{m/f} \sim \text{Binomial}^*\left(M_{t,a}^{R,m/f}, S_a\right) \qquad 0 \leq a \leq x\text{-}2$$

where $M_{t,a}^{R,m/f} = R_{t,a}^{m/f} - C_{t,a}^{m/f} + U_{t,a}^{m/f}\delta_{a+1}$ and

Binomial*(n,p) is defined by $\frac{n}{\lceil n \rceil}\text{Binomial}\left(\lceil n \rceil, p\right)$ where $\lceil n \rceil$ is the smallest integer $\geq$n

$$R_{t+1,x}^{m/f} \sim \text{Binomial}^*\left(M_{t,x}^{R,m/f}, S_x\right) + \text{Binomial}^*\left(M_{t,x-1}^{R,m/f}, S_{x-1}\right)$$

where $M_{t,x}^{R,m/f} = R_{t,x}^{m/f} - C_{t,x}^{m/f}$

$$U_{t+1,a+1}^{m/f} \sim \text{Binomial}^*\left(M_{t,a}^{U,m/f}, S_a\right) \qquad 0 \leq a \leq x\text{-}2$$

where $M_{t,a}^{U,m/f} = U_{t,a}^{m/f}\left(1 - \delta_{a+1}\right)$

Births

Define $B_{t+1,0}^{m/f}$ as the number of m/f births occurring at the start of year t+1.

Replace equations (2) of Appendix 3 with:

$$B^{m/f}_{t+1,0} \,\big|\, N^f_{t+1} \sim \text{Binomial}^*\left(N^f_{t+1}, b_{t+1,0}\right)$$

where $b_{t+1,0} = 0.5B_{init}\{1+A(1-(D_{t+1} / D_{init})^z)\}$ is the birthing/calf survival probability; if $b^{m/f}_{t+1,0} \notin [0,1]$ insert the appropriate bound (0 or 1).

Next, let

$$U^{m/f}_{t+1,0} = (1-\alpha_0)B^{m/f}_{t+1,0}$$
$$R^{m/f}_{t+1,0} = \alpha_0 \quad B^{m/f}_{t+1,0}$$

The number of births in successive years are stochastic and independent. The total number of births is correct on average. Note that this method does not place any constraints on the calving for individuals. Explicit constraints to limit the calving rates of individual whales may be added in the future.

Environmental Stochasticity with no Autocorrelation

To introduce simple environmental stochasticity into the birthing/calf survival process, let the expected birthing/calf survival probability in year t+1 be given by $b_{t+1.0}$ as above. The realised number of births in year t+1 is then a random variable, $B^{m/f}_{t+1,0}$, which has a binomial distribution with parameters N^f_{t+1} and p_{t+1} where p_{t+1} is itself a random number given by:

$$p_{t+1} = \frac{e^{q_{t+1}}}{1+e^{q_{t+1}}}$$

and where q_{t+1} is a Normal random variable distributed. $N(\mu_{t+1},\sigma^2_q)$. Then $U^{m/f}_{t+1,0}$ and $R^{m/f}_{t+1,0}$ are computed from $B^{m/f}_{t+1,0}$ as above. Choose μ_{t+1} (by integration) so that $E(p_{t+1}) = b_{t+1.0}$ and let σ^2 be a constant. The value of $\sigma^2_q = 0.31$ yields a value of approximately 0.41 for the CV of p_{t+1} when $E(p_t+1) = 0.25$, (and $\mu_{t+1} = -1.17$) which equates roughly to the analysis by Givens *et al.* (1995) of bowhead calf data (Angliss *et al.*, 1995). Hence the value of $\sigma^2_q = 0.31$ is selected for the initial set of trials incorporating simple environmental stochasticity.

Environmental Stochasticity with Autocorrelation

This case is modelled as above, but treating $p_{t+1} = \frac{e^{q_{t+1}}}{1+e^{q_{t+1}}}$ as random, where q_{t+1} is generated from the model

$$q_{t+1} - \mu_{t+1} = \rho(q_t - \mu_t) + \varepsilon_{t+1} \quad \text{where } \varepsilon_{t+1} \sim N(0,\sigma^2_\varepsilon) \text{ and } |\rho| < 1$$

Choose ρ such that $\text{cor}\left(\frac{e^{q_{t+1}}}{1+e^{q_{t+1}}}, \frac{e^{q_t}}{1+e^{q_t}}\right) = 0.75$ for the case when var $q_{t+1} = \sigma^2_q = 0.31$ and $\mu_{t+1} = -1.17$, so that $E(p_{t+1}) = 0.25$.

Choose σ^2_ε to solve $\sigma^2_q = \frac{\sigma^2_\varepsilon}{1-\rho}$

Preliminary calculations indicate this yields $\rho = 0.67$ and $\sigma^2_\varepsilon = 0.076$; hence these values are selected for the initial set of trials incorporating environmental stochasticity with autocorrelation.

Appendix 4

CONSIDERATION OF CONDITIONING AND STOCHASTICITY FOR FISHERY TYPE 2 TRIALS

Geof Givens

Initial Exploration Trials are intended to provide a *Strike Limit Algorithm* development framework which roughly reflects the operating conditions (productivity, abundance, life history, environment, aboriginal need) that an implemented *Strike Limit Algorithm* would face. Since these conditions are unknown, trials are chosen to span the range of uncertainty. The Committee and the AWMP SWG have recognised the value of limiting the number of trials, where possible, to simplify the initial evaluation of candidate *Strike Limit Algorithms*. One way the SWG has limited the current number of type 2 (bowhead-like) trials is by constructing each trial to include 100 variations which span a range of uncertainty represented by probability distributions for certain biological parameters.

Each type 2 *Initial Exploration Trial* assumes a specific fixed value of MSYR. In SC/50/AWMP2, Punt notes that each trial currently uses a distribution of biological life history parameters which is not specific to the value of MSYR being assumed. He suggests that, for a fixed value of MSYR, the biological parameters should be sampled from their conditional distribution (given MSYR) rather than their marginal distribution.

This proposal is mathematically correct and addresses the goal that trial scenarios use jointly realistic parameter sets. However, it is also important that trials reflect realistic uncertainty about future stock status. The suggested revision has several consequences:

(1) It nearly eliminates the possibility of trials using any highly unrealistic combinations of MSYR and biological parameters whose values are separately reasonable. This beneficial effect can be seen in table 1 of SC/50/AWMP2.

(2) It makes the most extreme trials (B3 and B7) more extreme. SC/50/AWMP2, fig.1a, shows that the 90% pointwise trajectory limits for the proposed revised trials are nearly non-overlapping with those from the current trials. In each case, the degree of optimism or pessimism about the stock recovery rate is exaggerated by the switch to the proposed trials.

(3) It severely reduces the uncertainty inherent in each trial scenario. This occurs because few trajectories are compatible with a fixed value of MSYR, a 150-year history of heavy catches, and a precisely known current abundance. SC/50/AWMP2, fig.1a, shows that the pointwise 90% trajectory limits are much narrower for the proposed trials than for the current ones. SC/50/AWMP2, table 1 shows that the effect of the proposed conditioning can be to make very strong assumptions about biological parameters and stock

status. For example, the proposed B3 conditioning leads to a 95% interval for age-at-sexual-maturity of (14,15) compared to the marginal interval of (15,24), and the proposed B9 conditioning amounts to assuming that current mature female depletion is between 0.391 and 0.409. Although this reduced conditional uncertainty is proper given the model, we should recognise that the model is an imperfect tool. Given doubt about model validity, such a substantial reliance upon the model to reduce uncertainty is unwarranted.

It is difficult for the Committee, including myself, to resist focussing on boundary cases like the B3 and B7 trials when comparing alternatives. The combined effect of (2) and (3) would be to make such trials less plausible and more precisely posed. These are the sorts of trials which can lead to the selection of a poor management algorithm.

SC/50/AWMP2 clearly shows that something must be fixed to improve the realism of the trials, and I agree with the motivation for Punt's proposal. The current method for relating the biological parameters and MSYR was an approximation intended to retain healthy within-trial uncertainty. If the approximation is to be replaced with Punt's exact conditional method, other steps should be taken simultaneously to address the corresponding reduction in uncertainty, otherwise the cure may be worse than the disease.

Several techniques which might be used instead or in addition to Punt's approach including the following.

(a) Switch to trials that are less extreme with respect to MSYR. For example, the proposed revised B1 trial in SC/50/AWMP2 is less problematic.

(b) Adopt Punt's proposal, but simultaneously adopt wider ranges for the biological parameter distributions. This option is not likely to fix the problem by itself.

(c) Simulate the management stock beginning in a more recent year to eliminate the strong model parameter dependencies introduced by the historical catch data. This option ignores an important and reliable data source, and is not guaranteed to fix the problem.

(d) Switch from fixed values to narrow distributions for MSYR. Or, adopt a wholly integrative approach for MSYR, as is done for the biological parameters. The fully integrative approach would reduce all type 2 *Initial Exploration Trials* to a single trial. This option would reverse a decision made two years ago by the SWG, but that should not prevent us from choosing this option if it is preferred.

(e) Introduce simple stochasticity to the production model. In recent years the Aboriginal Subsistence sub-committee has considered the merits of such an approach for bowhead assessment. Perhaps the SWG should lead the way by agreeing preliminary specifications at this meeting. Such a revision to the current model would require modest coding time and Secretariat support. I do not see why the alteration need be too complex.

The intentions of the AWMP trial structure are not best met by extreme, over-precise scenarios. We should aim instead for plausible scenarios with an appropriate expression of uncertainty.

Annex G
Report of the Sub-Committee on Aboriginal Subsistence Whaling

Members: Walløe (Convenor), Addison, Albert, Allison, Baker, Berggren, Best, Born, Borodin, Breiwick, Brownell, Buckland, Butterworth, Carlson, Childerhouse, Clark, Cooke, DeMaster, Donahue, Donovan, Ensor, Finley, George, Givens, Goto, Gunnlaugsson, Hakamada, Hatanaka, Hester, Innes, Kamatsu, Kasuya, Kawachi, Kock, Lawrence, Lens, Magnusson, Martin, Melnikov, Moronuki, Nakamura, Nishiwaki, Øien, O'Hara, Ohsumi, Okamura, Peréz-Cortés, Pinedo, Polacheck, Poole, Punt, Read, Reeves, Reijnders, Rogan, Rooney, Schweder, Senn, Skaug, Smith, Stachowitsch, Swartz, Sweeney, Tomita, Wade, Walters, Witting, Yagi, Yamamura, Zeh, Zhu.

1. CONVENOR'S OPENING REMARKS

Walløe welcomed the participants.

2. ELECTION OF CHAIRPERSON AND RAPPORTEURS

Walløe was elected Chair. DeMaster and Smith agreed to act as co-rapporteurs.

3. ADOPTION OF THE AGENDA

The adopted Agenda is given as Appendix 1.

4. REVIEW OF THE DOCUMENTS

Documents available to the sub-committee and discussed by it included SC/50/AS1-15, SC/50/AWMP1 and Raftery and Zeh (1998).

5. BOWHEAD WHALES

5.1 Comprehensive Assessment of the Bering-Chukchi-Beaufort Seas Stock

A thorough assessment of bowhead whales was carried out in 1991, and in-depth discussions have taken place in the Aboriginal Subsistence sub-committee in subsequent years. This occurred especially in 1994, following the successful census of the Bering-Chukchi-Beaufort stock in 1993, and in 1995, following the identification of a possible serious theoretical difficulty (Borel's Paradox) with the Bayesian synthesis method which had been used for the stock assessment beginning in 1993. Extensive sensitivity analyses in the years since the discovery of this problem have not identified a strong effect for the bowhead assessment.

The Bayesian synthesis method was developed to allow various sources of direct and indirect data to be integrated through a deterministic population dynamics model to provide a unified analysis. Being a Bayesian method, it collects the direct data in a likelihood function and the indirect data (or subjective judgements) in prior distributions. The results from a Bayesian Synthesis are presented in the format of posterior distributions.

In some cases there are more items of indirect data (prior distributions) than there are free parameters in the population dynamic model. Without harmonising these priors, the results from the original Bayesian synthesis model depend on the way the model is parameterised. This unfortunate indeterminance is called Borel's Paradox.

Partly because of this concern, a likelihood method was discussed as being an alternative to Bayesian synthesis that could improve on standard maximum likelihood methods and more properly incorporate uncertainty. Furthermore, after much discussion over several years, in 1997 it was agreed that at least one solution to the Borel paradox was to avoid having more than one prior distribution for a parameter, and to use a standard Bayesian analysis, rather than use the specific Bayesian synthesis method. For this reason, the sub-committee dropped the use of a prior distribution on juvenile survival (for which there was in any case little information available, even from comparison with similar species) to avoid creating a second prior distribution on MSYR, the growth rate parameter.

Debate has also occurred regarding the merits of two standard Bayesian analysis methods. In one, a prior distribution is specified for K (carrying capacity) and the population model is projected 'forwards' to the current time. In the second, a prior is specified for current abundance, and the model is projected 'backwards' to find the value of K that would be necessary for this value of current abundance.

An alternative solution was developed, which involved the geometric pooling of multiple prior distribution. 'full pooling' of the joint prior distributions would lead to an analysis that was invariant to transformations, and thus could resolve the Borel paradox. This was recognised as a significant result and a correct method for combing multiple priors in cases where this was necessary, but some felt that it would be better in the bowhead assessment to simply avoid the use of multiple priors for a single parameter, especially since (they argued) these priors did not have equal levels of reliability.

5.1.1 Biology, genetics and distribution

Melnikov reported (SC/50/AS3) bowhead whale sightings data collected around the Chukotka Peninsula between 1994-6. Sightings were reported by thirty observers working at fifteen locations spread along the three sides of the Peninsula. Observations were made from April-November in 1994 and year round in 1995. In 1996, observers worked in January and from March-September, with limited

observations in November. Observations were made primarily from shore stations using binoculars. The distance offshore at which whales were sighted, the height of the shore stations and several factors affecting visibility were recorded. Special care was taken with determining the numbers of whales sighted, especially for groups of twenty or more animals. The average number of whales observed per person per day worked was calculated for separate villages or regions. Most whales were sighted within 5km from the shore. In addition, some observations were made from hunting boats 10 or more km from shore.

Bowhead whales winter in leads and polynas along the southwestern shore of the Chukotka Peninsula, in the Anadyrskiy Gulf. Some whales remain along there year round. In May, some whales migrate north along the southeastern shore of the Peninsula. In August or September bowhead whales are sighted along the northern shore of the Chukotka Peninsula. Whales then migrate east along the northern side of the Chukotka Peninsula, still feeding, before freeze-up begins. The timing and numbers of whales observed along this coast varied between years related to the ice conditions in the Chukchi and, perhaps, the Beaufort Seas.

The authors related their observations to seasonal observations made by others in the Bering, Chukchi, East-Siberian and Beaufort Seas. They noted that the timing of northward migration out of the Anadyrskiy Gulf, along the southeastern side of the Chukotka Peninsula, is later in years when the ice persists longer. They also noted that whales are observed feeding in this area in the spring, in areas where high concentrations of euphausiids have been observed. In contrast, they suggest that some whales migrating north toward Point Barrow earlier in the spring are travelling to Barrow Canyon to feed on the high zooplankton concentrations that develop in that highly productive area, and that they disperse after the zooplankton concentrations decrease. It is not known where the whales arriving along the north coast of the Chukotka Peninsula in the autumn are coming from, and it is speculated that they could be animals migrating out of the Beaufort Sea.

In discussion, it was asked what these observations tell us about interpreting the shore-based counts made at Barrow, Alaska. For example, are some whales circulating in the region? The authors suggest that animals leaving Barrow Canyon could disperse northeast towards the Beaufort Sea and perhaps also towards the west. From ice-based census data, aerial surveys north and west of Barrow, and from photogrammetric evidence, it appears, however, that the migration is uni-linear, with few animals sighted travelling south and few animals seen twice in a season.

Zhu briefly presented SC/50/AS4. Dissections of the eyes of bowhead whales have revealed that the muscles are well developed. The musculature of the eye possesses some unusual features. For example, some fibres of the extra-ocular muscles also insert into the eyelids, thereby suggesting these muscles also play a role in movement of the eyelids. The ventral oblique muscle also passes through a pulley-like structure derived from the fibrous connective tissue of the ventra rectus. Based upon morphological data, particularly the size and complexity of the eye muscles, the author concluded that the bowhead whale probably has significant eye mobility.

George presented SC/50/AS10. Age was estimated for 42 bowhead whales using the aspartic acid racemisation ageing technique. This technique estimates age based on intrinsic changes from the L (left) enantiomeric isomeric form of aspartic acid in the eye lens nucleus to a mixture of the D and L (right) forms. Racemisation rate for aspartic acid was estimated using data from earlier studies of humans and fin whales. The ratio of right to left enantiomeric isomeric forms at birth (D/L_0) was estimated using animals $\leq$ 2yrs ($n=8$), since variability in the D/L measurements is large enough that differences among ages in this range are immeasurable. Age is then estimated by dividing the difference between the D/L ratio of the sample and the D/L_0 estimate, by the racemisation rate. The standard error of the age estimates increased with estimated age, but coefficients of variation were lower for older animals.

Based on these data, growth appears faster for females than males and age at sexual maturity occurs in the mid 20s. Age at sexual maturity and growth rates agree reasonably well with estimates based on photogrammetric recaptures and from 'baleen' ageing techniques. Growth slows markedly for both sexes at roughly 40-50 years but does not stop altogether. Age estimates for four whales (all males) were considerably greater than 100 years. These results generally confirm other independent approaches at ageing bowhead whales and estimating survival rates, which suggest slow growth, great longevity and high survival rates.

Six 'traditional' Eskimo harpoon points, four of which were stone, have been recovered from dorsal caudal blubber of whales harvested by Eskimo whale hunters. Archaeologists suggest that *stone* tools have generally been out of use for over 100 years.

The authors plan to apply this ageing method to additional whales, to continue work on error estimation and attempt to estimate ovulation rates.

In discussion, the fit of the modified von Bertalanffy curve to the age and length data was noted to be poorer for females, with the possibility of higher growth rate and asymptotic size. The high variability of the age estimates was noted, and it was suggested that the error structure may be more complex than assumed. A higher survival rate for males could account for the fact that the five oldest animals were male. However, it was also noted that this could be a residual effect of the fishery, because the age of the oldest females corresponds to the time of cessation of the commercial hunt, which was directed toward large females. The oldest ages were noted to be consistent with the apparently slow increase in degree of scarring that has been observed in photographic identity studies.

Brownell presented SC/50/AS11. To investigate the possibility that bowheads in the Okhotsk Sea were derived from the Bering-Chukchi-Beaufort Seas population, the authors analysed tissue samples collected from 25 whales in the Okhotsk Sea and from 29 whales harvested off Barrow, Alaska. Both mtDNA d-loop sequences and genotypes from three microsatellite loci were determined. The number of mtDNA nucleotide differences, and microsatellite allelic and genotypic differences all showed small but significant differences between the two groups, suggesting that the sampled animals are from separate gene pools. Further studies are planned.

Future sampling in the Okhotsk Sea is planned to cover a wider geographic area in order to obtain a better understanding of genetic variation, and hopefully to allow a genetic mark-recapture estimate of population size. The possibility of collaborative US and Russian studies have recently been discussed, including collection of biopsy material, and historic and recent baleen for genetic analyses.

In discussion, it was noted that the differences in haplotype diversity imply differences in historical

population sizes, and that these are consistent with previous estimates of historical abundance (Mitchell, 1977).

Rooney presented SC/50/AS14. The primary objectives of the investigation were: (1) to quantify genetic variability in the Bering-Chukchi-Beaufort Seas stock using mtDNA control region sequences; and (2) to determine the likelihood of a potential genetic bottleneck in the Bering-Chukchi-Beaufort Seas stock as a result of commercial whaling. The level of potential genetic diversity was found to be 1.63%. This is much higher than certain populations of other marine mammal species. Results show that had a minimum population size of 1,000 occurred, an expected loss of 1×10^{-4} of average pairwise sequence divergence would result. In the case of a minimum residual size of 20 individuals, an expected loss of either 4×10^{-3} or 3.4×10^{-3} average pairwise sequence divergence would ensue, depending on the initial level of diversity used (2.0% or 1.7%, respectively). Given what is known about the extent and time frame of the Bering-Chukchi-Beaufort Seas commercial whaling era, the results show that: (1) any reduction in total population size would result in only a negligible loss of diversity; and (2) the expected pre- and post-bottleneck levels of diversity are not significantly different from each other. Thus, the likelihood of a genetic bottleneck in the Bering-Chukchi-Beaufort Seas stock is tenuous, at best. The fact that genetic variability is slightly lower than in certain populations of other marine mammal species is most likely an historical effect that is best explained by a lowered effective population size due to isolation from the eastern Arctic stocks (caused by changing patterns of sea ice distribution some 10,000 years ago) and subsequently maintained, perhaps, by environmental carrying capacity.

In discussion, Schweder noted that the maximum likelihood estimates of the BALEEN II model in SC/50/AS2 are minimal historical abundances in the hundreds, between the two values considered in this paper. The author noted that he had relied on published estimates (Woodby and Botkin, 1993) but in that case, this would make little difference. The possibility of testing for neutrality was suggested as possibly being useful to determine if a bottleneck has occurred. It was noted, however, that the published test may not be useful in this case because the among site rate heterogeneity was large.

5.1.2 Catch related data

George presented SC/50/AS9. During the 1997 subsistence hunt of bowhead whales, 66 whales were struck and 48 landed, giving an efficiency of 73%. [These numbers include a whale (97S1) taken at Savoonga on 4 January which the AEWC reported in the autumn 1996 harvest.] Of the landed whales, 29 were female and 19 male. Of the females, 10 (34.5%) were larger than 13m and presumably mature. One of the mature females (97G3, 17.1m) was pregnant with a 409cm foetus. A large whale taken at Wainwright (97WW3; 16.1m, male) carried a triangular slate harpoon point 56mm wide × 76mm long embedded in the dorsal caudal lumbar blubber.

Preliminary analysis of weather and harvest records at Barrow confirm what Eskimo whale hunters have long said; hunting success is greatly influenced by wind direction and wind speed. During the spring hunt along the Chukchi Sea coast, open leads, moderate to strong offshore winds (easterly), and stable ice are required to successfully land whales. During the autumn hunt offshore of Point Barrow (Beaufort and Chukchi Seas), calm to moderate winds and relatively ice free waters are required to effectively hunt whales. Wind direction, however, does not appear to affect autumn hunting success. The effect of such variability in hunting conditions argues for flexible hunting regulations which allow for hunting failures (due to environmental factors) during some seasons.

In discussion, the authors noted that the study had been initiated, in part, to determine the effects of environmental influences on the struck and loss rate, and that this was the next step.

5.1.3 Data gathering methodology

SC/50/AS12 provided some background information on the value of acoustic methods in the bowhead census, especially their value for quantifying the proportion of whales that are greater than 4km offshore. SC/50/AS12 also presented a description of a relatively new method for collecting recordings of whale sounds, with possible application to the bowhead census and the remote acoustic sampling of blue whales in the Southern Oceans. The method is an adaptation of the oceanographic technique of deploying autonomous data collection systems on the sea floor. The acoustic data collection system discussed in SC/50/AS12 is referred to as a 'pop-up'. An array of pop-ups deployed across the direction of the migration, in conjunction with an array deployed along the nearshore ice edge of the lead parallel with the migration, is proposed for the next bowhead census effort. The proposed pop-up array could significantly expand the area of reliable acoustic locations, and extend this area out to ranges of 15-20km. This would improve quantification of the offshore distribution of whales. Furthermore, this could improve the population estimate and reduce uncertainty in that estimate, especially in years when there is variability in offshore distribution and a large percentage of animals are greater than 4km offshore.

5.1.4 Assessment methodology

An intersessional e-mail group had functioned well since the last meeting. This group had clarified an agreed reference set of prior distributions, which should be used to compare the results of the different proposed assessment methods, and had clarified details of calculations, catch history, and abundance estimates (Appendix 2).

Punt presented SC/50/AWMP1. This paper presents the full technical specifications of the BALEEN II population dynamics model. This model forms the basis for the assessments reported in SC/50/AS1 and SC/50/AS6. A variety of methods for parameterising the model are described. These include the 'backwards' and 'forwards' methods, as well as using the maximum rate of increase instead of MSYR as the parameter that determines the productivity of the population. The sensitivity of $MSYL_{1+}$ and $MSYL_{mat}$ to different input specifications for MSYL and MSYR are examined. If $MSYL_{mat}$ is set equal to 0.6, the corresponding $MSYR_{1+}$ can be larger than the pre-exploitation size K. However, if $MSYL_{1+}$ is set equal to 0.6, the corresponding $MSYL_{mat}$ can occur at a population size less than $0.3K$.

In discussion, it was clarified that the population dynamics model incorporated in SC/50/AWMP1 was virtually identical to that developed by de la Mare (1992) much earlier, although several optional methods of parameterising the model are included in the version presented. Noting the differences in the illustrated relationships between sustainable yield and depletion, some members suggested that it was preferable to parameterise the maximum sustained yield level in terms of the 1+ population

size rather than in terms of the mature population. Particularly, this avoids the maximum sustained yield level being greater than the carrying capacity when expressed in terms of the full population.

Punt and Butterworth presented SC/50/AS1. Four methodological aspects of the Bayesian approach to assessment of the Bering-Chukchi-Beaufort Seas bowhead population were addressed. It first suggested that the prior on MSYR be replaced by one on the rate of increase at low population size, as this (rather than MSYR) was the parameter for which basic data were available from other stocks. Second, different approaches were developed for the inclusion of abundance information in the analysis, particularly the N_4/P_4 time series and its relationship to absolute abundance. These included the authors' preferred approach of taking account of correlations in the N_4/P_4 series. Third, a basis to commence the analysis in a more recent year, rather than 1848 when commercial catching started, was developed. This has the advantage of avoiding the need to consider factors such as uncertainty about the 19th century catch levels and possible changes in parameters, such as the carrying capacity K, since that time. Finally, the 'backwards' and 'forwards' variants of the Bayesian assessment approach were tested by simulation using population models where parameters were selected in turn from distributions corresponding first to forwards and then to backwards assessments. Whichever of the latter scenarios was considered, the 'backwards' variant performed better, both in terms of less bias and less variability of estimates. RY98 estimates were indicated to be negatively biased in all instances, though less so for 'backwards' estimates. Preference was expressed for the 'backwards' over the 'forwards' approach on the basis of these simulation test results. An objection to 'forwards' as a method was also expressed because (unlike 'backwards') it would update the prior input for MSYR before any data were included in the assessment; this seems an intuitively undesirable property.

In discussion, the authors noted that, in sampling from the prior distributions, they omit entirely parameter combinations that are inconsistent with the model. The authors clarified that they were sampling from the joint posterior in both the backwards and forwards cases for their simulation study. Butterworth also noted that the present work had avoided one of the problems of over-determination of the model by not specifying a prior on juvenile survival. However, in some cases priors had been set on both the current and the historical population size, thus giving rise to the possibility of Borel's Paradox.

Raftery presented Raftery and Zeh (1998). This paper describes the Bayes Empirical Bayes (BEB) and N_4/P_4 bowhead abundance estimates for 1993, as well as the updated rate of increase estimate. In discussion, Raftery noted that the paper had not accounted for the correlation among the N_4/P_4 values for different years.

Poole and Raftery presented SC/50/AS6. This paper is a continuation of the investigation into the difference between the forwards and backwards results. The full pooling method, which is now known to resolve the difference, is applied to the bowhead assessment using BALEEN II. Results were intermediate between those using forwards and backwards methods, and were invariant to the direction in which the PDM is run. The forwards method makes a prior assumption that K is independent of the other inputs, while the backwards variant makes the same assumption regarding P93 and the other inputs. These assumptions can both be questioned. Full pooling creates a joint prior that reflects relationships between parameters as determined by the population dynamics model. It thus circumvents the independence assumptions of both methods while simultaneously yielding a unique solution. As a result, full pooling does not require a choice between the forwards and backwards labellings of the model.

In discussion, the authors clarified that they treated parameter combinations, which were inconsistent with the model, exactly the same way as the authors of SC/50/AS1, and that indeed they were using the same computer programs. The authors also clarified that while the backwards and forwards methods were special cases of the full pooling method, other methods developed earlier such as 'sideways' were not. However, in concept they could be incorporated into the same framework.

Breiwick presented SC/50/AS7. This paper implemented the reference set of priors and the likelihoods using a forwards method. The analysis was based on the age- and sex-specific Leslie matrix model with density-dependence in the fecundity term. Two methods were used to sample from prior distributions. The first put a prior distribution on λ_{max}, the maximum growth rate of the population, and the 2nd was the 'reference' case where a prior was put on MSYR. The prior distribution for λ_{max} was given a uniform distribution over 1.005 to 1.10. This range was chosen on the assumption that it encompassed the range of likely values for this parameter. In calculating juvenile survival from the populations dynamics equation, all the priors were resampled from, rather than just those necessary to compute juvenile survival, as was done previously. This had the effect that the induced priors from the two methods were more similar than previously.

The first sample size for each method was set at 2.7 million, resulting in about 600,000 trajectories for method 1 and about 400,000 trajectories for method 2. These trajectories were resampled 5,000 times using the SIR method and resulted in 2,193 unique trajectories for method 1 and 1,515 unique trajectories for method 2. Percentiles of the estimated posterior distributions were generally similar for the two methods but RYs where quite different. The 5th percentile for method 1 was 82 while it was 126 for method 2. Posterior medians for the two methods were 178 and 193, respectively. The posterior medians for ROI were 0.017 and 0.019 for methods 1 and 2, respectively.

The earlier discrepancy between some of the induced priors for the two methods is thought to be due to the repeated resampling to obtain a feasible juvenile survival rate for method 1. Many of the solutions finally obtained lie at the edge of the parameter space that satisfies the constraint that juvenile survival be less than adult survival. An examination of trajectories that did not result in a feasible juvenile survival, shows a preponderance of larger λ_{max} values, corresponding to low MSYL values.

In discussion, it was noted that although the results for the two methods were similar for λ_{max}, this was not true for some other parameters of interest.

Wade presented SC/50/AS8. Analyses in this paper investigated the sensitivity of the bowhead assessment to certain assumptions. The particular implementation of the assessment was a forwards projection from K (carrying capacity) in 1848. Two versions were used, one where a prior was placed on λ_{max} (the maximum growth rate at low population size) with juvenile survival and MSYR then calculated, and another where a prior distribution was instead placed on juvenile survival with λ_{max} and MSYR then calculated.

In general, the two versions gave similar results. In the first assumption investigated, the assessment was not found

to be particularly sensitive to the marginal prior distributions put on adult survival and age of sexual maturity, as using less informative priors than the 'reference set' did not influence the results. Second, the assessment was not found to be very sensitive to the data on the fraction mature and the fraction calves in the population, but was strongly influenced by the rate of increase (ROI) data. It was noted that the estimate of ROI that results from the Bayesian analysis (the median of the posterior distribution, roughly 2%) differs substantially from the estimate of ROI from the observed data on trends in abundance (roughly 3%), even though those data were included in the analysis.

The sensitivity trials mentioned above confirmed that the explanation of this was not because of the particular marginal prior distributions specified or the other data in the analysis. Instead, this resulted because the joint prior distribution favoured very low values of ROI, so that the posterior distribution for ROI was roughly intermediate to this prior and the likelihood from the data. SC/50/AS8, as well as results reported in SC/50/AS1 and SC/50/AS7, indicated that this resulted from the elimination of higher values of λ_{max} (and thus MSYR) when impossible combinations of the marginal prior distributions for life-history parameters (adult survival, age at sexual maturity, fecundity) were combined, such as when the juvenile survival rate needed to be greater than 1.0 to make the other parameters agree with one another.

An additional analysis was presented in SC/50/AS8 that fitted a Leslie matrix (with no density-dependence) projected from 1975-1998 to the data; this analysis confirmed that the marginal prior distributions for the life-history parameters could closely agree with the observed data on ROI. Based on these analyses, the author of SC/50/AS8 suggested that changing the assumption of independence between the prior distributions on the life-history parameters (such as allowing for higher values of ASM to be correlated with higher values of adult survival) would allow the marginal distributions on the life-history parameters to permit greater values of λ_{max}, which, consequently, should lead to results where the posterior median of ROI would be closer to the observed ROI. It was noted that this influence of the joint prior is to favour lower productivity in the current population; assessments based on this joint prior would therefore be more conservative in the estimation of catch related quantities than an alternative joint prior that would allow greater probability of higher values of λ_{max}. Finally, SC/50/AS8 examined the influence of the assumption that the historical catch record is known without error. Even if there was substantial bias in the recorded harvests in the 19th century, there was little effect on the estimated catch-related quantities, although estimates of depletion level were, as expected, much lower.

In discussion, it was noted that there was substantial difference between the MSYL prior and its post-model pre-data distribution. It was suggested that this was caused by the prior on λ_{max}, and that increasing MSYL implies increasing current growth rate as fraction of λ_{max}. The author was encouraged to make a formal statistical model comparison to establish that the density independent Leslie matrix model in fact fit the ROI data better, although a difference in the means was apparent. It was noted that while the width of the intervals increased, in fact the lower bound remained relatively unchanged, suggesting that it may be more important to compare the interval and not just the means of the intervals of the posteriors.

Schweder presented SC/50/AS2. In this paper, the likelihood of direct and indirect data relevant for the 1998 IWC-assessment of the stock of Western Arctic bowhead whales is investigated. The indirect component of the likelihood is constructed from the prior distributions as described in Schweder *et al.* (1997). It is argued that several of the prior distributions are only weakly supported by data, and should be disregarded. The 7-parameter BALEEN II model is fitted to the direct data (ROI, abundance estimate for 1993 and proportion calves and matures in the survey period) and to various subsets of the indirect data. The likelihood is in each case concentrated on a narrow curved band in the 7-dimensional parameter space of the BALEEN II model. Maximum likelihood estimates are found by using automatic differentiation. The model fits the data very well, which is not surprising since the number of free parameters equals the number of data points or is slightly less. Due to this over-parametrisation, a 5-parameter version of the BALEEN II model with no differentiation between juvenile and adult survival was also fitted successfully. The interest parameter, replacement yield for 1998, is a rapidly varying function of the basic parameters of the model. This is reflected in the eigenvalues of its matrix of second derivatives being very large. This sensitivity makes it difficult to find confidence intervals for replacement yield. This sensitivity also shows up in the estimated replacement yield dropping from 197 to 175 when the number of free parameters is reduced from 7 to 5. To obtain a valid lower 5% point for replacement yield using this estimation method, the Baleen II model needs to be reparameterised, or replaced with another model for the population dynamics, to make the likelihood more Gaussian in shape. Bootstrapping is another option, but to bootstrap the indirect data more information on their nature is required.

In discussion, the method being developed was noted to be interesting, and further work was encouraged. The interpretation of prior distribution as confidence intervals as might be derived from bootstrap, was questioned. And here followed the usual frequentists *versus* Bayesians thrust and parry, *sans touché*.

Raftery and Poole presented some additional analyses designed to evaluate the significance of some options presented in SC/50/AS1. They pointed out that omitting the 1993 BEB abundance estimate leads to a simpler analysis, but the posterior on 1993 abundance was then somewhat less than the BEB estimate. They presented an analysis that does incorporate the BEB abundance estimate. They were concerned about differences in SC/50/AS1 due to assuming a prior on λ_{max} instead of MSYR, especially as the results appear sensitive to the prior assumed.

Butterworth and Punt presented some additional comments, noting that the full pooling approach was a valuable method, but that it would be appropriate in this case only if there were equally reliable priors on K and on the 1993 abundance. Furthermore, simulation tests had revealed that the backwards method was preferable to the forwards. Thus, they concluded that backwards is the better method to use.

5.1.5 Stock abundance and trends

The sub-committee agreed on the basic data required for an assessment, as shown in Appendix 3. The catch data are complete through 1997 and thought to be generally reliable (Appendix 3, table 1). Abundance data included the 1993 BEB abundance estimate (8,200, SE = 564) and a series of estimates termed N_4/P_4 (Appendix 3, table 2). These were combined to form an index of abundance, and a relative abundance series with covariances was calculated

(Appendix 3, table 3). It was noted that aerial photographic data had been used to estimate length distributions for the proportions of calves and mature and the rate of adult survival. Further analyses of the survival data are underway. No more recent abundance surveys have been completed, with the next planned for 1999. Relative to the catch data, it was noted that the suggestion that the commercial fishery preferentially took larger females, given to explain the lower maximum age for females in SC/50/AS10, raised questions about sex ratio in the historic catch. This was identified as an issue for future sensitivity investigations.

Of the papers reviewed, concerns were raised in several about technical difficulties encountered in estimating parameters of interest in some situations. The cause of these difficulties and their implications for the present assessment was discussed. Subsequently, possible ways of minimising or avoiding such difficulties in the future were identified. Cooke noted that the BALEEN population model had been developed over the 1970s and 1980s for the purpose of fitting stock trajectories to series of catch and effort data and later also absolute to abundance estimates. Only the carrying capacity, and sometimes also the MSYR, were originally treated as free parameters to be estimated. All the remaining biological parameters were fixed inputs. It is not necessarily the most suitable model for the kinds of assessments performed by this sub-committee in recent years and can be especially problematic in cases where the population was reduced to a very low level at one point in history.

There was disagreement as to whether some of these difficulties were related to the specific parameterisations being used (especially dependencies among parameters, to over parameterisation given the data), or to inadequacies in the underlying population dynamics model. Schweder described the likelihood surface as having a very steep ridge and said that parameters of interest such as replacement yield are very steep saddle-like functions. These characteristics may arise from dependencies among parameter values, and he suggested that the behaviour may relate to how the models have been parameterised. For example, he suggested not distinguishing between juvenile and adult survival, and indeed avoiding parameters that take values near logical boundaries. Butterworth noted that reparameterising, for example working with ratios such as the age of maturity divided by the average age, might make the assumptions of independent priors more defensible. He also noted that distinguishing juvenile and adult survival was essential for this assessment to have sufficient flexibility in the model to fit observations of both rate of increase and the fractions of matures and calves in the population.

There was general agreement that, although there may be issues with the underlying population dynamics model and its parameterisation, these difficulties did not preclude sampling from the posterior in the Bayesian analyses presented. These issues should be addressed in the future.

The sub-committee compared the three basic methods of fitting the models, termed forwards, backwards and full pooling. It was agreed that the forwards procedure had little to recommend it, performing in simulation studies consistently worse than the backwards method. Further, the forwards model requires specifying a prior on pre-exploitation population size, K, about which there is little information other than the recorded catch series. It was noted that the forwards and backwards methods assume independence between MSYR and carrying capacity and between MSYR and current abundance, respectively. There were differences of opinion about the validity of these two assumptions, and hence the applicability of the two methods. The full pooling method was agreed to be an important new methodology that combines these two assumptions, while avoiding Borel's Paradox and yielding a unique situation. There was disagreement, nonetheless, about the applicability of this procedure in the present case.

Several members considered the backwards method preferable, while some members considered the full pooling method preferable or preferred to examine the results of both. Based on this, it was agreed to conduct an assessment using the backwards method and to examine the results from full pooling as well.

The group reviewed the prior distributions that it had used previously for input parameters for the assessment. Appropriate values for use in the present assessment were agreed (Appendix 3, table 4), although some noted that for several parameters there were no direct data available to help set prior distributions. This was noted especially for the maximum calving interval, MSYR, survival rate of adults, age of transition between mortality rates and carrying capacity. Relative to the latter, it was noted that the history of catches was likely to have been considered in setting this prior, and it was suggested that using a prior based on that data, and also using that same data in the model calculations, may constitute using the same data twice. There was no agreement on this point.

The relationship between natural mortality and age that is in the present parameterisation was noted to be an approximation to the U-shaped mortality schedule common to mammals. It was noted that recently research was focusing on the degree to which the mortality rates actually increase with older ages, and that this might be reviewed. Several complications resulting from the piecewise approximation to a U-shaped schedule were identified, including the necessity to specify prior distributions for juvenile mortality rates, ages of transition between mortality rates, and maximum ages.

Given that 10% of the sample of animals considered in SC/50/AS10 were estimated to be older than 100 years, the group was concerned about the way the mortality rates for older animals were handled. Here, it was noted that a maximum age of 100 years serves as a proxy for an increasing mortality rate from 80 to 120 years. It was noted that given the timing of the cessation of commercial whaling, there should not yet be a large proportion of the population older than 100, and thus the issue was unlikely to have a significant effect on the assessment. It was agreed that for this assessment it would be sufficient to explore this further, by considering two alternative calculations; one involving not setting a maximum age and constraining adult survival rate to be less than 0.995; and the other of retaining the maximum age but allowing survival to be as high as one.

The relationship between the form specified for a prior distribution and the form induced by the population dynamics model in concert with the catch data (post-model, pre-data prior) was discussed. It was noted particularly that the shape of a prior distribution may not be as important as the shape of the induced prior and that it might be useful to choose priors that would result in uniform induced priors. It was agreed that routinely displaying the prior distributions specified, the induced prior distributions, and the posterior distributions for parameters was useful in allowing the results of an assessment to be better evaluated.

A number of points were identified that should be addressed in the future. As there is no data from the population at very low abundances to use in setting maximum fecundity, it was suggested to reparameterise the model to use current rather than maximal rates. It was also

suggested that the current population model might be made more realistic by including density-dependence in juvenile survival as well as in fecundity. The difference between the survey data, which includes young of the year prior to substantial mortality, and the population model component (animals age one and older) that is being compared to the data was noted. Because about 5% of the modelled population can be young of the year, the group agreed that the modelled abundance including calves should be used. The possibility of reparameterising MSYR in terms the maximum population growth rate (λ_{max}) was considered because the actual data from which MSYR values have been inferred are for populations thought to be at low levels. Alternatively, consideration might be given to parameterising MSYR in terms of the current rate of increase. Given the complexity of the way the mortality schedule is incorporated, it was agreed that simplifications might usefully be pursued. For example, it might be possible to parameterise in terms of average age or life expectancy, or other methods that might avoid the 'cliff-hanger' form of survival rates with especially long-lived species. It was also noted that given the extremely high ages, it would be useful to look for female reproductive senescence.

Some members identified the difficulties associated with trying to model population trajectories when the populations have reached very low levels, noting that changes in input values for carrying capacity of much less than an integer could change modelled trajectories greatly. However, others suggested that in their experience this type of sensitivity was not associated with the complexity of the model *per se* because similar behaviour arose (SC/50/Rep4) with much simpler models. There was further discussion of the possibility of avoiding some of these difficulties through rounding to integer numbers of whales. Also, the use of stochastic models as had been suggested last year (Raftery and Poole, 1997) was identified as a promising approach.

5.1.6 Assessment and management advice

Assessments using the methodologies of SC/50/AS1 and SC/50/AS6, making the assumptions agreed under Item 5.1.4 were presented (Appendix 4 and Appendix 5). Both Appendices included calculations using the backwards method under two sets of assumptions. One set assumes a maximum age of 100 and maximum survival of 1.0, and the other set assumes no maximum age and a maximum survival of 0.995. Appendix 5 also presented the results of the full pooling method under these two cases. The authors of Appendix 5 noted, however, that their computations assuming no maximum age were somewhat tentative because approximate methods had to be used given the press of time. They indicated that they will finalise these calculations later.

The authors of Appendix 4 also presented their backeards method results compared to population size including calves, and noted that this resulted in slightly higher values of, for example, the current replacement yield. They also included information on the induced prior distributions.

The posterior distributions of several statistics summarising the assessments are reported, including the replacement yield and another criteria Q_0, that accounts for the situation when the population might be above MSYL. This quantity was defined to be 90% of MSY when a population is above MSYL (IWC, 1998b, item 6.1.1).

The best estimates of replacement yield (RY) from these alternative assessments ranged from 184 to 210. The sub-committee agreed, as in the last bowhead assessment, to use the lower 5th percentiles of the posterior distributions of RY and Q_0 to provide management advice. The sub-committee recognised that this was a conservative approach and that the AWMP currently under development will probably provide a better approach. The relevant 5th percentiles, along with the best estimates (medians) of depletion, are shown in Table 1.

Table 1

Lower bounds (5th percentiles) of replacement yield (RY) and Q_0 for 1998, and the median estimated depletion in terms of 1+ population size for four combinations of assessment method from the two assessments of the status of the Bering-Chukchi-Beaufort bowhead population, extracted from Appendix 4 and Appendix 5. The alternate case results are from the Backward method from the combinations of assumptions considered that resulted in the lowest values among the alternates considered of RY and Q_0, namely assuming no upper bound on life span and comparing the results to the population size including calves

	SC/50/AS6		SC/50/AS1	
Quantity	Full Pooling	Backwards	Backwards	Alternate case
RY	108	119	123	113
Q_0	102	114	120	110
Depletion	61%	68%	68%	66%

The backwards method as implemented by the authors of Appendix 4 and Appendix 5 were noted to be similar, as would be expected given that the method is the same. The differences reflect expected levels because Monte Carlo methods are used. The full pooling method gives lower values of the 5th percentile of replacement yield (108) and of the quantity Q_0 (102) than were obtained using the backwards method. The other cases considered resulted in values intermediate between the backwards and the full pooling methods.

It was noted that the differences in the estimates of values which are of management concern are relatively small, and that regardless of the methods used, the management advice would be the same. The population appears to be near MSYL, and would very likely increase under catches of up to 108 animals.

In terms of sub-paragraph 13(a) of the Schedule, appropriate catch levels in these circumstances should not exceed 90% of MSY. The calculations reported therefore indicate that it is very likely that a catch limit of 102 whales or less would be consistent with the requirements of the schedule.

5.2 Other Stocks

5.2.1 Baffin Bay-Davis Strait and Hudson Bay stocks

A brief description of the distribution, current abundance and status of the two putative stocks of bowheads in eastern Canada, the Davis Strait 'stock', which is known to be shared with Greenland and the Hudson Bay/Foxe Basin stock, was given in IWC (1992, pp.138-139). Pertinent new information available since 1991 is summarised in the following paragraphs.

The sub-committee noted that Canada has agreed to the request by the Nunavut Wildlife Management board for Inuit hunters in eastern Baffin Island to strike up to two and catch up to one bowhead whale from the Davis Strait/Baffin Bay stock in the summer of 1998. This planned hunt follows the

initiation of legal hunting on the Hudson Bay/Foxe Basin stock in 1996. An estimate of 270 (CI 210-331) for the northern Foxe Basin part of the Hudson Bay/Foxe Basin stock's summer range in August 1994 has been published (Cosens *et al.*, 1997). In addition, Innes referred to an estimate of 59 (CI 20-120) for the northwest Hudson Bay part of this stock's range in August 1995 (Cosens and Innes, In press). Both estimates are from systematic aerial survey and are unadjusted to account for detection bias, i.e. for animals not at the surface during the overpass or at the surface but missed by observers.

No recent information on absolute abundance or trend is available for the Davis Strait/Baffin Bay stock. The statement in IWC (1997, p.90) that the DS/BB and HB/FB stocks have been conservatively estimated at 450 whales *each*, citing Zeh *et al.* (1993), is incorrect. Zeh *et al.* (1993) estimated that there were at least 450 whales in the two stocks, *combined*. Of this total, about 350 were estimated for Davis Strait/Baffin Bay and 100 for Hudson Bay/Foxe Basin.

Finley presented SC/50/AS15. Observations of bowheads at Isabella Bay, northeastern Baffin Island, were made in 11 autumn seasons (310 field days) between 1983 and 1997. Except for 1983, bowheads were observed most days, averaging 23.5 (± SD 20.35) in 80 daily scans.

This study indicates that up to 99 bowheads can be present in Isabella Bay, northeastern Baffin Island, at one time during the autumn. The 11-year time series of scan samples from a shore observation site at Isabella Bay has not been fully analysed, but preliminary analyses suggest no evidence of a trend in this component of the Davis Strait/Baffin Bay stock between 1983 and 1997. The recovery of Davis Strait/Baffin Bay bowheads may be limited by predation by killer whales. At Isabella Bay, up to one third of adult bowhead whales have been scarred by killer whale attacks, and there are anecdotal and direct observations of killer whales attacking and killing bowhead whales.

According to Innes, a recent series of interviews with hunters carried out by the Nunavut Wildlife Management Board revealed the hunters' firm belief that bowheads have increased substantially throughout the eastern Canadian Arctic since the end of commercial whaling 75-80 years ago (Hay, 1995).

For both of these stocks the sub-committee expressed its appreciation for the recent studies on abundance and distribution, using traditional knowledge, sighting surveys, photography and biopsy samples, and encouraged additional work along these lines. Given the apparent interest in continuing harvests from these two stocks that were depleted by commercial whaling, additional knowledge of their status is crucially needed.

The sub-committee remains concerned for the viability of the Hudson Bay/Foxe Basin stock because of its small size, especially in light of the aboriginal harvest of one whale in 1996 (IWC, 1998a, p.92).

The sub-committee also expressed concern about the approval for up to two strikes of whales in 1998 from the Davis Strait stock because of its small size and possible lack of increase.

5.2.2 Okhotsk Sea stock

Only one paper was available that presented information on this stock. The results contained in SC/50/AS11 were documented earlier in this report. Previously reported estimates for this population are 250-300 whales but no quantitative data are available. SC/50/AS11 suggested that the population size could be estimated using a genetic mark-recapture study.

5.2.3 Other stocks

The sub-committee remains concerned about the status and apparent low abundance of the Spitzbergen stock, about which little is known (Burns *et al.*, 1993). It encouraged additional studies on abundance and distribution to be undertaken.

6. GRAY WHALES

6.1 Eastern Pacific Stock

One paper was presented regarding this stock of gray whales (SC/50/AS13). The author reported on the results of observation studies in Mechigmenskiy Zaliv and adjacent waters from 1984-96. He noted that most sightings of gray whales in this area occurred between June and November, with peak numbers occurring in August or September in most non-El Niño years. During the years influenced by El Niño, peak usage occurred in June.

It was also reported that in 1997, the Russian State Committee on Environment issued an allowance to the Chukotka Autonomous Okrug for the harvest of 140 gray whales, which is within the limits of the aboriginal quota set by the IWC for the needs of the small native populations of the region. In accordance with the requests it received, the Okrug Administration distributed an allowance of 101 whales between nine settlements. During the 1997 hunting season, 79 whales were harvested: 48 males and 31 females.

Hunting was conducted from whaling boats and sea kayaks under the direct control of fishing inspectors from the Chukotka Regional Fisheries Inspection Agency. In the majority of settlements, rifles were used during the hunt. In 1997, 20 darting guns with exploding bombs, received as humanitarian aid from Alaskan Eskimos, were used for the first time in the gray whale harvest. Using the darting guns, 17 shots resulted in 16 catches (i.e., one animal was shot twice with the darting gun). The time required for catches, where dart guns were not used, was between 30 and 120 minutes (average time per whale: 77 minutes); whereas, the time required for catches, where dart guns were used, was about half as long (average time per whale: 36 minutes).

In regard to last year's recommendation, the sub-committee was informed (SC/50/ProgRep Mexico) that studies in the gray whales' breeding lagoons had continued and expanded to include most of the wintering range of this species (stock) in Mexican waters. Systematic boat surveys were conducted at the lagoons (Ojo de Liebre, or Scammon's, San Ignacio and Magdalena Bay). Also, aerial surveys were conducted over the Baja California coastline and the lagoons. Among the objectives of this season's research was to evaluate the impact of ENSO on the distribution and use of the lagoons. Although no detailed information was presented to this meeting, due to the short period in between the end of the field season and this meeting, preliminary information suggests that whales were present in fewer numbers in the southernmost breeding lagoon in Baja California (Magdalena Bay) and further, that they left this location earlier than they had been observed to in previous years.

Regarding advice to the Commission concerning management, the sub-committee has no changes to the recommendations made during last years meeting of the Scientific Committee.

6.2 Western Pacific Stock

One paper (SC/50/AS5) was presented regarding this stock. Zhu summarised the location and year of sightings, strandings, and catches of gray whales in Chinese coastal waters. He noted that five sightings of gray whales that were not related to catching operations were reported between 1953 and 1979. In addition, seven gray whales were reported stranded between 1933 and 1996, and 13 gray whales were reported caught by fishermen between 1916 and 1958.

The sub-committee thanked the author for his efforts to summarise this information. Given the severely deplete d nature of this stock, the information presented in SC/50/AS5 is very important in establishing base lines for sightings and stranding studies that may be used to infer trends in abundance for this stock in the future.

Zhu stated that reports in early 1998 of five stranded gray whales along the southern Chinese coast were an error. The animals turned out to be false killer whales.

7. MINKE WHALES OFF GREENLAND

There were no papers presented during the meeting on the two stocks of minke whales that occur off Greenland. Born reported that in 1997 a total of 146 minke whales (99 females, 42 males and 5 with sex undetermined) were landed from the West Greenland stock. Additionally, two whales were struck and lost. A total of 65 biopsy samples were collected from the catch (see SC/50/ProgRep Denmark).

Born also reported that eleven minke whales (10 females, 1 male) were landed from the eastern Greenland stock in 1997. Three whales were struck and lost. The question of management advice is discussed under Item 10.

8. FIN WHALES OFF GREENLAND

There were no papers presented during the meeting on this stock. Born reported that in 1997 eleven fin whales (5 females, 5 males and 1 of undetermined sex) were landed from this stock. In addition, two whales were struck and lost. Four biopsy samples were collected from the catch (see SC/50/ProgRep Denmark). The question of management advice is discussed under Item 10.

9. HUMPBACK WHALES OFF ST VINCENT AND THE GRENADINES

On 26 February 1998, two humpback whales were taken and landed at the whaling station on Petit Nevis. The whales were landed after 1700hrs. As the Fishery Officer did not receive word immediately, he did not arrive until the following day, after the smaller whale had been butchered and distributed. It was described to him by the fishermen to have been a male of 4-6m in length. He measured, photographed and examined the remaining whale, which was in the process of being cut up. It was a non-lactating female 15.3m in length. Information regarding other data and samples that may have been collected will be released at a later date.

Regarding advice to the Commission concerning management, the sub-committee has no changes to the Committee recommendations made during last year's meeting. The sub-committee draws attention to the Scientific Committee's intention to undertake a Comprehensive Assessment of North Atlantic humpback whales at its meeting in 2000. Furthermore, additional information on the status of humpback whales in the North Atlantic can be found in Annex E.

10. LONGER TERM PRIORITIES

The sub-committee noted the actions taken by the Commission last year, of approving five-year aboriginal catch limits for Bering-Chukchi-Beaufort Seas bowheads before the Committee had completed a new assessment, and of approving coincident five-year aboriginal catch limits for both bowheads and eastern Pacific gray whales, West and East Greenland minke whales and West Greenland fin whales. Furthermore, the time required to complete a new assessment for a stock, precludes doing more than one during an Annual Meeting. The sub-committee therefore agreed that it did not appear necessary, and was not in any event feasible, to match the time between assessments with the time period of catch limits.

Recognising the usual Commission request that the Committee keep the stocks under annual review in any event, and that developing aboriginal whaling management procedure intervals between assessments of up to six years are being considered, the sub-committee suggests the Committee give attention to the more important of the stocks subject to aboriginal harvest every six years. The sub-committee also noted that the sub-committee on Other Great Whales has proposed undertaking a Comprehensive Assessment of North Atlantic humpback whales in the year 2000. Furthermore, the sub-committee noted its own concerns arising during this meeting about other stocks of bowhead whales. Finally, the sub-committee encouraged that suggestions for future work to improve the Bering-Chukchi-Beaufort bowhead assessment models be pursued.

Greenland stocks

The sub-committee noted that it has never been able to provide satisfactory scientific advice on either the fin or minke whales off West Greenland. This is a matter of great concern, given that the provision of management advice on stocks subject to whaling is a high priority task assigned to the Committee by the Commission. The reason that satisfactory advice cannot be given is the lack of requisite data, particularly on stock structure and abundance. The Chairman of the sub-committee on Aboriginal Whaling Management Procedures indicated that even at this stage in the development process, it was clear that developing a *Strike Limit Algorithm* for the Greenland Fisheries that would fulfil all the Commission's objectives would be an extremely difficult, if not impossible task, given the available data.

The sub-committee recognised that the logistical difficulties of obtaining the necessary information are enormous, both in terms of the physical environment (including weather conditions) and the level of resources required. The sub-committee believed that it was unacceptable to merely continue to provide less than satisfactory advice and make general recommendations for further work.

It therefore recommends that the Committee establishes a Working Group, in collaboration with Greenlandic scientists, to determine a costed research programme that will enable the Committee to provide satisfactory advice to the Commission as soon as possible. At a minimum this programme will address questions of stock identity and abundance. The programme should take into account the

work of the Aboriginal Whaling Management Procedures sub-committee, where the important relationship between data requirements and management procedures has already been stressed.

Born supported that idea of developing such a research proposal. He commented that research directed at better understanding of the stock structure using a variety of techniques has been initiated this year. This study would be done in cooperation with Norwegian scientists. Furthermore, Born noted that within the next five years, a survey for the purpose of estimating abundance of cetacean stocks off Greenland was planned. The sub-committee welcomed the Greenland research initiative.

Based on these developments, the sub-committee recommended, that while keeping all stocks subject to aboriginal whaling under review annually, primary attention be given to continuing work on the aboriginal whaling management procedure and to intensive assessments of stocks in future meetings as outlined in Table 2.

Table 2

Timetable for stock assessment consideration at future Annual Meetings.

Year	Stock to be considered
1999	Bowhead whales other than the Bering-Chukchi-Beaufort stock
2000	North Atlantic humpback whales
2001	Fin whales off Greenland
2002	Minke whales off Greenland
2003	Eastern and western Pacific gray whales
2004	Bering-Chukchi-Beaufort Seas bowhead whales

11. ADOPTION OF REPORT

The report was adopted on 2 May 1998 and the final text for Item 10 was circulated to sub-committee members on 3 May 1998.

REFERENCES

Burns, J.J., Montague, J. and Cowles, C. (eds.). 1993. *Special Publication*. No. 2. *The Bowhead Whale*. D. Wartzok (ed.) Society for Marine Mammalogy, Lawrence, Kansas. xxxvi+787pp.

Cosens, S.E. and Innes, S. In press. Distribution and numbers of bowhead whales (*Balaena mysticetus*) in norhtwestern Hudson Bay in August, 1995. *Arctic*.

Cosens, S.E., Qarnukaq, T., Parker, B., Dueck, L.P. and Anardjuak, B. 1997. The distribution and numbers of bowhead whales, *Balaena mysticetus*, in northern Foxe Basin in 1994. *Canadian Field Naturalist* 111:381-8.

De la Mare, W.K. and Cooke, J.G. 1992. BALEEN II; the model used in the HITTER/FITTER programme. International Whaling Commission, Cambridge, UK. 25pp.

International Whaling Commission. 1992. Report of the Scientific Committee, Annex E. Report of the bowhead whale assessment meeting. *Rep. int. Whal. Commn* 42:137-55.

International Whaling Commission. 1997. Report of the Scientific Committee. *Rep. int. Whal. Commn* 47:59-257.

International Whaling Commission. 1998a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48: 53-127.

International Whaling Commission. 1998b. Report of the Scientific Committee. Annex J. Report of the Sub-Committee on Aboriginal Subsistence Whaling. *Rep. int. Whal. Commn* 48: 237-248.

Mitchell, E.D. 1977. Initial population size of bowhead whale *Balaena mysticetus* stocks: cumulative estimates. Paper SC/29/33 presented to the IWC Scientific Committee, Canberra 1977 (unpublished).

Raftery, A.E. and Poole, D. 1997. Bayesian Synthesis assessment methodology for bowhead whales. Paper SC/49/AS5 presented to the IWC Scientific Committee, September 1997 (unpublished). 40pp.

Raftery, A.E. and Zeh, J.E. 1998. Estimating bowhead whale population size and rate of increase from the 1993 census. *J. Am. Stat. Assoc.* 93(442):1-13.

Schweder, T. and Hjort, N.L. 1997. Indirect and direct likelihoods and their synthesis-with an appendix on minke whale dynamics. Paper SC/49/AS9 presented to the IWC Scientific Committee, September 1997, (unpublished). 24pp.

Woodby, D.A. and Botkin, D.B. 1993. Stock sizes prior to commercial whaling. pp. 387-407. *In:* J.J. Burns, J.J. Montague and C.J. Cowles (eds.) *Special Publication. No. 2. The Bowhead Whale*. 1st Edn. Society for Marine Mammology, Allen Press, Lawrence, Kansas. 787pp.

Zeh, J.E., Clark, C.W., George, J.C., Withrow, D., Carroll, G.M. and Koski, W.R. 1993. Current population size and dynamics. pp. 409-89. *In:* J.J. Burns, J.J. Montague and C.J. Cowles (eds.) *Special Publication No. 2. The Bowhead Whale*. 1st Edn. Society for Marine Mammology. Allen Press, Lawrence, Kansas. 787pp.

Appendix 1

AGENDA

1. Convenor's opening remarks
2. Election of Chairperson and rapporteurs
3. Adoption of the Agenda
4. Review of documents
5. Bowhead whales
   - 5.1 Comprehensive Assessment of the Bering-Chukchi-Bowhead Seas stock
     - 5.1.1 Biology, genetics and distribution
     - 5.1.2 Catch related data
     - 5.1.3 Data gathering methodology
     - 5.1.4 Assessment methodology
     - 5.1.5 Stock abundance and trends
     - 5.1.6 Assessment and management advice
   - 5.2 Other stocks
     - 5.2.1 Baffin Bay – Davis Strait stock and Hudson Bay stock
     - 5.2.2 Okhotsk Sea stock
     - 5.2.3 Other stocks
6. Gray whales
   - 6.1 Eastern Pacific stock
   - 6.2 Western Pacific stock
7. Minke whales off Greenland
8. Fin whales off Greenland
9. Humpback whales off St Vincent and the Grenadines
10. Longer-term priorities
11. Adoption of report

Appendix 2

AD-HOC BOWHEAD ASSESSMENT GROUP (E-MAIL CORRESPONDENCE GROUP)

The *ad-hoc* Bowhead Assessment Group ('bag'), chaired by Steve Buckland, has corresponded via e-mail since the 1997 Scientific Committee meeting in Bournemouth (IWC, 1998, appendix 2). More than 40 messages to the list have been archived on a NOAA computer in Seattle (URL *http://nmml01.afsc.noaa.gov/iwc-bag/iwc-bag.htm*). In addition to archived e-mail messages, the web-site also contains a link to the revised Bering-Chukchi-Beaufort Seas bowhead whale catch table, 1848-1997, used in current assessments (Appendix 3, table 1). The standard data required for 'reference set' assessment runs are also given at the web site. Topics discussed by the group include: replacement yield calculations; ROI statistics; abundance estimates; the 'reference' prior distributions; and the need for an intersessional meeting of the group. The e-mail correspondence group proved to be a quick and effective means of communication amongst the group members and aided the work of those carrying out Bering-Chukchi-Beaufort Seas bowhead whale stock assessments for this meeting. It was agreed that no intersessional meeting was required, and the tasks undertaken by members of the group are reported in SC/50/AS1, 2, 6, 7 and 8.

REFERENCE

International Whaling Commission. 1998. Report of the Scientific Committee. Annex J. Report of the Sub-Committee on Aboriginal Subsistence Whaling. *Rep. int. Whal. Commn* 48: 237-248.

Appendix 3

DATA USED IN THE BOWHEAD WHALE ASSESSMENT

Table 1

Bering-Chukchi-Beaufort Seas bowhead whale kill, 1848-1997.

Year	Total kill	Year	Total kill	Year	Total kill	Year	Total kill
1848	18	1886	168	1924	41	1962	20
1849	573	1887	240	1925	53	1963	15
1850	2,067	1888	160	1926	35	1964	24
1851	898	1889	127	1927	14	1965	14
1852	2,709	1890	136	1928	30	1966	24
1853	807	1891	284	1929	30	1967	12
1854	166	1892	346	1930	17	1968	27
1855	2	1893	180	1931	32	1969	32
1856	0	1894	234	1932	27	1970	48
1857	78	1895	117	1933	21	1971	25
1858	461	1896	118	1934	21	1972	44
1859	372	1897	130	1935	15	1973	51
1860	221	1898	309	1936	24	1974	42
1861	306	1899	234	1937	53	1975	32
1862	157	1900	148	1938	36	1976	74
1863	303	1901	55	1939	18	1977	72
1864	434	1902	162	1940	20	1978	17
1865	590	1903	116	1941	38	1979	23
1866	554	1904	86	1942	26	1980	38
1867	599	1905	105	1943	14	1981	26
1868	516	1906	69	1944	8	1982	14
1869	382	1907	96	1945	23	1983	16
1870	637	1908	123	1946	20	1984	16
1871	138	1909	61	1947	21	1985	14
1872	200	1910	37	1948	8	1986	22
1873	147	1911	48	1949	11	1987	29
1874	95	1912	39	1950	23	1988	28
1875	200	1913	23	1951	23	1989	25
1876	76	1914	61	1952	11	1990	41
1877	270	1915	23	1953	41	1991	47
1878	80	1916	23	1954	9	1992	46
1879	266	1917	35	1955	36	1993	51
1880	480	1918	27	1956	11	1994	38
1881	435	1919	33	1957	5	1995	57
1882	242	1920	33	1958	5	1996	45
1883	42	1921	9	1959	2	1997	62
1884	160	1922	39	1960	33	**Total**	**22,3877**
1885	377	1923	12	1961	17		

Sources: 1848-1972: IWC, (1995).
1973-1993: Suydam *et al.* (1995a); Soviet shore kills for 1973-75, see IWC (1995).
1994: Suydam *et al.* (1995b).
1995: 1996: Suydam *et al.* (1997).
1997: George *et al.* (1998).

Notes: These are recorded catches; the presence of zero can equally refer to no information as to no catch. The assignment of 'struck and lost' to the shore kill follows the methodology of Breiwick *et al.* (1982) which was 1848-1969, 100%; 1970-1977, 50%; 1978-1980, 75%, and a poor chance of survival or probably died for 1981-1996 (Suydam *et al.*, 1995a).

Since 1981, struck and lost whales have been assigned a chance of survival by whaling captains: 'excellent', 'fair', 'poor', 'died', and 'unknown'. The number of struck and lost estimated to have subsequently died is equal to the number of whales in the categories 'poor' and 'died' plus the number of whales in the category 'unknown' which were assumed to have died. The number of 'unknown' assumed to have died was equal to the number in that category times the fraction of whales in 'known' categories assigned to 'poor' and 'died' (cf. Suydam *et al.*, 1995a).

The table includes all available past soviet catches including the period 1972-75 when 8 bowheads were taken (see Soviet Union progress report, Anonymous, 1979, p.131). No bowheads are known to have been taken by Chukotkan natives since 1975.

Includes one bowhead taken by Canada in 1991 and one in 1996.

Table 2

Data used in the construction of an index of abundance for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Source: Zeh *et al.*, (1993). The N_4/P_4 estimates are based on the analyses conducted by Zeh *et al.* (1993).

	N_4		P_4		N_4/P_4	
Year	Estimate	SE	Estimate	SE	Estimate	CV
1978	3,383	289	N/A		5,019	0.294
1980	2,737	488	N/A		4,061	0.336
1981	3,231	716	0.750	0.108	4,308	0.266
1982	4,612	798	N/A		6,843	0.333
1983	4,399	839	N/A		6,527	0.343
1985	3,134	583	0.519	0.131	6,039	0.317
1986	4,006	574	0.518	0.062	7,734	0.187
1987	3,615	534	N/A		5,364	0.320
1988	4,862	436	0.739	0.053	6,579	0.115
1993	7,249	505	0.933	0.013	7,770	0.071

Table 3

Estimates, CVs (actually standard errors of the logarithms) and the correlation matrix for the indices of abundance for the Bering-Chukchi-Beaufort Seas bowhead stock. The values are based on the estimation procedure described in Appendix 1 of SC/50/AS1 (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

Table 4

Parameters for bowhead assessment.

Parameter	Value
$MSYL_{1+}$	U[0.4, 0.8][1]
$MSYR_{1+}$	U[0.01, 0.07][2]
a	DU[1,9][3]
ASM	Grouped N(20,3^2), truncated at 13.5 and 26.5[4]
k	log(k) ~ U[log(7,000), log(31,000)][5]
s (adult)	N(0.99,0.02^2) truncated at 0.995[6] with maximum age = 100 or, N(0.99, 0.022 truncated at 1 with no constraint on maximum age
s (immature)	Constrained by population dynamics equation to be less than s (adult)[7]
$f$max	1/$f$max ~ U[2.5, 4] (1/$f$max = minimum average calving interval)[8]

[1] The prior specified in IWC (1995, p.148) for $MSYL_{mat}$ was considered to be appropriate for $MSYL_{1+}$ for reasons given in Annex F.

[2] Justification is based on the reported estimates of current rate of increase (ROI) (Appendix 3, Table 5) and the functional relationships defining $MSYR_{1+}$ (see IWC, 1994b, p.182), where the upper confidence interval for several ROIs exceeded 9% per year, which supports the upper range of 7% for $MSYR_{1+}$, while the lower confidence interval for at least one ROI is in the 2-3% per year range, which supports the lower limit of $MSYR_{1+}$. Further, the Working Group noted that its choice for a lower bound of 1% for the $MSYR_{1+}$ range was consistent with the recommendation for $MSYR_{1+}$ values used in the development of an Aboriginal Whaling Management Plan (IWC, 1994a, annex I).

[3] As in IWC (1995, p.148).

[4] As in IWC (1995, p.148).

[5] It was believed that a prior in which log(K) is uniform would be less informative (on key quantities of interest, such as RY) and more justifiable than one in which K is uniform. The upper and lower limits of log(31,000) and log(7,000), respectively, were proposed for computational convenience, as experience with these types of models has shown there is virtually a zero likelihood for log(K) values outside this range.

[6] As in IWC (1995, p.148), except that the upper truncation point was reduced from 1 to 0.995. Support for the 0.995 value was based on the belief that the expected longevity of a reproductively active bowhead whale would be unacceptably high were the upper value of the range set above 0.995. Using the 0.995 value in combination with a maximum age of 100 in the model should produce average longevities in the range of 60-90 years. Although new data (Whitcher *et al.*, 1996) was available since the choice of prior in IWC (1995, p.148) it did not increase the precision of the previous evidence.

[7] It was considered that juvenile survival should merely be constrained to be less than adult survival, since there was no independent knowledge on which a plausible prior could be based.

[8] It was considered more appropriate to set a uniform prior on the minimum possible average calving interval rather than the maximum historic ratio of calves to mature females. The limits on the latter in IWC (1995, p.148) transform to (2,4); as 2 was considered impossible for bowheads, it was revised to 2.5.

Table 5

Estimated annual rates of increase (with 95% confidence intervals) for several severely depleted stocks of baleen whales. Source: Best, (1993).

Stock	Point estimate	95% CI
South African right whale	0.068	[0.048, 0.086]
Argentine right whale	0.073	[0.038, 0.108]
West Australian right whale	0.127	[0.076, 0.178]
Northwest Atlantic humpback whale	0.094	[-0.12, 0.30]
West Australian humpback whale	0.088	[0.030, 0.146]
East Australian humpback whale	0.097	[0.06, 0.13]
Northeast Atlantic blue whale	0.051	[0.026, 0.076]

REFERENCES

Anonymous. 1979. Soviet Union. Progress report on cetacean research, June 1977 - May 1978. *Rep. int. Whal. Commn* 29:131-4.

Best, P.B. 1993. Increase rates in severely depleted stocks of baleen whales. *ICES J. Mar. Sci* 50(3):169-86.

Brueggeman, J.J. 1982. Early spring distribution of bowhead whales in the Bering Sea. *J. Wildl. Manage.* 46(4):1036-44.

George, J.C., O'Hara, T.M., Brower, H.J., Suydam, R. and Albert, T.F. 1998. Results of the 1997 subsistence harvest of bowhead whales by Alaskan Eskimos with observations on the influence of environmental conditions on the success of hunting bowhead whales off Barrow, Alaska. Paper SC/50/AS9 presented to the IWC Scientific Committee, April 1998 (unpublished).

International Whaling Commission. 1994a. Report of the Scientific Committee, Annex I. A programme to implement the catch limit algorithm. *Rep. int. Whal. Commn* 44:153-67.

International Whaling Commission. 1994b. Report of the Scientific Committee, Annex M. Report of the Working Group on MSY rates. *Rep. int. Whal. Commn* 44:181-9.

International Whaling Commission. 1995. Report of the Scientific Committee, Annex F. Report of the sub-committee on aboriginal subsistence whaling. *Rep. int. Whal. Commn* 45:142-64.

Suydam, R.S., Angliss, R.P., George, J.C., Braund, S.R. and DeMaster, D.P. 1995a. Revised data on the subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaska eskimos, 1973-1993. *Rep. int. Whal. Commn* 45:335-8.

Suydam, R., George, J.C., Nader, P.B. and Albert, T.F. 1995b. Subsistence harvest of bowhead whales (*Balaenoptera mysticetus*) by Alaska eskimos, 1994. Paper SC/47/AS12 presented to the IWC Scientific Committee, May 1995 (unpublished). 6pp.

Suydam, R., George, J.C., O'hara, T.M. and Albert, T.F. 1997. Efficiency of the subsistence harvest of bowhead whales by Alaskan Eskimos 1973 to 1996, with observations on the 1995 and 1996 subsistence harvests. Paper SC/49/AS21 presented to the IWC Scientific Committee, September 1997 (unpublished). 14pp.

Whitcher, B.J., Zeh, J.E., Rugh, D.J., Koski, W.R. and Miller, G.W. 1996. Estimation of adult bowhead whale survival rates. Paper SC/48/AS12 presented to the IWC Scientific Committee, June 1996 (unpublished). 22pp.

Zeh, J.E., Clark, C.W., George, J.C., Withrow, D., Carroll, G.M. and Koski, W.R. 1993. Current population size and dynamics. pp. 409-89. *In:* J.J. Burns, J.J. Montague and C.J. Cowles (eds.) *The Bowhead Whale*. Allen Press, Lawrence, Kansas. Special Publication No. 2 of the Society for Marine Mammalogy. 787pp.

Appendix 4

RESULTS FOR TWO SELECTED ASSESSMENTS OF THE BERING-CHUKCHI-BEAUFORT SEAS STOCK OF BOWHEAD WHALES

André E. Punt

Tables 1 and 2 present post-model-pre-data and posterior distributions for 15 management-related quantities for two assumptions about w (the age at which mortality is assumed to be infinite) and S_{max} (the maximum survival rate for adults). These two sets of assumptions are: (a) $w = 100$, $S_{max} = 1$ and (b) $w = \infty$, $S_{max} = 0.995$. Two sets of posterior distributions are shown for each assumption about w and S_{max}. The first '(1+ abundance data)' assumes that the N_4/P_4 and BEB estimates are absolute indices of 1+ abundance whereas the other '(0+ abundance data)' assumes that these estimates are absolute indices of 0+ abundance (i.e. calves are assumed to be counted during the surveys at Point Barrow).

The data included in the likelihood function are the percentages of calves and mature animals from 1985–92 and the abundance indices. The contribution of the abundance indices follows equation (3) of SC/50/AS1, except that:

(a) the BEB estimates for 1993 are assumed to be independent of the other estimates and normally rather than log-normally distributed, and

(b) the N_4/P_4 estimates for 1978–1988 are multiplied by 8,200/7,778 to account for the difference between the N_4/P_4 and BEB likelihoods for 1993. This is equivalent to the limit of equation (7) of SC/50/AS1 as $\sigma_b \rightarrow 0$

The 15 management-related quantities in Tables 1 and 2 are:

- K_{1+} - the pre-exploitation size of the 1+ component of the population.
- RY (1998) - the replacement yield for 1998.
- Q_0 (1998) - the value of the quantity Q_0 (see Wade and Givens (1997) for details) for 1998.
- P^{1+}_{1998}/K_{1+} - the ratio (expressed as percentage) of the size of the 1+ component of the population at the start of 1998 to K_{1+}.
- P^{f}_{1998}/K^{f} - the ratio (expressed as percentage) of the size of the mature female component of the population at the start of 1998 to the corresponding pre-exploitation size.
- $P^{1+}_{1998}/MSYL_{1+}$ - the ratio (expressed as percentage) of the size of the 1+ component of the population at the start of 1998 to *MSYL*.

$MSYR_{1+}$ - *MSYR* for uniform selectivity harvesting of the 1+ component of the population, expressed as percentage.
Slope - the annual rate of increase of the 1+ population from 1978 to 1993, expressed as a percentage.
S_{juv} - the survival rate for juveniles.
S_{adult} - the survival rate for adults.
a_m - the age-at-maturity.
f_{max} - the maximum fecundity rate.
P_{1993} - the size of the 1+ component of the population at the start of 1993.
$MSYL/K_{1+}$ - the *MSYL* of the population (in terms of the 1+ component).
λ_{max} - the maximum rate of increase (at low population size).

A posterior for the current (1998) calving interval was estimated as part of these analyses. The results indicate a posterior median of 4.2–4.3 with a posterior 90% interval of roughly [3–7].

REFERENCE

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: 871-74.

Table 1

Estimates of eight management-related quantities for the Bering-Chukchi-Beaufort Seas stock of bowhead whales based on the 'backwards' approach. The point estimates given are posterior medians, followed by posterior means in round parentheses. Posterior 90% probability intervals are given in square parentheses. Results are shown in this Table for the case w=100, S_{max}=1. In addition to those for the post-model-pre-data distribution, results are shown for analyses that assume that the N_4/P_4 and BEB estimates are absolute indices of 1+ and 0+ abundance.

	Estimation procedure					
Quantity	Post-model-pre-data		Posterior (1+ abundance data)		Posterior (0+ abundance data)	
K_{1+}	14,834 (14,750)	[11,065.8, 18,422.7]	12,872 (13,098)	[10,687.0, 17,056.8]	12,845 (13,123)	[10,788.6, 17,125.2]
RY (1998)	160 (164)	[95.4, 263.8]	208 (203)	[123.4, 275.9]	210 (204)	[117.1, 282.4]
Q_0 (1998)	154 (162)	[92.1, 273.7]	205 (203)	[119.5, 290.4]	204 (200)	[113.6, 286.9]
P^{1+}_{1998} / K_{1+}	56.5 (58.2)	[38.1, 89.1]	68.0 (68.0)	[48.2, 91.0]	64.5 (64.5)	[45.5, 87.7]
P^{f}_{1998} / K^{f}	39.9 (40.7)	[27.7, 60.0]	43.5 (44.0)	[35.7, 56.1]	40.8 (41.3)	[33.7, 53.4]
P^{1+}_{1998} /MSYL$_{1+}$	84.9 (85.5)	[55.1, 124.3]	96.4 (96.0)	[70.4, 122.6]	92.1 (91.5)	[66.0, 119.4]
MSYR$_{1+}$	1.78 (1.96)	[1.07, 3.75]	2.49 (2.53)	[1.35, 4.06]	2.51 (2.51)	[1.31, 4.02]
Slope	1.68 (1.84)	[0.92, 3.67]	2.43 (2.45)	[1.23, 3.91]	2.47 (2.47)	[1.20, 3.92]
$MSYL/K_{1+}$	0.70 (0.68)	[0.53, 0.80]	0.71 (0.71)	[0.60, 0.80]	0.71 (0.71)	[0.60, 0.80]
S_{juv}	0.904 (0.883)	[0.703, 0.984]	0.928 (0.918)	[0.817, 0.987]	0.929 (0.918)	[0.811, 0.988]
S_{adult}	0.988 (0.987)	[0.971, 0.999]	0.990 (0.989)	[0.974, 1.000]	0.990 (0.989)	[0.974, 0.999]
A_m	20 (20)	[16.0, 26.0]	20 (20)	[16.0, 26.0]	20 (20)	[16.0, 25.0]
f_{max}	0.32 (0.32)	[0.26, 0.40]	0.31 (0.31)	[0.26, 0.39]	0.31 (0.31)	[0.26, 0.39]
λ_{max}	4.24 (4.43)	[2.91, 6.93]	5.02 (5.08)	[3.42, 7.32]	5.05 (5.09)	[3.40, 7.33]
P_{1993}	7,812 (7,812)	[5,657.9, 10,328.7]	7,957 (7,948)	[7,175.1, 8,829.8]	7,500 (7,527)	[6,806.8, 8,405.9]

(Table 2 on following page)

Table 2

Estimates of eight management-related quantities for the Bering-Chukchi-Beaufort Seas stock of bowhead whales based on the 'backwards' approach. The point estimates given are posterior medians, followed by posterior means in round parentheses. Posterior 90% probability intervals are given in square parentheses. Results are shown in this Table for the case $w=\infty$, $S_{max}=0.995$. In addition to those for the post-model-pre-data distribution, results are shown for analyses that assume that the N_4/P_4 and BEB estimates are absolute indices of 1+ and 0+ abundance.

	Estimation procedure					
Quantity	'Backwards' reference analysis		Preferred - y_1=1848		Preferred - y_1=1950	
K_{1+}	14,337 (14,249)	[10,740.5, 17,709.1]	12,410 (12,657)	[10,225.3, 16,660.6]	12,307 (12,626)	[10,329.3, 16,680.8]
RY (1998)	144 (150)	[91.8, 240.5]	186 (184)	[117.6, 248.0]	191 (187)	[112.6, 258.5]
Q_0 (1998)	144 (151)	[89.7, 255.0]	190 (189)	[114.9, 270.0]	190 (188)	[109.7, 263.3]
P^{1+}_{1998}/K_{1+}	58.0 (59.7)	[39.3, 91.0]	69.7 (69.4)	[49.2, 91.5]	66.3 (66.1)	[46.5, 88.6]
P^{f}_{1998}/K^{f}	38.3 (39.3)	[26.9, 58.6]	41.2 (41.7)	[34.0, 53.4]	38.4 (39.1)	[31.9, 50.8]
$P^{1+}_{1998}/\mathrm{MSYL}_{1+}$	87.7 (88.5)	[57.0, 126.3]	98.7 (97.9)	[71.9, 123.3]	94.2 (93.6)	[67.6, 121.7]
MSYR_{1+}	1.73 (1.89)	[1.06, 3.63]	2.40 (2.44)	[1.31, 3.97]	2.43 (2.44)	[1.29, 3.91]
Slope	1.53 (1.69)	[0.88, 3.37]	2.26 (2.28)	[1.18, 3.67]	2.34 (2.32)	[1.15, 3.73]
MSYL/K_{1+}	0.69 (0.68)	[0.53, 0.79]	0.72 (0.71)	[0.60, 0.80]	0.71 (0.71)	[0.59, 0.79]
S_{juv}	0.905 (0.883)	[0.707, 0.981]	0.929 (0.918)	[0.813, 0.983]	0.927 (0.917)	[0.816, 0.983]
S_{adult}	0.986 (0.984)	[0.970, 0.995]	0.986 (0.985)	[0.972, 0.995]	0.987 (0.986)	[0.973, 0.995]
A_m	20 (20)	[16.0, 26.0]	20 (20)	[16.0, 25.0]	20 (20)	[16.0, 25.0]
f_{max}	0.32 (0.32)	[0.26, 0.39]	0.31 (0.32)	[0.26, 0.39]	0.31 (0.31)	[0.26, 0.39]
λ_{max}	4.12 (4.26)	[2.74, 6.55]	4.82 (4.87)	[3.33, 7.01]	4.86 (4.89)	[3.26, 7.07]
P_{1993}	7,823 (7,818)	[5,664.1, 10,442.9]	7,926 (7,909)	[7,159.9, 8,741.6]	7,455 (7,481)	[6,764.5, 8,360.3]

Annex H
Report of the Standing Working Group on Environmental Concerns

Members: Reilly (Convenor), Addison, Berggren, Best, Borchers, Born, Carlson, Childerhouse, Clark, Clarke, DeMaster, Donahue, Donovan, Ensor, Fabbri, Findlay, Finley, Friday, Fujise, Givens, Goto, Hakamada, Hammond, Hatanaka, Hofmann, Kato, Kawachi, Kasuya, Kim, Kock, Komatsu, Lawrence, Lens, Moronuki, Nakamura, Nishiwaki, Notarbartolo di Sciara, O'Hara, Øien, Palka, Pastene, Pérez-Cortés, Perrin, Pinedo, Polacheck, Reijnders, Robineau, Rogan, Rojas Bracho, Senn, Shimadzu, Simmonds, Smith, Stachowitsch, Swartz, Thiele, Tomita, Van Waerebeek, Von Bismarck, Wade, Walløe, Walters, Witting, Yamamura, Zhu.

1. CONVENOR'S OPENING REMARKS

Reilly welcomed the participants.

2. ELECTION OF THE CHAIR, APPOINTMENT OF RAPPORTEURS

The group elected Reilly as its Chairman. Donahue acted as rapporteur.

3. REVIEW OF DOCUMENTS AVAILABLE

Documents of relevance to the Standing Working Group (SWG) included SC/50/E1-9, SC/50/SM2 and SM11, SC/50/O7, O11 and O32, SC/50/CAWS18, SC/50/AS15, O'Hara *et al.* (1998), Kemper and Gibbs (1998), Simmonds (1997) and Hofmann (1998).

4. ADOPTION OF AGENDA

The Agenda was adopted as given in Appendix 1.

5. POLLUTANT AND CONTAMINATION ISSUES

5.1 Review of progress on research initiative

Last year the Commission adopted a Resolution endorsing the recommendation of its Scientific Committee to (a) initiate a research programme to establish pollutant cause-effect relationships in cetaceans (Aguilar *et al.*, 1997); and (b) to hold and fund a Planning Workshop as the first phase in implementing the proposal. The Committee established a Steering Group (Aguilar, Bjorge, Donovan and Reijnders [Convenor]) to organise the Planning Workshop. The Workshop, which will last 3-4 days, will be held in November 1998 in Barcelona, Spain. The Steering Group has identified, and will soon contact, persons representing institutions or organisations that might be interested in the analyses and/or sample collection and funding. In addition, advisory experts on specific subjects, e.g. toxico-pathology will be invited. The Steering Group expects approximately 30 participants. The agenda for the Workshop will include:

(1) objectives of the programme;
(2) identification of variables to be measured with respect to pollutants, indicators, biological variables and pathology;
(3) analytical techniques to be used with respect to pollutants, indicators, biological variables and pathology;
(4) sampling (by species, area and variable to be measured),
  (a) sample size and composition (age, sex),
  (b) collection method,
  (c) short-term storage,
  (d) long-term storage and shipment;
(5) designation of responsible laboratories with respect to,
  (a) sample collection,
  (b) analyses;
(6) organisation and coordination,
  (a) coordinator and Steering Group,
  (b) timetable,
  (c) budget and funding,
  (d) report and publications;
(7) report of the Planning Workshop.

It was stressed that in the original proposal the programme was intended to address specifically the main recommendation of the IWC Pollution Workshop held in Bergen. Further, researchers should be encouraged to address the other recommendations of that Workshop and consider other species and sources of samples. The group noted that the priorities of the IWC Research Programme were not meant to imply that other approaches were untenable, including the opportunistic collection of data from stranded animals, although data from such sources were likely to be subject to the concerns identified at the last meeting of the SWG (IWC, 1998).

In this context, it was noted that the Parties to ASCOBANS at their Meeting in Bonn, December 1997, expressed strong support for the aforementioned IWC Research Programme and they recommended that the Parties seek ways to facilitate the execution of that Programme.

The SWG was informed that sufficient funds were available for the Planning Workshop, at which further discussions regarding the financing of the entire research project would take place. It was re-iterated that sufficient

funding for the overall Programme had not yet been secured and sources of potential funding were encouraged to consider supporting the project.

The duration of the Research Programme is expected to be at least four years. The products of the Programme are expected to include an integrated report of all the Programme's components, a set of guidelines to assist others who wish to pursue similar research projects and a summary of the entire Programme in terms of the identified parameters

5.2 Other topics

The SWG reviewed three documents related to pollutants and chemical contamination. O'Hara presented a summary of SC/50/E5, an analysis of contaminant levels in bowhead whale tissues. Resulting mean levels of metals in bowhead liver and kidney samples were considered low or normal for most mysticete species. Unlike levels detected in some odontocetes, mercury (Hg) levels in these tissues were low and not a cause for concern. Mean levels of metals in blubber, epidermis, and muscle were considered low or normal for most mysticete species. The mean cesium-137 (Cs-137) levels (Bq/kg w.w.) were considered very low and the increasing rank for tissues is blubber < kidney/liver < skin/muscle. Preliminary data indicated that strontium-90 (Sr-90) and plutonium (Pu-239/240) were mostly below detection levels and thus very low. Polonium-210 (Po-210) was above detection level at approximately 5Bq/kg and considered low. Most (7 of 11) of the organochlorines measured occurred at higher levels in longer (older) males. In females, hexachlorobenzene appeared to decrease with increasing length while levels of other contaminants did not change. Overall, bowhead tissues had relatively low levels of most natural and anthropogenic contaminants of the inorganic, organochlorine and radionuclide classes when compared to other marine mammal species. From a subsistence perspective, kidney samples represented a significant source of cadmium (Cd) which requires further investigation. Levels for other elements presented no cause for concern regarding subsistence.

In discussion, the dependency of SC/50/E5 on extrapolation using information from non-cetacean species to identify the potential effects on cetaceans was noted. Using information from non-cetacean species for assessing these potential effects is not ideal; however, the paucity of cetacean-derived data leaves researchers with few alternatives. The use of in vitro assays using mysticete cell cultures to assess cellular responses to metals is being pursued. The use of proper toxico-pathology was also emphasised. The use of bone to study accumulating radionuclides was suggested. Bone-accumulating radionuclides like Sr-90 were measured in soft tissues, but bone was not collected because the study's priority was to address human exposure. It was noted that the lack of information on bioavailability (absorption) in humans critically hampers a proper risk assessment for consumers of marine mammal tissues. It was also noted that an assessment of the potential effects on humans is subject to critical threshold levels, which have been changing over time with the identification of more sensitive indicators ('biomarkers') and critical life stages (such as exposure in utero and via lactation).

Simmonds summarised SC/50/E6, an opportunistic study of organochlorine and mercury concentrations in tissues from a sample of cetaceans from the northeast Atlantic. The data again confirm that levels in small cetaceans in this region are high and suggest that the eastern Irish Sea is a 'hot spot' of contamination. Data were presented for blubber, liver and kidney from most animals sampled. Organochlorine concentrations generally correlated closely with lipid content in all tissues sampled. However, there were notable exceptions where high levels were recorded in the kidney of one animal and the liver of another. Simmonds noted that this phenomenon might be expected in cetaceans and related to blubber lipid mobilisation or the failure of elimination systems. Discussion of the significance of blubber lipid mobilisation (and consequently lipophillic contamination) followed, in which the usual pattern of age-related accumulation was noted. Hammond noted that female bottlenose dolphins in the Moray Firth in Scotland were more heavily afflicted by skin lesions than males. One hypothesis was that this related to regular lipid mobilisation in mature females.

SC/50/SM11, a report on the progress of toxicological and pathological investigations of harbour porpoises from the North and Baltic Seas and from waters around Greenland, was summarised briefly. Contents and patterns of chlorinated contaminants in harbour porpoise blubber samples indicated significant variation between the three areas, suggesting that contaminant levels examined could be indicative of separate populations.

In addition to these three documents, the SWG reviewed briefly and endorsed the protocol for skin/blubber biopsy collection for the study of chemical pollutants presented in Appendix 2.

6. CLIMATE CHANGE AND HABITAT

6.1 Review of progress on SOWER 2000 planning

6.1.1 Report of e-mail group

Reilly reported that the SO-GLOBEC small-scale process study originally planned for 1999/2000 has been delayed until 2000/2001 because of ship scheduling conflicts. Consequently, SO-GLOBEC's small-scale process study will not occur concurrently with CCAMLR's large-area synoptic survey to estimate total krill biomass. Re-iterating the unique opportunity that the research activities planned by SO-GLOBEC and CCAMLR present for the IWC to conduct research on the distribution of whales in relation to their environment and prey, the SWG discussed alternatives regarding IWC participation in these CCAMLR and SO-GLOBEC research activities. The SWG agreed to proceed with the existing proposal to work with CCAMLR in 2000 by having IWC observers conduct whale sightings during CCAMLR's synoptic krill survey in Area 48. After discussing the implications of the one year delay in the SO-GLOBEC small-scale process studies, the SWG re-confirmed its decision to work with SO-GLOBEC despite the delay. Thus, the SWG re-iterated its support for the collaborative research activities with SO-GLOBEC and CCAMLR, which were originally proposed at last years meeting and were subsequently endorsed by the Commission.

6.1.2 CCAMLR

Kock summarised SC/50/O11, which re-iterated that research activities planned by CCAMLR present a unique research opportunity for the IWC to conduct research on whale distribution in relation to prey distribution and the environment over a range of spatial and temporal scales. Several areas of mutual interest between the Scientific Committees of CCAMLR (SC-CCAMLR) and the IWC were identified:

(1) coordination of CCAMLR and IWC research activities;
(2) analysis of historical and recent datasets;
(3) CCAMLR surveys as platforms of opportunity for whale sightings;
(4) considerations for re-establishing minke whales as a monitoring species in the CCAMLR Ecosystem Program (CEMP);
(5) annual exchange of information.

To better achieve collaboration between CCAMLR and the IWC, the formation of a liaison group between the Scientific Committees of the IWC and CCAMLR was suggested. The SWG noted that the establishment of such a group was also endorsed by the Commission and recommended that this endorsement be forwarded to the 1998 meeting of the WG-EMM and SC-CCAMLR for final consideration. The SWG was informed that the first planning workshop for the CCAMLR Area 48 study would be held in June 1998 in La Jolla, California with a second workshop to follow the WG-EMM meeting in India. Committee participation was encouraged and Reilly confirmed that he would be attending the planning workshop in La Jolla. The SWG agreed that it would be especially beneficial to collaborate in the area of methodology development because of the similarities in krill and whale survey methodologies.

The CCAMLR planning workshop in La Jolla will focus on a retrospective analysis of existing physical and biological data for Area 48. The workshop convenor asked if the IWC could provide the following information for the area of interest: (1) an inventory of the relevant IWC data, (2) summaries of those data (graphic and tabular presentations), and (3) the actual datasets. Allison notified the SWG that there were two kinds of relevant data, namely the IWC catch data, which were available without restrictions and have already been transferred to CCAMLR, and other data for which restrictions need to be worked out before being released. Shimadzu informed the SWG that Japanese catch records would be made available to CCAMLR. Biological data, except age and reproductive status, for these catch records would also be made available. He indicated that the scouting boat data would also be accessible to CCAMLR. Reilly suggested that a small working group be established within the SWG to identify other sources of data that may be relevant for that area and to prepare a paper with these data for presentation at upcoming CCAMLR meetings.

A Working Group consisting of Allison, Borchers, Findlay, Hammond, Kato, Kock, Reilly, Slooten and Thiele was established to facilitate collaboration between the IWC and CCAMLR. Furthermore, the SWG suggested that the following persons from countries participating in the CCAMLR Area 48 krill survey communicate with their national CCAMLR representatives regarding these collaborative efforts: Hammond (United Kingdom), Kato (Japan), Reilly (United States), Thiele (Australia) and Findlay (South Africa). Russia was identified as a potential participant in the Area 48 study for which contact persons could be appointed at a later date.

6.1.3 SO-GLOBEC

A report of the SO-GLOBEC Planning Group (Hofmann, 1998) was presented, which outlined SO-GLOBEC's updated implementation plan for its 2000/2001 small-scale process studies. One outcome of this planning meeting was a narrowing of the project's focus in terms of target species and location, although an ecosystem approach of studying habitat, predators, prey, and competitors was still intended. The modifications to the existing SO-GLOBEC science and implementation plan included the following:

(1) selection of Antarctic krill (*Euphausia superba*) as the primary target species, including a focus on habitat, prey, predators, and competitors of this species;
(2) temporal expansion of the programme to a year-round study, with an emphasis on austral winter processes.

Two primary field sites were identified for the study: the Antarctic Peninsula region, and 70°E and the surrounding area. The Antarctic Peninsula area would be studied year-round through a multi-nation, multi-ship effort in order to obtain the recommended seasonal coverage, especially in the austral winter. Studies in the 70°E region would be primarily seasonal. Use of additional research sites, such as those occupied by national programmes, was encouraged providing studies there related to SO-GLOBEC research questions. Activities at these sites would be more seasonally limited, mostly to the austral summer, but would provide a slightly different focus for each area despite some overlap in activities. In addition to the SO-GLOBEC Programme, associated programmes were identified that support SO-GLOBEC-related research. For example, the Australian Southern Pelagic Monitoring Cetacean Program includes collection of cetacean sightings throughout the Antarctic 'season' on all voyages, a multidisciplinary winter polynya voyage (July-September 1998), and a fine-scale krill survey (1999/2000). It was suggested that the IWC could use the data from the 1999/2000 fine-scale survey as a pilot study to test data collection methodologies in preparation for its participation in the CCAMLR 2000 and SO-GLOBEC 2000/2001 projects. Given this suggestion, the importance of discussing optimal research methodologies at the upcoming Sightings Workshop in St Andrews was stressed. The SWG was informed that SO-GLOBEC also considers the 1998 polynya study as a good opportunity for methodology testing and expects the information from the project to be incorporated into its regional planning workshops. The first regional planning meetings for the SO-GLOBEC programme will occur in the next six months and the IWC was encouraged to participate, especially regarding input on the types of data that would be most suitable to collect in order to study linkages between baleen whales and their habitat and prey. The SWG agreed that it was important for the IWC to get involved early on with the planning of both the SO-GLOBEC and CCAMLR programmes.

Hammond presented an observer's report of the SO-GLOBEC Planning Group meeting in March 1998 (Appendix 3). Three items recommending IWC action were identified at the meeting:

(1) participation in SO-GLOBEC regional planning meetings;
(2) provide input on preferred measurements for small-scale process studies in order to increase overall the comparability of data by defining standard core measurements and methods;
(3) nominations of IWC participants for SO-GLOBEC working groups on data management and modeling.

A Working Group under the SWG, consisting of Fukuchi, Hammond, Hofmann, Palka, Reilly and Rogan, was established to facilitate collaboration between the IWC and SO-GLOBEC. Appendix 4 lists five SO-GLOBEC planning activities that will require IWC input in preparation for the 2001 field programme. Individuals to represent the Scientific Committee in these activities will be identified in consultation with the Chairman of the Committee.

6.1.4 Sightings Workshop

6.1.4.1 REPORT OF E-MAIL GROUP

As agreed at the last Scientific Committee meeting, an intersessional workshop is being planned to develop sightings and analysis methods for cetacean components of multidisciplinary research programmes. This Sightings Workshop is tentatively scheduled for late March 1999 and will be held in St Andrews, Scotland. Borchers presented a draft agenda and reported that potential participants and the workshop budget had been left for consideration by the full SWG at this meeting. The SWG found the agenda to be well organised and comprehensive but was concerned that the entire agenda could not be accomplished. After modifying the agenda to exclude trend estimation methods, the SWG agreed to the draft agenda. The group also noted the importance of having GLOBEC and CCAMLR participants at the workshop, especially in light of the sampling and analytical methodologies that may be common to all three groups.

A Steering Group, consisting of Borchers, Donovan, Hammond, Hoffman, Kato, Kock, Palka, Reilly and Thiele, was established to complete planning for the Sightings Workshop. The group was asked specifically to prepare a draft budget for the Commission, name invited participants and identify potential participants to present the review materials identified in the Workshop's draft agenda, item 2. The proposal, draft budget and planning schedule for the Sightings Workshop can be found in Appendix 5. Details regarding invited participants and sources of review papers will be determined through intersessional correspondence.

6.2 Habitat

The SWG reviewed several documents related to habitat. SC/50/E1 investigated minke whale sightings in relation to sea surface temperature in Area II (Weddell Sea) of the Antarctic using data from IWC/IDCR cruises from 1981/82 and 1986/87. Substantial differences in minke whale distribution were found between 1981/82 and 1986/87 and were attributed to yearly variation in oceanographic features of the Weddell Gyre. In 1986/87 the cold-water intrusion with sea ice in mid-January extended from the Antarctic Peninsula to 20°W, whereas in 1981/82 the feature only extended to 40°W. High densities of minke whales were observed in areas corresponding to the margin of the cold-water intrusion and in the region of offshore fronts between the cold-water and warm-water intrusions in 1986/87. In 1981/82, the cold-water intrusion was observed farther westward and the warm-water intrusion, although present, was weaker than in 1986/87. No clear offshore fronts were apparent between the cold- and warm-water intrusions in 1981/82 when higher concentrations of minke whales were observed in coastal areas and near sea ice edges.

Reilly thanked the authors for presenting SC/50/E1, which he cited as one type of study pertinent to the SWG's interest. He was encouraged that the large IWC/IDCR databases were being examined in relation to environmental variables and looked forward to similar investigations in the future. The discussion that followed noted it would be interesting to extend this type of study geographically and temporally. While noting the advantageous combination of environmental and top predator sightings data, the SWG noted that other accessible datasets containing more comprehensive oceanographic data exist and could further elucidate this relationship. The European Center for Medium Range Weather Forecasting (ECMWF) was identified as one source of such data. Some concern was expressed that sea surface temperature was not sufficiently indicative of the general oceanography and circulation of this environment in this part of the Southern Ocean. Thus, the potential benefit of using additional datasets that could provide more extensive measurements of the water column was re-iterated.

In SC/50/E2, interspecific relationships in density among whales on Antarctic feeding grounds were examined using sightings data from the Japanese Antarctic Research Program (JARPA) from 1989/90 to 1995/96 and the IWC/IDCR from 1978/79 to 1987/88. Environmental gradient effects were examined to determine their influence on potential interspecific relationships in cetacean densities. Differences in densities relative to environmental gradients between mysticetes and odontocetes were identified. Sperm whales and ziphiid densities were low in the continental shelf waters where minke whale densities were highest. No density associations between minke and humpback whales were found in any area. Density distributions of killer and minke whales were positively correlated. Between sperm whales and ziphiids no specific relationship in density was found. Environmental gradients were identified as the major factors covarying with the distributions and densities of whales in the area. However, after excluding these environmental gradient effects, a significant positive correlation in densities of minke and blue whales was observed except in the highest density areas of minke whales and of blue whales.

Reilly expressed his appreciation to the authors for submitting SC/50/E2, which incorporates environmental variables into an analysis of whale distributions and densities. The group recommended being cautious when drawing conclusions about interspecific interactions based on an empirical study such as this one. Although the group thought it inappropriate to draw conclusions regarding interspecific competition from such a study, it was encouraged by the environmental and multi-species aspects of the research.

Kato summarised SC/50/E3 on the oceanographic sampling during the IWC/SOWER/Blue whale cruises in 1995/96 and 1996/97. CTD and XBT profiles were collected in the middle latitudinal areas of the Southern Hemisphere. Although the primary purpose of the cruises was to establish criteria for distinguishing between true and pygmy blue whales, it was acknowledged that collecting oceanographic data concurrently with sightings data was important to studying whales' distributions. Kato informed the SWG that these data will be submitted to the IWC Secretariat and will be made available to the public with some restrictions. He also indicated that a continuation of this type of oceanographic sampling on subsequent cruises was intended.

DeMaster presented SC/50/CAWS18 which addressed critical habitat and abundance of right whales in the southeast Bering Sea. Based on data collected during a survey in the summer of 1997, density and abundance estimates for right whales for the middle and outer shelf domains of the southeast Bering Sea were made. In addition, the oceanographic conditions and features supporting the right whale population in this area were studied. In conjunction with retrospective analyses of sighting data since 1985, the results of this survey suggest that right whales predictably occupy the middle shelf and near-Inner Front regions of the Bering Sea shelf during the summer. These results are not consistent with historical distributions based on whaling records, although survey coverage of the areas of highest historical distribution was not possible during the summer 1997 cruise. The paper noted three

anomalous oceanographic conditions occurring in the Bering Sea during the summer of 1997. An extensive coccolithophore bloom was coincident with warmer than average sea surface temperatures and low macronutrient concentrations.

The density and abundance estimates were derived from the two sightings of right whales made during the survey. Since so few right whales were sighted, the probability of detection was based on sightings data for humpback whales. The SWG noted the difficulty of trying to produce reliable abundance estimates for rare animals with limited sightings data. However, it was encouraged that the researchers concentrated their survey efforts in an area where they predicted finding right whales based on previous sightings data and oceanographic characteristics. DeMaster noted that the marine mammal component of the cruise, which had a primarily oceanographic focus, was a 'piggyback' project and consisted of a small fraction of the entire scientific personnel. He cited this project as a good example of cooperation between biological and oceanographic researchers. The senior author of the paper (Tynan) intends to collect additional sightings data aboard a similar cruise in 1999, pending further funding.

DeMaster brought to the attention of the SWG to a recently published paper regarding the ecological importance of the Southern Boundary of the Antarctic Circumpolar Current (Tynan, 1998). Historical data on cetacean distribution and krill catches were used to show the importance of the Southern Boundary of the Antarctic Circumpolar Current to the complex and predictable food web of the Southern Ocean. It was noted that some of the cetacean distribution data used may be compromised because of unreported catches of whales by Soviet pelagic whaling operations. The author does not expect any changes in the original data source to significantly affect the reported results. The SWG noted that this study was the result of another successful piggyback operation. Reilly commented on the interest and importance of this paper for the SWG's long-term work on the ecology of whales in the Southern Ocean.

7. OTHER CONCERNS

7.1 Noise

Simmonds presented summaries of SC/50/E8 and E9. These papers provided overviews of the complex topic of noise in the oceans and its potential significance for marine mammals. It was noted that this topic is often difficult to address because of its highly technical and specialist nature, and a lack of published material coupled with a preponderance of grey literature. Both papers reviewed a number of topics including marine mammal audition, sensitivities to sound and the established sources of noise in the marine environment. It was suggested that observations indicating that an animal seemingly tolerates, and does not obviously respond to, a noise does not necessarily mean it was unaffected. However, behavioural responses typically were used to try to evaluate such impacts and Richardson *et al.* (1995) proposed a useful conceptual framework within which this might be considered (i.e. zones of audibility, responsiveness, masking, and possibly a zone of discomfort and injury). Various indicators of each type of response (such as the displacement of individuals or populations) can be sought. Overshadowing such impacts are considerations that relate to habituation and sensitisation. With respect to physical hearing damage (such as that concerning permanent threshold shift), the levels of energy required are presently unknown, although there was some evidence that vessel traffic may have caused this in one area (Andre *et al.*, 1997). SC/50/E8 and E9 considered established sources of marine noise as well as identifying the following new and potential important sources.

(1) Seismic surveys, which are extending now into deeper waters as technology improves, potentially bring such noise sources into more cetacean habitats. Sperm whales have been found to be displaced to an estimated distance of 60 km when seismic surveys took place in the Gulf of Mexico (Mate *et al.*, 1996). More recently, it has been confirmed that seismic guns also produce a significantly high frequency component in addition to the better-studied low frequency lobe (Goold and Fish, In press). Therefore, they are likely to be perceived by odontocetes as well as mysticetes, and indeed avoidance behaviour has been indicated in common dolphins in the northeast Atlantic Ocean (Goold, 1996).
(2) Sonars have been used in whaling since World War I and have recently provoked new controversy and concern, particularly during three research projects testing the responses of whales to the US Navy's Surveillance Towed Array Sensor System Low Frequency Active (SURTASS-LFA) sonar system.
(3) Other 'new' sources include those relating to the Acoustic Thermometry of Ocean Climate (ATOC) programme and the increasingly widespread use of acoustic anti-predation devices. The latter include 'seal scammers' employed in fish farms to deter predators as well as those attached to nets to reduce or eliminate bycatch. SC/50/E8 provided an example of the levels of noise produced by 'seal scammers' on fish farms in the Shetlands, Scotland. At a distance of 600m, levels were some 60dB above background. Some sources appeared to be pinging continuously. Further investigation of these devices was encouraged.

During its discussion of these papers and additional material presented by Clark (Appendix 6), the SWG noted the difficulty of assessing the potential impact of various sources of anthropogenic noise on marine mammal populations. The issue was raised of noise affecting marine mammals in ways currently undetectable to researchers. A serious handicap is the difficulty of obtaining various measurements that may better reveal an animal's responses to noise (e.g., heart rate). Irrespective of this, it may not always be accurate to assume no impact is occurring even in the absence of a measured response. Overlying these issues is the difficulty in defining the level at which an impact might be biologically significant. Thus, two concerns were identified when assessing studies that attempt to measure the impact of noise on marine mammals: (1) measuring the appropriate variables in a statistically sound way, and; (2) the biological significance of a response. Clark reported that sufficient sample sizes have been obtained in studies under the ATOC Marine Mammal Research Programme to address adequately the issue of statistical power in that study for some behavioural responses. However, in two of the three SURTASS-LFA research projects that have been conducted, Level I behavioural responses were not observed, and small sample sizes will limit the power of statistical analyses.

Previous studies conducted in grey whale breeding lagoons were discussed that compared responses of whales to novel versus more routine sounds. Novel sounds (such as pure tones and certain non-biological sounds) appeared to elicit more overt, obvious responses (such as flight or cessation of vocalisation) than more regularly occurring

sounds (e.g., outboard motors) to which the animals may be more accustomed. In addition, killer whale sounds were found to elicit an obvious flight response. Thus, the context of the sound was identified as an important aspect of the overall issue.

The SWG noted the large scope of assessing the impact of noise (both anthropogenic and non-anthropogenic) on marine mammals, and many important issues were identified here. While recognising that this issue is relevant and important, the SWG agreed that attempting a major initiative on the impact of noise on cetaceans was not within the current purview of the group. Furthermore, it was noted that given the limited amount of reliable data on the issue, it might be premature to conduct such a review. Since many sources of low frequency sound, such as the high levels of shipping noise, are not being monitored currently and information pertaining to similar sources (e.g., military exercises involving low frequency sound in the Mediterranean) is not readily available, the extent of information was thought to be presently insufficient to recommend a major initiative on this subject.

The need for more information on effects of noise also drew attention to a more general question regarding how to measure behavioural responses, a question which also arose in the sub-committee on Whalewatching (Annex J) and is discussed in the Report of the Workshop on the Comprehensive Assessment of Right Whales (SC/50/Rep4). Recognising both the importance of this issue and the gaps in the knowledge necessary to assess related impacts, a more comprehensive evaluation of the relevant sources of noise and their frequency ranges was suggested. Specific ideas included, for example, the more extensive use of pop-up acoustic recorders to better determine existing ambient noise levels in order to improve our characterisation of the underlying noise field. The importance of looking at the response side of the issue was also noted. A furthering of our understanding of the fundamental biological and physiological mechanisms involved, and an identification of methodologies appropriate to measuring the effects of noise on animals were recommended. The interdisciplinary nature of the investigations identified as relevant to addressing the larger issue of noise and marine mammals was emphasised.

7.2 Ozone depletion

DeMaster summarised SC/50/E4 on the mechanisms by which ozone is destroyed, the recent trends in ozone depletion in polar regions, and the sources of ozone and UV/B measurement in the Arctic. Ozone depletion occurs when chlorine activation occurs (during cold winter periods) and sunshine is present. Thus, ozone loss typically occurs in February and March. Factors contributing to the non-homogeneous pattern and interannual variability of ozone depletion were reviewed. The 1997 polar-averaged, column-integrated ozone depletion was approximately 21% and was comparable to the depletions observed during the previous four winters. Sources of ozone measurement in the Arctic include several satellites and ground stations. Geographic coverage by the ground stations is patchy and is thought not to sample the Arctic adequately. The paper lists several ongoing programmes investigating ozone depletion in the Arctic.

The SWG was reminded of the thorough summary of the potential impacts in the Arctic and the Sub-Arctic presented in Hayman and Parr (1997). It had been noted there that potential ecological consequences of ozone depletion include altered trophic interactions, reduced biomass production, changes in species composition and diversity and alterations of biochemical processes.

The SWG noted that while several studies have been undertaken on the relationships between UV and various biological processes, such as photosynthesis in plankton and larval fish development, further research to elucidate the connections between ozone depletion and biological productivity was encouraged.

7.3 Physical and biological habitat degradation

An idea was presented for an intersessional workshop on habitat degradation and its effect on cetacean populations (Appendix 7). After considerable discussion it was agreed that the preferable course might be to combine important aspects of the proposal with one recommendation from the Right Whale Workshop to focus on defining and estimating critical habitat for cetaceans. It was agreed that a proposal combining these two initiatives would be presented to Plenary if one could be developed at this meeting.[1]

As discussed at last year's meeting, the review of information on certain environmentally related activities, such as oil and seismic exploration, would be helpful to focus the Committee's work on these issues in the future. Thiele informed the SWG that she and V. Peddemors were preparing such reviews.

The SWG noted the submission of SC/50/O7, which reported oceanic debris observations from the eastern edge of the Indian Ocean Whale Sanctuary, and thanked the authors for bringing this information to the attention of the Committee.

7.3 Effects of fisheries

Kemper and Gibbs (1998) reported marine mammal entanglements in tuna farms in South Australia. The SWG noted that because plans to build similar fish farms in other countries have been proposed, they are a potential source of marine mammal mortality.

The SWG recognised that SC/50/SM2 included information on bycatch of cetaceans in fisheries, but did not consider at this point that it was its function to compile such information, which was reviewed elsewhere in the Committee (Annex I). The group considered it an appropriate subject for an in-depth review at a later date.

7.4 Disease and mortality events

O'Hara summarised O'Hara *et al.* (1998), which presented results of a viral serologic survey of bowhead whales in Alaska. Although the impact of the viruses identified on bowhead whales could not be determined from this serological study, the level of exposure to the various viruses and the disease distribution were studied. Disease ecology was identified as a potentially informative way to understand better the effect of various environmental alterations such as climate change and habitat degradation on animals. However, it was stressed that more background work on how disease impacts animals, be it through direct mortality or through nutritive or reproductive level effects, needs to be pursued. The SWG agreed that such a scientific basis was required for understanding effects on cetaceans of complex environmental problems and encouraged studies in this direction.

[1] Editors note. After the conclusion of the sub-committee, it was agreed to try to develop a proposal for next year.

Simmonds presented SC/50/E7 which drew the SWG's attention to possible new opportunities for collaboration arising from recent international developments, particularly those relating to the 'Year of the Ocean,' and identified some major perturbations in the marine environment that occurred since the last meeting. These included the pinniped mortalities in Latin America associated with the El Niño phenomenon. The authors suggested that any similar associated losses in cetacean populations would be more difficult to detect. They also noted that this winter a further series of sperm whale multiple live stranding events had occurred in the North Sea (SC/50/ProgRep Germany).

Simmonds also presented Simmonds (1997) which suggested a framework to consider cetacean strandings. The SWG noted that attempts to understand better the meaning of cetacean strandings were important, albeit ambitious. Nevertheless, it was recognised that information gathered from strandings, when viewed from a larger context and considering possible environmental effects, could help build a basis for understanding these events. Von Bismarck informed the group of the ongoing programme 'HEED Global Change' at Harvard University, which organises historic data in one standard format, assesses the integrity and coverage of the data, and provides a method for interpreting marine mammal stranding events in the context of coastal environmental change. The programme proposes a global marine mammal monitoring network and offers its methodology and skills towards such an effort.

8. ARCTIC

SC/50/E4, which is of relevance to this Item, was discussed under Item 7.2.

In SC/50/AS15, large annual variations in the number of bowhead whales at Isabella Bay, Baffin Island were reported, with few whales being observed in El Niño years. The author reported that regional distribution patterns are consistent with historical data and provide a better understanding of the influence of climate and ice on behaviour and distribution. For further discussion of this paper, see Annex G.

The subject of environmental concerns in the Arctic was discussed further under Item 9. The SWG agreed to establish an e-mail group to address this subject, and members interested in participating were instructed to contact DeMaster or O'Hara.

9. LONGER-TERM PRIORITIES AND DIRECTIONS

In further discussion of Arctic environmental issues, it was agreed that a research initiative focussing on Arctic cetaceans would be appropriate at some time in the future. Some members commented that because the Small Cetacean sub-committee was intending to focus on white whales and narwhals at the 1999 Scientific Committee meeting, this will provide an impetus for the SWG to focus on environmental concerns for these species, which had been identified as priority species in both the Pollution and Climate Change Workshops. It was agreed that both this project and the habitat definition/degradation initiative would be of lower priority in the coming year than the two ongoing research initiatives.

SC/50/E7 mentioned some recent marine environmental perturbations with comments on the implications for the IWC. In a vein similar to this paper, some members proposed to form an informal information review group to collect and review intersessional developments in the marine environment likely to impact cetaceans, and to provide the SWG with what might be called an 'Annual State of the Cetacean Environment Report.' The group might collaborate with the Emergency Task Force of the Marine Mammal Action Plan. Slooten, Simmonds and von Bismarck offered to act as focal persons for information collection and report production.

The SWG was informed that ICES has formed a Working Group on Marine Mammal Habitat Issues. It was noted that many of the concerns (pollutants and contaminants, noise, etc.) the group is addressing are shared by the SWG. Donovan and Reijnders will participate and represent the SWG's interests in future meetings of the ICES Working Group.

After considerable discussion, the SWG agreed that its priorities for the near-term and mid-term could be summarised as follows.

(1) The two ongoing research initiatives were identified as having the highest priority:
   (a) significance of pollutants and chemical contaminants on cetaceans;
   (b) baleen whale habitat and prey studies in the Southern Ocean related to climate change (with CCAMLR and SO-GLOBEC).
(2) The following two projects were considered next in priority:
   (a) identifying and evaluating the parameters defining cetacean habitats, and use of those to evaluate the effects of physical and biological habitat degradation on cetaceans;
   (b) investigating effects of environmental change on populations of Arctic cetaceans.
(3) The SWG identified a number of other issues it considered important, but that were not identified as priority items for the upcoming year. They include:
   (a) investigating the impact of environmental factors found in individual cetaceans for consequences on the population level;
   (b) investigating the possible impact of oil pollution on cetacean health.

10. INTERSESSIONAL WORK PLAN

Intersessional activities were planned under the agenda Items given in Table 1 (estimated costs given in brackets).

Table 1

Planned intersessional activities.

Item	Activities
5.	Pollutants and contaminants Prepare and hold the Planning Workshop (Barcelona, November 1998) related to the pollutant and contaminants research initiative (no new funds required)
6.	Climate change and habitat Complete planning and conduct the Sightings Workshop (St Andrews, March 1999) (£25K) Continue planning activities in conjunction with CCAMLR and SO-GLOBEC for the SOWER 2000/2001 programme (£7K)
7.	Other concerns Refine proposal for a workshop on habitat definition/degradation, and, if funding is secured, hold the workshop intersessionally (no estimate available yet)
8.	Arctic Establish an e-mail group to identify potential issues and activities related to assessing environmental effects on Arctic cetaceans (no cost)

11. OTHER BUSINESS

There was no other business discussed.

12. ADOPTION OF REPORT

The report was adopted as amended.

REFERENCES

Aguilar, A., Bjorge, A., Donovan, G. and Reijnders, P. 1997. Proposal to the IWC on furthering the Recommendations of the Pollution Workshop. *Rep. int. Whal. Commn* 48: 425-8.

Andre, M., Kammiga, C. and Ketten, D. 1997. Are low frequency sounds a marine hearing hazard: a case study in the Canary Islands. *Proceedings of the Institute of Acoustics* 19(9): 77-84.

Goold, J.C. 1996. Acoustic assessment of populations of common dolphin (*Delphinus delphis*) in conjunction with seismic surveying. *J. Mar. Biol. Assoc. UK* 76: 811-20.

Goold, J.C. and Fish, P.J. In press. Broadband spectrum of seismic survey air-gun emissions with reference to dolphin auditory thresholds. *J. Acoust. Soc. Am.*

Hayman, G.R.F. and Parr, J.C.W. 1997. Ozone depletion over the Northern Hemisphere: current status and potential impacts on Arctic and Sub-Arctic marine ecosystems. Paper SC/49/O 32 presented to the IWC Scientific Committee, September 1997, (unpublished). 20pp.

Hofmann, E. (ed.) 1998. Report of the meeting of the Southern Ocean Planning Group, San Diego, California, 1-3 August 1997. GLOBEC Report No. 7A. International GLOBEC. 21pp.

International Whaling Commission. 1998. Report of the Scientific Committee. Annex F. Report of the Standing Working Group on Environmental Concerns. *Rep. int. Whal. Commn* 48: 160-9.

Kemper, C. and Gibbs, S. 1998. Dolphin and sea lion entanglements in tuna farms in South Australia, 1994-1996. (Unpublished ms.). 2pp.

Mate, B.R., Stafford, K.M. and Ljungblad, D.K. 1996. Change in sperm whale (*Physeter macrocephalus*) distribution correlated to seismic surveys in the Gulf of Mexico. *J. Acoust. Soc. Am.* 96:3268-9.

O'Hara, T.M., House, C., House, J.A., Suydam, R.S. and George, J.C. 1998. Viral serologic survey of bowhead whales in Alaska. *J. Wildl. Dis.* 34(1):39-46.

Richardson, W.J., Greene, C.R.J., Malme, C.I. and Thomson, D.H. 1995. *Marine Mammals and Noise.* Academic Press Inc., San Diego, CA. 576pp. [Book Review by P.L. Edds-Walton in *Marine Mammal Science*, 14(2):398-400.]

Simmonds, M.P. 1997. The meaning of cetacean strandings. *Bull. Inst. R. Sci. Nat. Belg. Biol.* 67-suppl:29-34.

Tynan, C.T. 1998. Ecological importance of the Southern Boundary of the Antarctic Circumpolar Current. *Nature, Lond.* 392:708-10.

Appendix 1

AGENDA

1. Convenor's welcoming remarks
2. Adoption of Agenda
3. Arrangements for meeting
   - 3.1 Election of Chairman
   - 3.2 Appointment of rapporteur(s)
4. Review of documents
5. Pollutants and contaminants
   - 5.1 Review of progress on research initiative
   - 5.2 Other topics
6. Climate change and habitat
   - 6.1 Review of progress on SOWER 2000 planning
     - 6.1.1 Report of e-mail group
     - 6.1.2 CCAMLR
     - 6.1.3 SO-GLOBEC
     - 6.1.4 Sightings Workshop
       - 6.1.4.1 Report of e-mail group
   - 6.2 Habitat
7. Other concerns
   - 7.1 Noise
   - 7.2 Ozone depletion and UV/B
   - 7.3 Physical and biological habitat degradation
   - 7.4 Effects of fisheries
   - 7.5 Disease and mortality events
8. Arctic
9. Longer-term priorities and directions
10. Intersessional work plan
11. Other business
12. Adoption of report

Appendix 2

SKIN/BLUBBER BIOPSY PROTOCOL

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Skin/blubber biopsy protocol – fixed samples only

Need

Vials of 10% formalin. After biopsy is retrieved, place on ice pack until you can work on the sample. Please try and keep the time delay as short as possible. Less than an hour is OK, more than three hours reduces sample quality.

To divide the samples

(Pursue instrument and biopsy tip clean up as needed by chemistry agenda if there is one). Remove biopsy from dart by pulling out with forceps from the threaded end. Make a pair of cuts through the whole plug, with the plug on the cutting plate, to generate a 2mm or less, central slice. Place the slice in formalin – in the fluid-filled plastic vial. Take the two outer remaining pieces. Cut off skin and place in DMSO. Place blubber in the glass vial for chemistry. Place blubber vial on ice and freeze in regular freezer as soon as possible. Keep formalin slice at room temperature. **Do not freeze.** Label all vials with Date, ID and Lat. Long. The fixed slice need not have the full depth of skin, or blubber. The area of special interest is 2mm above the 4mm below the skin/blubber (black/white) interface, with as much surface area as possible in two dimensions. The slice can be as thin as you can cut it (see Fig. 1).

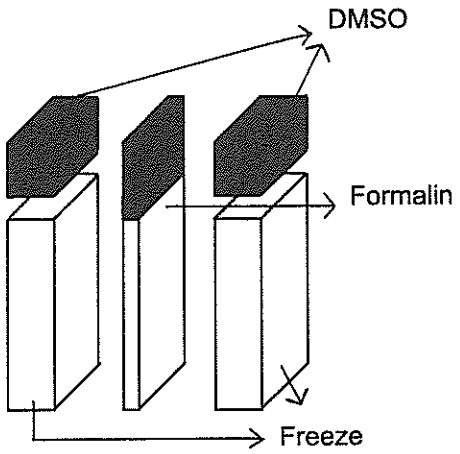


Fig. 1.

The protocol is easy to do in the field and is compatible with genetic and organic chemistry agendas. The volume of hazardous reagent (formalin) is very approximately 3ml per sample.

Skin/blubber biopsy protocol – fixed and frozen

Need

Styrofoam box or cooler for keeping samples cold and shipping frozen samples. Scalpel handle, blades, forceps, cutting plate, methylene chloride, liquid soap, vials of 10% formalin, glass vials for chemistry, marking pens, freezer block, parafilm, dental brushes.

Prior to shooting, clean tip thoroughly with soap and water if possible, using the dental brush to get inside. Dip in methylene chloride using forceps to hold. After biopsy is retrieved, place on ice pack until you can work on the sample. Please try and keep the time delay as short as possible. Less than an hour is OK, more than three hours is pushing it.

To divide the samples

It is possible to do this in a *Zodiac* – a small tray would help – the lid of a cooler will do. Clean cutting plate with soap and water – at least at start of day. Wipe dry and rinse with methylene chloride between samples. Assemble a scalpel blade in its handle, wash with soap and rinse in methylene chloride before use. (None of the clean up protocol needs to be followed if you are not freezing for chemistry analysis – the fixed samples are unaffected by handling as long as they are not frozen or overheated.) If you have to use a lubricant on the dart use KY jelly, not any grease based ointment if you are sampling for chemistry. If dart is flamed, follow this with a methylene chloride rinse.

Remove biopsy from dart by pulling out with forceps from the threaded end. Make a pair of cuts through the whole plug, with the plug on the cutting plate, to generate a 2mm or less, central slice. Place the slice in formalin – in the fluid-filled plastic vial. Take the two outer remaining pieces. Cut off skin and place in DMSO. Place blubber in the glass vial for chemistry. Place blubber vial on ice and freeze in regular freezer as soon as possible. Keep formalin slice at room temperature. **Do not freeze.** Label all vials with Date and ID. The fixed slice need not have the full depth of skin, or blubber. The area of special interest is 2mm above and 4mm below the skin/blubber (black/white) interface, with as much surface area as possible in two dimensions. The slice can be as thin as you can cut it (see Fig. 1).

The protocol is easy to do in the field and is compatible with genetic and organic chemistry agendas. The volumes of hazardous reagents (formalin and methylene chloride) are small.

Appendix 3

OBSERVER'S REPORT OF THE MEETING OF THE SOUTHERN OCEAN GLOBEC PLANNING GROUP, PARIS, FRANCE, 17-20 MARCH 1998

P.S. Hammond

The GLOBEC Southern Ocean Planning Group met for the second time during the GLOBEC Open Science Meeting held at UNESCO Headquarters, Paris, France, 17-20 March 1998. The objectives of the SO-GLOBEC meeting were to assess the current state of planning for Southern Ocean GLOBEC field activities and to set a time line for possible field studies in the Antarctic Peninsula and 70°E regions.

At the first SO-GLOBEC Planning Meeting, held in San Diego, CA, 1-3 August 1997, it was decided that field activities would take place beginning in field season 1999/2000. The field activities were to be concentrated in the Antarctic Peninsula area and the 70°E region, have six months of continuous coverage, and encompass the summer and winter seasons. At the end of the August 1997 meeting there was a possible ship schedule scenario for the Antarctic Peninsula that would provide the coverage needed to address the SO-GLOBEC science objectives. However, since then the objectives of several national Antarctic programmes have changed, requiring changes in ship schedules. As a consequence of these changes, the primary field effort for SO-GLOBEC will now be delayed until 2000/2001. It has been determined that sufficient ship resources will be available within this time frame to provide year-round coverage in the Antarctic Peninisula region and seasonal coverage, especially in the winter, in the 70°E region. The next effort for SO-GLOBEC will consist of focussed regional planning meetings that will design the field study efforts. These meetings will take place within the next six to eight months. Participation by the IWC in these planning efforts is encouraged.

Prior to the 2000/2001 SO-GLOBEC field effort there will be studies in limited regions that will provide information related to SO-GLOBEC science objectives. The particular emphasis of these studies will be on winter processes, especially the overwintering strategies of Antarctic krill (*Euphausia superba*). Potential studies within this time frame comprise a March-May 1999 German cruise and three Australian cruises in 1999 (July-August, September-October, December) that will focus on demographic features of krill populations. The Australian cruises will provide a limited time series of winter to summer changes. The British Antarctic Survey core programme at South Georgia in 1999/2000 is focussed on various aspects of krill biology. The results of these field efforts will be incorporated into planning for the larger field effort.

The SO-GLOBEC Planning Group identified a critical need for standardization of techniques that should occur across regions. In particular, there is a need to standardize winter krill measurements. A set of core measurements for the next two-year period prior to the larger field effort is required. An effort is now underway through SO-GLOBEC to define standard core measurements and methods so that data from different regions and times can be directly compared. Input from the IWC on measurements for the short-term focus studies (1999/2000) is requested.

Given the multinational effort required for a year-round SO-GLOBEC field programme, the need for a central coordination office was identified. At present, discussions are underway with the individuals/nations that have expressed an interest in hosting this office. It is anticipated that the SO-GLOBEC coordination office will be established within the next six to eight months. It will be separate but coordinated with the International GLOBEC Planning Office at the Plymouth Marine Laboratory in England. This will allow coordination with other International GLOBEC and IGBP programmes.

SO-GLOBEC is in the process of setting up working groups on data management and modelling. Nominations for membership in these working groups have been received and additional nominations are being solicited. Nomination of individuals from the IWC community would be welcome.

IWC participation in SO-GLOBEC was welcomed by all members of the Planning Group. It was felt that IWC participation could only benefit the science objectives of SO-GLOBEC. It was also believed that collaboration between SO-GLOBEC and IWC would further the IWC interests in determining potential effects of climate change on cetaceans. The SO-GLOBEC field effort will provide an opportunity to map the distribution and estimate the relative abundance of cetaceans in relation to krill distribution and abundance in the Antarctic Peninsula and 70°E regions. By supplementing existing studies with other vessels it will also allow investigation of changes in baleen whales foraging behaviour in response to changes in krill distribution and abundance.

Collaboration with the IWC provides SO-GLOBEC with an opportunity to obtain information on top predators.

Appendix 4

IWC PARTICIPATION IN SO-GLOBEC

(Exclusive of field activities)

1. Nomination of an individual for SO-GLOBEC Modelling Working Group (D. Palka):

   Provide support for individual to attend working group meetings;
   1 meeting/18 months;
   Potential venue - British Antarctic Survey, Cambridge, England.

2. Nomination of an individual for SO-GLOBEC Data Management Working Group (C. Allison):

   Provide support for individual to attend working group meetings;
   1 meeting/18 months;
   Potential venue - to be determined.

3. Designate individual(s) to attend Antarctic Peninsula field study planning meeting and provide support to attend meeting (Reilly and/or Hammond, depending on venue):

   Meeting to occur in early autumn 1998 (3-4 days);
   Potential venue is US or Germany (AWI).

4. Designate individual(s) to attend 70°E field study planning meeting and provide support to attend meeting (D. Thiele):

   Meeting to occur in early autumn 1998;
   Potential venue is Hobart.

5. Request input from IWC on measurements and methodologies for short term focus studies in 1999-2000 (E. Rogan):

   Done by e-mail, no financial support needed.

Appendix 5

PROPOSED WORKSHOP TO DEVELOP SIGHTING SURVEY METHODS FOR MULTIDISCIPLINARY CRUISES

At its 1996 meeting the IWC Scientific Committee agreed upon several long-term objectives for research that may allow the prediction of the effects of environmental change on cetaceans. These can be combined into an overall objective to

> 'Define how spatial and temporal variability in the physical and biological environment influence cetacean species in order to determine those processes in the marine ecosystem which best predict long-term changes in cetacean distribution, abundance, stock structure, extent and timing of migrations and fitness'.

At its 1997 Annual Meeting, the Committee endorsed the research proposal 'Baleen whale habitat and prey interactions in the Southern Ocean' (referred to here as the SOWER2000 programme) as a means for addressing the above overall objective. The Committee concluded that an intersessional workshop would be an effective means to develop methods for data collection and analysis for whale sighting surveys to be conducted as part of multidisciplinary resource assessment cruises, as proposed in the SOWER2000 research programme.

The proposed surveys differ from the standard IWC sightings surveys in two fundamental ways.

(a) First, the primary goal of collecting sightings data is not to estimate total abundance of whales of a population or stock, but rather to quantify the relationships between whales and their environment and prey. In the context of SOWER2000, this will be done to gain information and test hypotheses on processes linking whales to their environment and prey, to provide insight into likely effects of climate change.

(b) Second, the primary activities of the cruises will be directed at plankton and oceanography in the case of SOWER2000 (but may be other items on other cruises, such as fish or cephalopods). Consequently the amount of time available to close on sightings will be limited, and most effort from vessels sampling plankton and oceanography will have to be in so-called passing mode.

An e-mail group was established to work intersessionally '...towards developing more detailed information including a draft agenda, suggested venue and budget and potential participant list.' Building on the work of that group, the SWG proposes the following.

Objectives

General objective: To develop methods for data collection and analysis for cetacean sightings surveys to be conducted as part of multidisciplinary resource assessment cruises.

Specific objective: To develop methods for use on the SOWER2000 programme.

Steering Committee

Borchers and Hedley (Convenors), Donovan (IWC), Hammond, Hofmann (SO-GLOBEC), Kato, Kock (CCAMLR), Palka, Reilly, Thiele.

Venue: University of St Andrews, Fife, Scotland.
Date: 5 days, 23-27 March 1999 (to be confirmed).

Draft Agenda

In the context of the SOWER2000 programme, and more generally, there are three types of sightings survey which need to be considered by the proposed workshop:

(1) 'piggyback' surveys (on CCAMLR and/or SO-GLOBEC vessels in the SOWER2000 context);
(2) small-scale surveys using IWC vessels(s) in conjunction with SO-GLOBEC (or equivalent) survey vessels, to estimate the small-scale distribution of whales in relation to prey, oceanographic and environmental variables; and
(3) larger-scale surveys using IWC vessels(s) in conjunction with vessels gathering data on the large-scale distribution of prey, oceanographic and environmental variables (CCAMLR vessels in the SOWER2000 context).

In addition, (2) or (3) might be combined with (1). The workshop should consider design and analysis methods for each type, as well as design and analysis for combinations of types. While the workshop will consider methods for multidisciplinary surveys in general, it will prioritise methods and issues relevant to the SOWER2000 programme.

With this in mind, the following agenda is proposed:

1. Overview of the SOWER2000 programme.

2. Reviews
   - 2.1 Design, procedures and operational constraints
     - 2.1.1 Review of similar full or pilot surveys conducted in the past
     - 2.1.2 Review of CCAMLR & SO-GLOBEC survey design and operational constraints
   - 2.2 Analysis methods
     - 2.2.1 Reviews of analysis methods for sightings, environmental and prey data, and associated data requirements
       - 2.2.1.1 Multivariate ordination methods
       - 2.2.1.2 Spatial modelling methods
       - 2.2.1.3 Distance sampling methods
       - 2.2.1.4 Other relevant methods
     - 2.2.2 Review of methods used by CCAMLR and SO-GLOBEC to analyse their data
   - 2.3 Overview of methods of integrating process models and survey data

3. Operational characteristics of the multidisciplinary cruises, and how to best collect sightings data on each type of survey
   - 3.1 Closing *vs* Passing mode
   - 3.2 School size estimation methods
   - 3.3 Responsive animal movement
   - 3.4 Use of complementary survey platforms (e.g. a helicopter operating from a ship; passive acoustics)
   - 3.5 Data gathering aids (computerised data entry, binoculars, angle boards, distance estimation aids)
   - 3.6 Target species considerations
   - 3.7 Other

4. Use of the data for making inferences about things other than relationships between whales, their prey and their environment
   - 4.1 Increasing the precision of abundance estimates
   - 4.2 Estimation of cetacean distributions

5. Recommendations
   - 5.1 Design of cetacean component within multidisciplinary surveys
   - 5.2 Analysis methods for sightings, environmental and prey data
   - 5.3 Recommendations regarding Cruise Planning Meeting for 2000/1 survey in conjunction with SO-GLOBEC in Area I.
   - 5.4 Identification of further work needed

6. Other

Workshop documents

The success of the workshop will depend on the preparation and presentation of papers giving background information and papers dealing with proposed survey and analysis methods. Below is a tentative list of topics to be covered by solicited documents.

The Steering Committee will develop guidelines to be distributed to prospective authors to focus the reviews on issues relevant to the workshop. Unsolicited papers on relevant topics which will help further the aims of the workshop would also of course be most welcome.

1. Logistic constraints for SOWER2000
   - 1.1 Cetacean survey from CCAMLR vessels
   - 1.2 Cetacean survey from SO-GLOBEC vessels
   - 1.3 IWC Survey vessels
2. Review of survey methods
   - 2.1 SO-GLOBEC
   - 2.2 CCAMLR
   - 2.3 Australian fine-scale krill process survey
   - 2.4 Similar multidisciplinary surveys
   - 2.5 Cetacean surveys
   - 2.6 Data gathering aids
     - 2.6.1 Computerised data entry
     - 2.6.2 Acoustics
     - 2.6.3 Other
3. Review of existing and proposed analysis methods
   - 3.1 Distance sampling methods
   - 3.2 Multivariate ordination methods
   - 3.3 Spatial modelling from line transect data
   - 3.4 Small-scale process study analysis
   - 3.5 SO-GLOBEC analysis methods
   - 3.6 CCAMLR analysis methods
4. Integrating process models and survey data
   (Models for investigating the effect of a changing environment on cetaceans must ultimately integrate small and large-scale process models with empirical models featuring spatial, oceanographic and/or environmental covariates so that uncertainty in all components is correctly handled. While the development of integrated models is beyond the scope of this workshop, data collection on the SOWER2000 and similar surveys should be informed to some extent by this ultimate use of the data)
   - 4.1 Overview of integrated analysis methods
   - 4.2 Implications of integrated analysis for data collection methods

Schedule

Some relevant meetings which will involve IWC input in relation to the SOWER2000 Programme:

(a) 26th–28th June 1998: CCAMLR Logistics and Planning meeting for their large-scale synoptic krill survey in 1999/2000.
(b) Early Northern Hemisphere Autumn 1998: SO-GLOBEC Planning meeting.

Workshop schedule:

(1) Immediately after the 1998 IWC meeting: invite participants; send background material (including annotated draft agenda and extracts from IWC reports

and the report of the intersessional planning meeting to discuss research on climate change and cetaceans) to possible participants, CCAMLR and SO-GLOBEC.

(2) As soon after 1998 IWC meeting as possible:
   (a) solicit workshop papers;
   (b) submit documents to SC-CCAMLR chairman and CCAMLR secretariat describing workshop and encouraging participation (Reilly to attend CCAMLR large scale synoptic krill survey logistics and planning meeting).

(3) Before autumn 1998 SO-GLOBEC Planning Meeting: Submit document(s) to SO-GLOBEC meetings describing workshop and encouraging participation. (IWC Scientific Committee member to attend SO-GLOBEC Planning Meeting.)

(4) February 1999: circulate meeting agenda, arrangements and (as far as possible) workshop papers.

(3) March 1999: hold workshop and produce report.

Budget

15 Invited Participants:	£24,500

SO-GLOBEC will fund the attendance of SO-GLOBEC scientist(s) at the workshop.

Funding for CCAMLR scientist(s) to attend the workshop will be sought from CCAMLR.

Equipment & Consumables:	£500
Total:	**£25,000**

Appendix 6

ON THE SUBJECT OF THE POTENTIAL IMPACT OF HUMAN-MADE NOISE ON WHALES

C.W. Clark

Recently there has been a dramatic increase in awareness of the potential impact of anthropogenic noise on marine mammals. The publicity surrounding this issue has highlighted our general ignorance on the subject and led to a tremendous amount of interest in and speculation about the likely consequences of exposing whales to man-made, underwater noises. My point here is to encourage continued awareness of the potential problem, while proposing that solutions should best come through scientific research and careful evaluation of evidence. The subject is complex, and real progress will come from interdisciplinary collaborations between biologists, oceanographers, underwater acousticians, auditory physiologists and statisticians.

Payne and Webb (1971) were the first to publish on this subject as it relates to the impact of shipping noise on baleen whale communication. They hypothesised that the increase in low-frequency ocean noise resulting from the increase in ocean shipping, starting with the advent of engine driven ships in the 19th century, could reduce the area over which animals can communicate by several orders of magnitude. In 1992-93, ATOC (the oceanographic research project led by Walter Munk at Scripps and intended to provide the critical empirical data by which to validate existing models of ocean-atmospheric heat exchange) was a lightening rod for concern on the impact of noise on marine mammals. The ATOC source transmits an m-sequence of coded '1's and '0's (a phase shifted 75Hz, 30Hz bandwidth signal at a source level of 195 dB re 1 μPa-1m) through the ocean, and receptions of the signal at remote sites are used to estimate the average ocean temperatures along multiple deep-ocean pathways. Post-processing gain allows detection (NOT audition) of the coded signal at ranges out to 5,000km, and the source signal samples the entire water column. There are two sources presently installed on the seafloor, both at depths of approximately 900m. One source is on the Pioneer seamount 85km off central California, and the other 14km off north Kauai, Hawaii. To date all use of the sources, except for brief periods of engineering testing, have been under the direction of a marine mammal research program.

Lack of basic information on auditory thresholds, behavioural responses, and numbers and distributions of whales made it difficult to predict the level of impact from ATOC sound transmissions. Lack of scientifically based evidence to bracket the risk combined with a broad passion for whales led to speculation that the ATOC sound could deafen whales, drive certain species to extinction, and otherwise wreak havoc on the ocean environment. This over reaction did have the positive effect of drawing together various scientific groups with vested interests in ocean systems. These initiated constructive discussions between scientists, concerned citizens, regulatory agencies and environmental groups which furthered the process of identifying the major gaps in knowledge and the research priorities that would provide information about the potential impact of man-made underwater sounds on whales. Sometimes, the lack of evidence on the subject was cited as good reason to do nothing. Other ongoing or planned acoustic research experiments that had not come forward to ask for either a permit or authorisation, continued; having seen that in the United States at least, it was best to avoid admitting that one was using sound to explore the ocean.

In summer 1996, the US Navy publicly announced that it would develop an Environmental Impact Statement (EIS) for its Surface Towed Acoustic Surveillance System Low Frequency Active (SURTASS-LFA) sonar. Many outreach meetings were held, a panel of scientific experts was formed to review present knowledge and recommend directions for research, and a sequence of research projects was planned (referred to as the LFA-Scientific Research Program = LFA-SRP). It is interesting to note that the two programs (ATOC and LFA-SRP) that have included significant marine mammal research programs to actually gather evidence on the potential impacts of man-made low-frequency sounds on marine mammals have received the greatest criticism. Clearly the issue is of great concern, and these research programs are only the first steps toward resolving the matter.

What is the basis for concern that low-frequency sound could harm whales? Essentially it is as follows.

(1) Whales are known to produce a great variety of sounds in the 10-1000Hz frequency range. Since whales produce sound, and light does not provide as effective a modality for communicating underwater, then whales rely on sound for survival more than they rely on any other sensory system. Dolphins use sounds for echolocation to 'image' their environment and are therefore a supporting example for the notion that whales rely mostly on sound.
(2) Sound travels a long way underwater and human activities introduce a lot of sound into the ocean. The physics of sound propagation in the ocean is a rapidly advancing science. Over the past 50 years humans have learned how to exploit underwater sound transmission properties as a means of probing the ocean, especially for industrial, military and scientific purposes. Noise from commercial shipping is by far the greatest anthropogenic contributor to ocean noise in the frequency band below 100Hz.
(3) There is a potential conflict between the animals' dependency on sound for survival and our increasing use of and production of low-frequency sounds. We do not yet know enough about what levels of sound exposure could physically harm whales. We do not know very much at all about the biological functions of acoustic signalling behaviour in whales and over what ranges this behaviour is used. Basic understanding of the functional significance of acoustic signalling behaviour are necessary to know the level of impact of such things as masking or acoustic interference.

There are a few, well supported cases where whales have been shown to react to human-made low-frequency (<500Hz) underwater sounds by avoiding some area surrounding the sound source. Thus, gray whales responded to playback of industrial noises by avoiding the area within 100-200m of the source, while bowhead whales have been observed avoiding (at ranges of *ca* 20km) areas of high industrial noise activity.

To the best of my knowledge, no observed responses by whales to human-made underwater sounds have been interpreted as biologically significant. The eastern Pacific gray whale population has increased throughout this century in the face of increasing human-made noise, even though animals have abandoned a calving/breeding lagoon when industrial activity was high. All indications are that the population of humpbacks that come to breed and give birth off Hawaii is increasing despite an increasing level of human activity (commercial and recreational) on and under the water.

Efforts to define potential noise impacts have oversimplified the mechanisms of impact by assuming that animals are responding to the sound's received level, rather than some other acoustic features of the sound field (e.g., sound gradient, bearing rate, spectral distribution). In most cases, estimating received level has used very simple models (spherical or cylindrical spreading loss) for predicting transmission loss between the sound source and the whale. Such models are relatively accurate at close range to a sound source (< 1km, where a good rule of thumb is –60dB loss at 1km), but these are not good predictors of sound exposure when animals are further from the source or when the source is not omnidirectional. Depth of the whale and its dive depth profile are critical for estimating sound exposure and its history of exposure. Most recently, collaborations with oceanographers and underwater acousticians have resulted in procedures for accurately estimating acoustic exposure by using sophisticated, empirically verified, models of transmission loss. It is imperative when attempting to determine relationships between low-frequency sound impact and animal responses, that sound exposure parameters be derived from an empirically verified transmission loss model and that depth of the animal is properly accounted for. Even in the best of circumstances one should expect estimates of acoustic exposure level for a given range and bearing from a sound source to have an uncertainty of ± 4-5dB.

Impacts can be divided into two categories, those that cause physical damage and those that only elicit a behavioural response. Physical damage may or may not have a biological impact, but it is widely agreed that such an impact is unacceptable. Physical harm to an animal will most likely occur either at a very high exposure level over a short time period, or after repeated and long-term exposure to high levels. There are no definitive data on what acoustic levels are damaging, but a typical assumed level has been that damage could occur from exposure to broadband received levels of > 180dB re 1 μPa.

A behavioural response can be obvious; for example, an observation of an individual whale orienting and swimming away from a sound source. It can also be statistical, for example the average swimming speed for a sample of whales is significantly different than that of a control group. Extrapolation of biologically significant impact based on a behavioural response requires interpretation of the biological context and some hypothetical extrapolation to a scale that involves a population. Thus, for example, migrating animals will most likely respond differently to a given sound source than will feeding animals. A few observations of animals responding to a noise source or a result indicating a statistically significant response is not necessarily evidence of a biologically significant or population level impact.

We have just completed several months of field research off north Kauai studying the responses of humpbacks to the ATOC sound. For California, we have just restarted the marine mammal research program, which includes aerial surveys, elephant seal translocations, and acoustic monitoring using seafloor acoustic recording units. All field research is expected to end in 1998. To date, there are no results from any of the ATOC marine mammal research indicating biologically significant responses. However, a few statistically significant differences have been found. For example, with sperm whales, when the average distance of all groups seen in the same aerial survey is the unit of analysis, there is a significant difference between whales seen during periods with ATOC transmissions compared to periods without ATOC transmissions. There is no statistically significant difference when the unit of analysis is the average distance of the group. There is no acoustic feature (estimated received level or number of exposures) that can be directly related to this statistically determined effect since the average sound exposure levels for the control and experimental conditions are essentially identical.

All three phases of the LFA-SRP project have been completed. In Phases I and III, when the actual vessel operating the LFA source was used to generate a sound field, there were no obvious and consistent responses during playback of the LFA sounds. In Phase I there was a statistical difference in the number of blue or fin whales producing patterned sequences of sounds, where the number of whales was determined subjectively during the field work. This result has not yet been verified from quantitative analysis of

the recorded data. In Phase I some animals were exposed to received levels as high as 150dB re 1 μPa and appeared to behave normally. In Phase III, although there were a few cases when a humpback whale terminated singing or moved away from the vessel, most whales continued to sing and engage in social interactions during exposure to LFA, even in cases when the received level at the whale was as high as 140-145 dB re 1 μPa. These results were surprising to the biologists collecting behavioural response data, since we expected responses at received levels of this magnitude. We did, however, observe responses to the approach of the observation vessel collecting behavioural response data in both Phase I and Phase III and to the tagging vessel (in both Phase II and Phase III). In Phase II we did see obvious responses by gray whales as they deflected around the playback source when it was moored *ca* 2km off the coast and source levels were as high as 185 dB re 1 μPa-1m. This response was not observed when the source was moored ca. 4km off the coast and source levels were as high as 200 dB re 1 μPa-1m.

At this point, data analyses and interpretations are still underway, but should be completed within the next year.

REFERENCE

Payne, R. and Webb, D. 1971. Orientation by means of long range acoustic signaling in baleen whales. *Ann. NY Acad. Sci.* 188:110-42.

Appendix 7

SUGGESTED STEPS TO FURTHER RESPOND TO THE COMMISSION'S DIRECTIVE ON ENVIRONMENTAL CONCERNS

A. von Bismarck, G. Notarbartolo di Sciara, D. Senn, M.P. Simmonds, E. Slooten and M. Stachowitsch

In Resolution 1997-7 the Commission directed the Scientific Committee to provide '...regular up-dates to the Commission on environmental matters that affect cetaceans...'. Specifically, the Resolution noted that the Standing Working Group on Environmental Concerns (SWGEC) had identified eight topics of particular importance: (1) climate/environmental change; (2) ozone depletion and UV-B radiation; (3) chemical pollution; (4) impact of noise; (5) physical and biological habitat degradation; (6) effects of fisheries; (7) Arctic issues; and (8) disease and mortality events.

The first three have been addressed by two workshops, which have led to corresponding research initiatives. We believe that it is **imperative** that they be fully implemented and be supported as the first priority.

Clearly, it is also beneficial for the success of the existing proposals and the work of the SWGEC that it continues to be pro-active and find ways to develop its broad agenda, including consideration of cumulative impacts.

Addressing outstanding environmental concerns

We recommend that a practical way to address a substantial part of the outstanding agenda is an intersessional workshop to consider 'biological and physical habitat degradation.' We believe that this might be best approached by a regional or species-specific program or a combination of both approaches.

We note the recommendation from the Right Whale Workshop, held in Cape Town, South Africa from 19-25 March 1998:

'It [the Workshop] noted the increasing importance the Scientific Committee has placed on environmental change and habitat studies (e.g. IWC, 1998). In this context it recommends that the Committee considers convening a workshop to develop approaches to quantify key features of whale habitats, including trophic structure; right whales should be considered as potential key species.'

Proposed broad objectives:

(1) to describe the parameters which define cetacean habitat;
(2) evaluate how these parameters affect cetaceans, particularly with respect to physical and biological degradation;
(3) identify and if need be develop objective criteria to measure such changes;
(4) determine methodology to assess significance of habitat degradation including cumulative effects.

We note that this would require a multidisciplinary approach.

The above objectives and further details of the focus and organisational aspects of the proposed workshop should be elaborated by a steering group.

The Central Institute for Research on the Marine Environment (ICRAM) of Italy has offered to host and assist in the organisation of such an intersessional workshop. The involvement of the Institute, its location, and the expertise that it provides will facilitate the attendance of suitable experts.

We note that the Mediterranean and Black Sea region could provide a good focus because:

(a) the Mediterranean is subject to intense human impact resulting in substantial coastline modifications, large-scale eutrophication and major algal events, extensive invasion of alien species and major shipping;
(b) the Mediterranean is also home to an estimated 4,000 fin whales which may be endemic;
(c) the Black Sea is a well-documented example of an 'ecosystem-flip' – where alien species (i.e. ctenophores) now dominate – with potentially associated problems for cetaceans.

Annex I
Report of the Standing Sub-Committee on Small Cetaceans

Members: Martin (Chair), Albert, Baker, Baldwin, Berggren, Borchers, Brownell, Buckland, Chen, Childerhouse, Clarke, DeMaster, Donahue, Donovan, Ensor, Fabbri, Findlay, George, Goto, Gunnlaugsson, Hakamada, Hammond, Hatanaka, Hiby, Kasuya, Kato, Kawachi, Kawahara, Kim, Kock, Lawrence, Lens, Melnikov, Miyashita, Moronuki, Nishiwaki, Notarbartolo di Sciara, Øien, Okamoto, Palka, Pastene, Peréz Cortés, Perrin, Pinedo, Read, Reeves, Reijnders, Robineau, Rogan, Rojas-Bracho, Senn, Simmonds, Slooten, Smith, Sweeney, Tanakura, Thiele, Van Waerebeek, Von Bismarck, Wade, Walters, Yagi, Yamamura, Zhu.

1. ELECTION OF CHAIRMAN

Martin was elected as Chairman.

2. ADOPTION OF AGENDA

The agenda was adopted unamended and is given as Appendix 1.

3. APPOINTMENT OF RAPPORTEURS

Read, Reeves and Simmonds acted as Rapporteurs.

4. REVIEW OF AVAILABLE DOCUMENTS

Documents relevant to the work of the sub-committee were SC/50/SM1-12; SC/50/O4-5; Van Waerebeek *et al.* (in press); Kemper and Gibbs (1998); Gordon *et al.* (1998); and SC/50/ProgReps.

5. REVIEW OF SMALL CETACEANS IN THE INDIAN OCEAN AND RED SEA, WITH SPECIAL REFERENCE TO THE MIDDLE EAST

Discussion at this meeting was limited to the northwestern part of the Indian Ocean, and in particular to the waters bordering the Arabian Peninsula. As a way of ordering the discussion, the group arbitrarily defined three zones within this region:

(1) the shallow, semi-enclosed Arabian (Persian) Gulf;
(2) the Arabian Sea including the Gulfs of Oman and Aden; and
(3) the Red Sea.

The Red Sea and Gulf of Aden were considered to a limited extent at the previous sub-committee meeting which had focused on Africa.

Two review papers formed the basis for discussion. SC/50/SM6 summarised relevant information from the literature, direct observations by the authors, and two databases – one maintained at the Oman Natural History Museum since 1988 and the other by the Emirates Natural History Group in Abu Dhabi since 1995. SC/50/SM1 provided a review of cetaceans in the Arabian Gulf with emphasis on the Saudi Arabian coastline. Interest in cetaceans is relatively new in this region, and most records refer to observations made within the past 2-3 decades. Previous compilations by Leatherwood (1986), de Silva (1987) and Robineau and Fiquet (1996), and papers contained in Leatherwood and Donovan (1991), were used as background by the authors of SC/50/SM1 and SC/50/SM6. It should also be noted that two recent popular books are available, one on cetaceans of Oman (Baldwin and Salm, 1994) and one on cetaceans of the United Arab Emirates (Baldwin, 1995).

Although it was not formally reviewed by the sub-committee, a paper by Ballance and Pitman (in press) contains valuable new data on cetaceans of the pelagic western tropical Indian Ocean, including the Gulf of Oman and a portion of the Arabian Sea coast of Oman. SC/50/SM6 included references to the sightings off Oman by Ballance and Pitman (in press).

The amount and quality of data on small cetaceans in the Middle East region are very strongly biased towards the few areas where competent researchers have spent time. Coastal waters of Oman have been relatively well studied by Baldwin and colleagues, while Robineau conducted surveys of a portion of the Saudi sector of the Arabian Gulf coast following the 1991 Gulf War. Otherwise, little is known about the cetacean fauna of the northern (Iran) side of the Arabian Gulf, the Arabian Sea coast of Yemen or the Gulf of Aden and Red Sea.

The sub-committee expressed its gratitude to the authors of SC/50/SM6, in particular, for their hard work in compiling, organising and presenting a thorough synthesis of data on small cetaceans in the northwestern Indian Ocean.

5.1 Arabian (Persian) Gulf

The Arabian Gulf is connected to the Gulf of Oman by the Strait of Hormuz. Most of the water flowing into the Arabian Gulf enters on the north side of the Strait. Circulation is poor with a turnover time of about 3-5 years for water entering the Gulf (SC/50/SM1). Average depth is only 35m. The high salinity, high turbidity and pronounced seasonal flux in water temperature make the Gulf a 'naturally stressful environment' for cetaceans and other fauna (SC/50/SM1).

Seven species of small cetaceans have been documented in the Gulf, including the false killer whale (*Pseudorca crassidens*), Indo-Pacific humpbacked dolphin (*Sousa chinensis*), pantropical spotted dolphin (*Stenella attenuata*), spinner dolphin (*Stenella longirostris*), common dolphin (*Delphinus* cf. *tropicalis*), bottlenose dolphin (*Tursiops* cf.

aduncus) and finless porpoise (*Neophocaena phocaenoides*). In addition, there are unconfirmed records of the killer whale (*Orcinus orca*), short-finned pilot whale (*Globicephala macrorhynchus*) and Risso's dolphin (*Grampus griseus*). Baldwin questioned the records for the latter two species noting that they are generally regarded as deep-water animals and that inexperienced observers might easily confuse pilot whales with false killer whales. Inability to track records to original sources made it impossible to evaluate them.

Only three species can be considered common in the Gulf. *Delphinus* were the most frequently encountered and most abundant cetaceans in Robineau's surveys off the Saudi coast. All *Delphinus* specimens observed at sea and examined in museum collections have been long-beaked forms. *Delphinus* were not sighted by Baldwin during 60 days of small-boat surveys in Gulf waters of the United Arab Emirates between March and July 1995, nor have they ever been reported alive in the UAE sector of the Gulf. These results, when compared to those of Robineau in Saudi waters, suggest that the high densities observed in the latter area are not representative for the entire Gulf. Humpbacked dolphins appear to be widely distributed throughout the Gulf, albeit mainly in waters less than 30m deep. Baldwin pointed out that there is a hiatus in records of this species in the Gulf of Oman, suggesting that the Arabian Gulf population is a separate stock. Bottlenose dolphins, all considered to be *aduncus*-type animals, are relatively abundant in the Arabian Gulf. A fourth species, the finless porpoise, is of major concern because of its limited distribution, vulnerability to bycatch and likely susceptibility to disturbance from coastal development, land reclamation, vessel traffic, etc. It seems to occur in the Gulf in low abundance. The finding of a newborn porpoise off the Saudi coast indicates that calving occurs in the Gulf.

The three other species definitely recorded from the Gulf – *Pseudorca crassidens* (5-6 records), *Stenella attenuata* (1-2 records) and *Stenella longirostris* (2-3 records) – are probably rare.

5.2 Arabian Sea, including Gulf of Oman and Gulf of Aden

This region is obviously much larger and more diverse than the Arabian Gulf. The shelf off northern Oman is generally more than 50km wide; water in the central part of the Gulf of Oman is more than 1,000m deep, and in some areas more than 3,000m deep. From Ra's al Hadd southwestwards, the shelf is narrow, and a strong seasonal upwelling supports kelp communities and extensive fisheries. Off the central coast of Oman, leeward of Masirah Island and south to Shuwaymiyah, the shelf is relatively wide (~20-50km), compared to other areas, such as Ra's al Hadd itself and near Salalah where water depths exceed 1,000m 5-10km from shore. There is some evidence (SC/50/CAWS21) to suggest that the seasonal upwelling, which brings elevated nutrient levels to coastal and offshore waters in this region, can maintain fisheries throughout the year (i.e. unseasonal upwelling events do occur).

Ballance and Pitman (1998) describe the cetacean community of the pelagic western tropical Indian Ocean, based primarily on observations from their dedicated sightings survey from March to July 1995. The list of species observed during their survey is similar to that given in SC/50/SM6 based mainly on opportunistic research from small boats and beach surveys. In Omani waters of the Gulf of Oman and the Arabian Sea, the following species have been confirmed (SC/50/SM6): dwarf sperm whale (*Kogia simus*), Cuvier's beaked whale (*Ziphius cavirostris*), melon-headed whale (*Peponocephala electra*), false killer whale, killer whale, rough-toothed dolphin (*Steno bredanensis*), Risso's dolphin, Indo-Pacific humpbacked dolphin, *Delphinus* sp., bottlenose dolphins (reportedly two forms), pantropical spotted dolphin, striped dolphin (*Stenella coeruleoalba*) and spinner dolphin. Species tentatively identified for Omani waters, but that need confirmation (SC/50/SM6), include the pygmy killer whale (*Feresa attenuata*) and *Globicephala* sp. Both have been reported elsewhere in the western tropical Indian Ocean, including off Somalia and Socotra Island (Ballance and Pitman, 1998), and Brownell reported sightings near the Maldive Islands southeast of India in early April 1998.

The occurrence of *P. electra* is only confirmed on the basis of Van Waerebeek *et al.*'s (in press) identification of a calvaria found on the Khuria Maria Islands (now called Juzor al Halaaniyaat) that had been reported by Gallagher (1991) as *Tursiops* sp. Although Ballance and Pitman (1998) saw two small groups of rough-toothed dolphins off the central coast of Oman in July 1995, the only other record of that species in the region is a calvaria from Ra's al Madrakah, Oman (19ºN, 57º50.5'E), also tentatively identified by P.J.H. van Bree (Gallagher, 1991) as *Tursiops* sp. and later identified as *Steno* by Van Waerebeek *et al.* (in press).

No records of pilot whales could be confirmed from coastal waters of the Arabian Peninsula (SC/50/SM6). Museum specimens from Oman previously listed as ?*Globicephala macrorhynchus* (Gallagher, 1991) were identified by Van Waerebeek as *Pseudorca crassidens* although the identity of one is still under study (Van Waerebeek, pers. comm.). Sightings of pilot whales were made east of Socotra Island by Ballance and Pitman (1998), near the Maldives by Brownell (pers. comm.) and off Djibouti (Robineau and Rose, 1984).

The complete lack of records of *Neophocaena* in Omani waters and west is of considerable interest. It appears that the Arabian Gulf and Iran coastal waters constitute the westernmost limits of the species' distribution.

The most frequently encountered species in Omani coastal waters are *Delphinus* sp., *Tursiops* sp., *Sousa chinensis* and *Stenella longirostris* (SC/50/SM6).

Common dolphins are widely distributed and abundant in the northwestern Indian Ocean (SC/50/SM6). They often occur in large groups (>100 individuals), sometimes in mixed schools with *S. longirostris*. It is of interest that all of the sightings of *Delphinus* made by Ballance and Pitman (1998) in 9,784 linear km of survey effort were off Oman between latitudes 18º28'N and 23ºN. This was in spite of the fact that only 13.1% of the total surveyed distance was in these waters (SC/50/SM6). All of the common dolphins observed by Ballance and Pitman (1998) were very long-beaked and judged to be the '*tropicalis*' form; they had a *delphis*-type colour pattern. Van Waerebeek noted that the skulls of some animals from Omani coastal waters appeared more *capensis*-like than those in the Arabian Gulf. He pointed out that about 18 specimens are available for study in the Oman Natural History Museum. Perrin noted that the most recent genetic results indicate that the *tropicalis* form may be a taxon distinct from the *delphis* and *capensis* forms.

Bottlenose dolphins, understood to include at least *Tursiops* c.f. *aduncus* and possibly also *T. truncatus*, are relatively abundant in Omani waters (SC/50/SM6). Group sizes near shore tend to be in the tens of individuals, while much larger groups (up to 750 individuals) have been

reported offshore (Ballance and Pitman, 1998). LeDuc and Curry (1996) have shown from cytochrome B genetic analysis that the nominal species *Tursiops aduncus* is a separate species from *T. truncatus* and that they are not even sister taxa. Collection of tissues for DNA analyses is especially encouraged to help resolve questions as to which species are present in the Indian Ocean. Baldwin noted that there is considerable specimen material (skulls) available for study in the Oman Natural History Museum.

Pseudorca crassidens are reported relatively often in offshore waters of the Gulf of Oman, sometimes in association with yellowfin tuna (*Thunnus albacares*). There is evidence from direct observations and from stomach contents that false killer whales prey on yellowfin tuna in this region (SC/50/SM6). Observations of a live-stranded calf, juveniles at sea and a possible birth in the Gulf of Oman indicate that the species may be resident.

The Indo-Pacific humpbacked dolphin is a coastal, shallow water species. As mentioned above, there is a gap in records between the Strait of Hormuz and Ra's al Hadd. To the south and west of the latter, the distribution may be continuous along the coast all the way to the Gulf of Aden and Red Sea (SC/50/SM6). If the populations in the Arabian Gulf and along the Arabian Sea coast to the west and south are indeed separate, it is unclear whether this separation is natural or the result of human activities (SC/50/SM6). Baldwin noted that the group sizes off Oman are, at times, considerably larger than reported group sizes for this genus anywhere else in its range.

The spinner dolphin is widely distributed in the Gulf of Oman and along the Arabian Sea coast of Oman and southwards into Yemen (SC/50/SM3; SC/50/SM6). Groups of hundreds to several thousand animals are seen regularly travelling parallel to shore in the Gulf of Oman approximately 2-6km offshore. SC/50/SM3 describes the skeletal and external morphology of eight spinner dolphins and summarises distribution and ecology of the species in the Gulf of Oman and northern Arabian Sea. All the spinner dolphins from Oman have a falcate dorsal fin. One large individual, observed from underwater, was seen to have a ventral keel, but otherwise ventral keels have not been observed on spinners in this region. The body sizes of three physically mature males were smaller than those of animals from any other known stock of spinner dolphins except the dwarf-form stocks from Thailand and Australia. Two colour morphs have been observed in Omani waters, the most common being the typical tripartite pattern similar to that of the subspecies *S. l. longirostris*. A smaller morph has a dark dorsal overlay that obscures most of the tripartite pattern, and it has a pinkish or white ventral field and supragenital patch. Perrin pointed out that his ongoing studies of spinner dolphins worldwide leads him to expect much complex variation in size and morphology across the species' pantropical range. The authors of SC/50/SM3 urged that the spinner dolphins of the northern Arabian Sea be viewed, at least provisionally, as a discrete population, pending a more extensive investigation.

5.3 Red Sea

At the previous meeting it was noted that at least eight species of small cetacean are known to inhabit the Red Sea (IWC, 1998), of which the Indo-Pacific humpbacked dolphin, the bottlenose dolphin (*aduncus* form and and other larger form in the Gulf of Suez) and the pantropical spotted dolphin are the most common. Spinner dolphins, rough-toothed dolphins, Risso's dolphins, killer whales and false killer whales are also present. No new data from the Red Sea were made available to the sub-committee at the present meeting.

5.4 Conservation problems

Several concerns have arisen in regard to the conservation status of small cetaceans in the region. There is a dearth of information about fisheries in the Arabian Gulf even though a substantial amount of fishing is known to occur. Robineau noted that fishing has expanded rapidly in recent decades (Esseen, 1996). Also, of seven stranded animals that he examined on Abu Ali Island, Saudi Arabia, in 1993, two were definitely killed in fishing gear (a common dolphin caught in an inter-tidal barrier trap and a bottlenose dolphin caught on a longline) but two more were probably bycaught. Robineau regards incidental takes as a major threat to cetacean populations in the Gulf.

Fishing with gillnets is practised throughout the region. Although bycatch is not systematically reported, it certainly occurs (SC/50/SM1; SC/50/SM6; Siddeek and Baldwin, 1996; Baldwin and Cockcroft, 1997). In the UAE and Oman, the taking of cetaceans is illegal so fishermen may cover up any catches, whether accidental or deliberate. The occasional discovery and reporting of butchered cetacean carcasses indicates that some use is made of the meat and/or blubber, but little is known about the nature or scale of such practices.

Baldwin pointed out that most of the islands off the coast of Abu Dhabi are privately owned and that, as a result, fishing is banned in waters surrounding these islands. This situation may create a mechanism by which at least some areas could be managed to reduce or eliminate bycatch.

The rich fishing grounds along the Oman coast, especially from Ra's al Hadd southwestwards, supports a large fishing industry. Offshore handlining, nearshore gillnetting and beach seining are common activities in the Muscat area. There is an offshore net fishery targeting sharks and other pelagics (e.g. kingfish, tuna), and trawlers and longline vessels from Korea and Taiwan also operate in Omani waters. The offshore net fishery involves the use of large (30-60ft) vessels as the primary platforms. Large-mesh nets up to 1km long are set between dhows (traditional fishing vessels). Fishing intensity is greatest from Masirah Island south to the Yemen border. Baldwin noted that a relatively large number of cetacean strandings occur on or near Masirah Island, possibly linked to fishery activities.

Effects of pollution are another major concern in this region. The poor circulation in the Arabian Gulf, particularly, means that contaminants remain concentrated there for long periods (SC/50/SM1). Not only has the Gulf experienced two very large-scale oil spills in recent years (Nowruz in 1983 and the Gulf War in 1991), but it is also estimated that some 1.5 million tonnes of oil are released into the Gulf each decade as a result of normal oil production and transport (Michel *et al.*, 1986). In 1983 after the Nowruz spill, at least 38 dugongs, 33 cetaceans and thousands of fish were found dead, but no direct link was established between the oil spill and these mortalities. The 1991 spill in the northwestern Arabian Gulf was the largest in history. Between January and May that year 600,000 to 1,000,000 tonnes of crude oil were intentionally released, covering some 500km of coastline between southern Kuwait and Abu Ali Island, Saudi Arabia. A large die-off of marine mammals occurred, including at least 57 bottlenose dolphins, 13 humpbacked dolphins, one finless porpoise and seven unidentified animals. Robineau noted that, according to a report by Preen (1991), no obvious direct relationship

between the oil spill and the die-off could be established. A confounding factor was that carcasses were found 120-250km south of where the oil slick stopped. However, Robineau noted that the latter area is a natural collection site and the animals observed appeared to have been dead for 4-6 weeks, so could have originated from the polluted area. One year after the beginning of the Gulf War oil spill, Robineau and colleagues were unable to find any evidence of abnormal cetacean mortality in the two bays of the Jubail Marine Sanctuary, Saudi Arabia. Furthermore, a small population of humpbacked dolphins was discovered in this previously heavily polluted area.

Robineau also called attention to a large die-off in the Gulf in 1986. In this event at least seven dead dugongs and some 520 dead cetaceans (including *Tursiops* sp. and *Sousa, Delphinus* and *Neophocaena*) were observed on the beaches of Qatar, Saudi Arabia, Bahrain, Iran, Kuwait and the UAE (Anon., 1986; Preen, 1991). Some 4-8,000 dead fish and 36 dead turtles were also reported. The cause of this mass mortality was never established, and its scale is likely to have been underestimated because intensive beach surveys were not conducted throughout the region. A red tide event might have been involved, but in the absence of detailed necropsies and tissue analyses, no possibility can be ruled out.

The sub-committee stressed that detailed studies are needed to elucidate the primary cause(s) of the observed die-offs. Those should include investigations of the rôle of bio-toxins, diseases and pollution with respect to both direct impacts on the cetaceans and indirect effects via their food-chain. Particularly relevant are pathological studies of cetaceans, focussing on the chronic toxicity of e.g. poly-aromatic hydrocarbons (PAHs), to assess the general health state of cetaceans in that area with respect to oil contamination.

A third concern, in addition to bycatch and pollution, is directed hunting. Data summarised in SC/50/SM6 indicate a long history of human consumption of dolphin products in Oman. Recent observations of butchered animals on beaches (including common, bottlenose, spinner and humpbacked dolphins in Oman) shows that there is still some demand for cetacean products in the region. In addition to human consumption of the meat, use of dolphin carcasses as shark bait has been reported from Masirah Island by Salm *et al.* (1993). Anecdotal reports indicate that some directed hunting continues in Oman despite its illegality (SC/50/SM6).

A final, more generalised concern is that habitat degradation and loss may have already had a substantial impact on coastal cetaceans in the region. For example, there are references to declining abundance of *Sousa* in the Arabian Gulf, and the finless porpoise is thought to be rare in the Gulf. Both of these species could be affected by coastal development (e.g. land reclamation, dredging, intensive motor vessel traffic). The rapid, continuing modernisation and industrialisation of the Gulf and Arabian Peninsula are themselves cause for concern about possible impacts on coastal marine resources generally.

5.5 Recommendations for further study

(1) The sub-committee noted that available information on small cetaceans in the region comes almost entirely from opportunistic work by individual scientists. In addition, several systematic surveys have been conducted in portions of the Arabian Gulf, prompted by concern about the immediate impacts of large oil spills. However, no formal abundance estimate is available for any population of small cetaceans in the region. In the light of concerns about bycatch and the possible effects on cetacean populations of pollution and other forms of habitat degradation and loss, the sub-committee **recommends** that governments initiate studies of stock identity and field surveys for stock assessment. Initially, these should focus on coastal populations of humpbacked, bottlenose and common dolphins. The possibility of using data from systematic aerial surveys of dugongs (past and future) to obtain estimates of bottlenose and/or humpbacked dolphin abundance should be investigated.

(2) The sub-committee agreed that the few records of cetacean bycatch in fisheries probably substantially under-represent actual bycatch levels. Everywhere else in the world where gillnet fishing occurs and cetaceans are present, there is some bycatch, and virtually all species of cetaceans are susceptible (Perrin *et al.*, 1994). The sub-committee **recommends** that credible programmes be established to monitor the species and numbers of cetaceans caught. Self-reporting is not adequate, so observer programmes will be necessary. Information on fisheries techniques and effort should also be obtained to enable evaluation of results of bycatch studies.

(3) The sub-committee commended Robineau, Gallagher, Van Waerebeek, Baldwin and other colleagues for their efforts to salvage and deposit specimens in museum collections. Papers submitted to the meeting demonstrated the usefulness of such efforts in providing basic knowledge about what species occur in the region. The sub-committee **recommends** that further work on specimen collection and curation be supported by appropriate governmental and non-governmental agencies. This should include the establishment of networks to detect, record, examine and collect biological samples from stranded cetaceans on a systematic basis. One value of such networks is that they provide measures of background stranding frequency. An understanding of background frequency is often necessary for judging when a mass mortality, or die-off, is underway. Specimen collection should be understood to include biopsies and other tissue samples for genetic analyses of population structure and pollutant assays (see following recommendation).

(4) The sub-committee noted that waters of the Arabian Gulf are highly polluted by oil, and also that at least three recent die-offs of cetaceans and other animals (1983, 1986, 1991) have been documented. The causes of these die-offs were not adequately investigated and therefore remain uncertain, although two were coincident with major oil spills. If one were looking for an area in which to study one or more populations of cetaceans that are chronically exposed to hydrocarbon contaminants, the Gulf would be an appropriate site to choose. It became clear from discussions that little or no work had been done to measure contaminant burdens of cetaceans in the Gulf or elsewhere in the Middle East. The sub-committee **recommends** that such studies be carried out.

(5) The sub-committee wished to draw particular attention to the need for detailed studies of the conservation status of humpbacked dolphins and finless porpoises in the Middle East and **recommends** that such studies be carried out. Continuation and expansion of studies of the systematics of spinner, bottlenose and humpbacked dolphins are also strongly encouraged. For these and

other studies the sub-committee emphasised the importance of training and involving local scientists from range states in the region.

6. FURTHER CONSIDERATION OF THE CRITERIA FOR ASSESSING THE STATUS OF HARBOUR PORPOISE POPULATIONS

At its 1997 meeting the sub-committee had agreed that no one algorithm for assessing the conservation status of small cetacean populations was likely to be appropriate in all circumstances. It also recognised that simulation studies, taking into account uncertainty in stock identity, would likely provide a way forward in resolving the question of which algorithms might best be used on a case by case basis. Because insufficient resources were available to the sub-committee during its annual meetings to develop this approach, a group had been set up under Bravington to work intersessionally and report back in 1998. At this meeting it was reported that Bravington's group had made limited progress, due largely to time constraints, but that a final summary report was expected by August 1998.

The sub-committee then considered a report from ASCOBANS (SC/50/SM12). This was pertinent to the discussions under this priority topic because it set out the conservation objectives of ASCOBANS, the multi-lateral agreement with conservation responsibilities for small cetaceans in the North and Baltic Seas. The aim of ASCOBANS was stated as 'to restore and/or maintain biological stocks of small cetaceans at the level they would reach when there is the lowest possible anthropogenic influence', and its interim conservation objective is 'to restore populations to, or maintain them at, 80% or more of the carrying capacity' (SC/50/SM12).

Last year the sub-committee had noted that its work would be facilitated if more specific conservation objectives were identified by ASCOBANS. The sub-committee therefore welcomed SC/50/SM12, which states such objectives, and noted that they provide a focus for this sub-committee to furnish scientific assistance regarding the conservation status of harbour porpoises in this region. Reijnders, in his capacity as Chair of ASCOBANS' Advisory Committee, indicated that liaison between that Committee and the IWC Scientific Committee would be welcomed, and that a formal proposal for scientific cooperation would be submitted to the Scientific Committee at this meeting. The sub-committee agreed that such collaboration would further its own work and that the most appropriate way to further this collaboration was for a joint ASCOBANS/IWC working group to be established. The sub-committee also agreed that it was important for its work to continue pending the formal establishment of this group. To facilitate this, a Working Group of this sub-committee was established under the Convenorship of Read, with the intention that this would form the IWC element of the joint working group, with a membership of Read, Berggren, Buckland, DeMaster, Donovan, Hammond, Martin, Palka, Reijnders, Rogan and Wade. The Convenor of this group was empowered to add others to this list as necessary. The Working Group's terms of reference were as follows:

> 'The working group should provide scientific assistance to the Advisory Committee of ASCOBANS on issues relating to assessment of the status of harbour porpoises in the North Sea and adjacent waters. This assistance should include: generating plausible hypotheses regarding population structure; providing information on life history parameters, abundance and trends in abundance; identifying methodology to estimate bycatch levels; identifying demographic models to assess the status of populations in the North Sea and adjacent waters. The Working Group should report on its progress at the 1999 meeting of the Scientific Committee.'

It was agreed that the Joint Working Group should meet intersessionally, but that the work of sub-committee members should be started as soon as possible by e-mail. Financial support for a meeting would not be sought from existing IWC funds, but members of the sub-committee indicated that other sources of support may be available. It was proposed that the meeting should occur in February 1999, allowing the completion of project BY-CARE which includes an investigation of harbour porpoise population structure in the North Atlantic.

In response to the ASCOBANS document, the sub-committee noted that several scientific approaches could be used to allow ASCOBANS to achieve its conservation objectives. Wade noted that he could provide a published example of one such method; this method is outlined in Appendix 2.

Okamoto noted that the ASCOBANS conservation objectives were not necessarily shared by non-ASCOBANS members. He also noted that in some areas harbour porpoises are subject to directed takes under completely different conservation philosophies, as mentioned in the 1996 report of this sub-committee.

7. REVIEW OF OTHER PRESENTED INFORMATION

7.1 White whales

Melnikov presented information on the distribution and seasonal movements of white whales in the Chukchi and northern Bering Seas (SC/50/SM4). Observations of white whales have been made from shore and whaleboats in this region since 1990. These observations have allowed conclusions to be drawn, for the first time, regarding the year-round distribution of this species in the waters around the Chukotka Peninsula.

In winter months (January-February), white whales are found in leads, broken pack ice, polynyas and wind-driven open water along the southern and eastern coasts of the Chukotka Peninsula, from Cape Dezhnev to the Anadirskiy Gulf. In April there is a steady northward movement of white whales out of the Anadirskiy Gulf, although the timing of these movements depends on ice conditions. By May, white whales are observed moving northward through the Bering Strait; this migration continues until June, considerably later than movements along the coast of Alaska. During the summer, white whales are largely absent from the coastal waters of the western Bering and southern Chukchi Seas. Melnikov suggested that the summer range of this species might lie near the ice edge of the northern Chukchi and East Siberian Seas. In autumn, white whales migrate south past Koluchin Bay, although the exact route and the timing of these movements are highly dependent on ice conditions. The animals appear to move southward in a broad front from the ice-edge towards shore, then along the shore in the direction of the Bering Strait. Some animals move south to St Lawrence Island and others move along the eastern coast of the Chukotka Peninsula and into the Anadirskiy Gulf.

Martin thanked Melnikov for his presentation of this new information and noted that the sub-committee would consider these findings again when it reviewed the status of white whales in a future meeting. Reeves asked whether white whales were hunted in the waters around the Chukotka Peninsula. Melnikov responded that small numbers were

taken and offered to obtain more detailed information on the number of whales taken by native hunters for the next meeting.

7.2 Harbour porpoises

Berggren introduced SC/50/SM7, concerning porpoise bycatch in the Baltic region. He noted that although the trend data were not quantitative, porpoises appeared to have significantly declined across the whole region. However, some data are available on population structure and morphological and genetic studies have found differences between animals in the Skagerrak-Kattegat Seas and the Baltic. Similarly, there are differences between porpoises from the Belt and North Seas; between animals from the Kiel-Mecklenburg Bights and the North Sea and between those in the Skagerrak-Kattegat Seas and the west coast of Norway. Some abundance estimates are available, as are some minimum estimates of bycatch. In SC/50/SM7, Berggren *et al.* calculated mortality limits for the various areas and determined that, for the Baltic Sea at least, even minimum bycatches exceeded the calculated mortality limit. It was noted that very few data on bycatches were available from this region and that the situation was likely to be even worse than indicated in SC/50/SM7.

Kock introduced SC/50/SM8, which described the objectives and outline of methodology to be followed in a study of potential anthropogenic threats to harbour porpoises in waters near the German island of Sylt in the North Sea. The study is designed to determine what level of protection is required to allow the coexistence of harbour porpoises and diverse human activities in this area. In response to questions, Kock noted that collection of data on fishing effort would be an important component of the study and would include catch and effort data from commercial fisheries and information on recreational gillnet fisheries. Reijnders noted that an important component of such a study would be a determination of whether human activities caused them to abandon important habitat. Population counts would not necessarily detect such an effect, as the disturbed animals might be replaced by naïve ones. Kock noted that it is difficult to conduct behavioural studies with this species, primarily because of the problems in identifying individuals in the field.

The sub-committee also noted SC/50/SM11, which described a comparison of contaminant loads and pathology of harbour porpoises from the Baltic Sea, the North Sea and western Greenland. Porpoises from the three areas could be separated by principal component analysis of organochlorine contaminant loads, supporting previous evaluations of population structure of this species in the North Atlantic.

7.3 Franciscana

Pinedo described the use of parasites as biological tags in a study of stock structure in franciscanas (*Pontoporia blainvillei*) from southern Brazil, with information from Uruguay (Aznar *et al.*, 1995) and northern Argentina (SC/50/SM10). The prevalence of four gastrointestinal parasites in samples of franciscanas from southern Brazil and Uruguay differed significantly from those from Argentina. Pinedo concluded that the different prevalence of these biological markers indicated that franciscanas in these two regions could, at least during Spring, be considered separate ecological stocks. Unfortunately, it was not possible to stratify the sample of franciscanas by age to determine whether ontogenetic variation in parasite loads might exist, because age information was not available for the Uruguayan or Argentinian samples. Pinedo emphasised the value of using these biological tags as a tool to assist in defining ecological stocks. Kasuya underscored the importance of knowledge regarding the residency time of these gastrointestinal parasites in their hosts, as this factor could also influence the results of such geographical comparisons.

7.4 Other

Estimates of bycatches of small cetaceans in two California gillnet fisheries were described in SC/50/SM2 and SC/50/SM5. Perrin briefly reviewed the contents of these two papers for the sub-committee. In the driftnet fishery for swordfish and sharks, 692 sets were observed (approximately 27% of total fishing effort), in which 41 small cetaceans were taken. The species included long- and short-beaked common dolphins, northern right whale dolphins, Pacific white-sided dolphins, Risso's dolphins, Dall's porpoises and short-finned pilot whales. No direct observations were made of the set net fishery for halibut and angel sharks, so mortality was estimated using data on bycatch rate obtained in previous years. Of particular interest to the sub-committee were the results of an experiment to test the effectiveness of acoustic alarms in the driftnet fishery. The observed rate of entanglement in driftnets with acoustic alarms (0.028 small cetaceans per set) was significantly lower than the corresponding value for nets without alarms (0.11). Wade noted that the success of this experiment had resulted in the mandatory use of acoustic alarms in this fishery, in addition to other mitigation strategies. Reeves commented that this was the first successful demonstration of the use of acoustic alarms for species other than harbour porpoises, although Rogan noted that a reduction was not observed for all species. The sub-committee looked forward to reviewing the results of this experiment in more detail at a future meeting.

Entanglements of bottlenose dolphins and common dolphins in anti-predator nets situated around tuna mariculture operations in Australia were described in Kemper and Gibbs (1998). It is likely that these small cetaceans are attracted to tuna mariculture operations because of the abundant prey around the cages. This is a relatively new source of anthropogenic mortality for small cetaceans.

Hiby reviewed the potential uses of passive acoustic techniques in surveys of small cetaceans, as described in Gordon *et al.* (1998). Previous reports have described the preliminary development of this technique (Chappell *et al.*, 1996), which has now been improved. The equipment consists of a single high frequency hydrophone, towed behind a survey vessel. Porpoise clicks, which are narrow band pulses centred around 130kHz, are detected automatically or recorded by an operator. Hiby noted that this approach could be used alone or as an adjunct to human observers using visual survey techniques. Limitations to this approach include the difficulty of estimating distance and bearing to porpoise groups and determining how many animals are present in a group. Some of these problems (resolving distance and bearing) may be partially resolved by the use of multiple hydrophones in a towed array.

One particularly promising application of this technology is the use of acoustic monitoring to make primary detections of porpoises in conjunction with a tracker team using visual techniques. Members of the sub-committee noted that it may be difficult to match groups identified using acoustic/visual techniques and variation in click production due to environmental conditions, time of day and behavioural state still needs to be addressed. Despite these limitations, the

sub-committee agreed that this approach holds considerable promise, particularly for small cetaceans that are found in low densities. Palka offered to test refinements of this system in surveys of harbour porpoises to be conducted in the Gulf of Maine during 1999.

Another application of the use of passive acoustic techniques in surveys of small cetaceans was described in SC/50/SM9. Notarbartolo di Sciara briefly reviewed this use of these techniques in surveys of striped dolphins conducted in the Ligurian Sea between 1994 and 1996. Hydrophone arrays were towed behind survey vessels and one-minute recordings were made at regular intervals. The location of each monitoring station was recorded, as were environmental conditions at each station. Analysis of these data incorporated wind speed, Beaufort sea state and time of day as covariates. In general, striped dolphins were found throughout the Ligurian Sea, although densities increased in offshore waters. Detection rate dropped with increasing wind speed and sea state and increased at night, suggesting that striped dolphins may be more active at night than during the day.

The sub-committee also received two documents on the distribution of small cetaceans. In SC/50/O4, Mignucci-Giannoni *et al.* reviewed stranding records of cetaceans in the waters of Puerto Rico and the US Virgin islands. Between 1867 and 1995, 129 stranding records were recorded, representing 16 species of small cetaceans. In SC/50/O5, records of cetaceans along the coast of southeastern Brazil were reviewed. Sixteen species of small cetaceans are known from this area through observations at sea, strandings and other records.

8. TAKES OF SMALL CETACEANS IN 1997

The sub-committee reviewed a draft of Appendix 3, the summary of small cetaceans taken in directed fisheries or as bycatch in commercial fisheries. Perrin noted that direct takes of Dall's porpoise in Japanese waters had increased from 12,396 in 1995 to 18,540 in 1997 and asked whether this increase represented a trend of increased harvest. Okamoto responded that the annual quota of Dall's porpoises in Japan had been set at 17,700 and that this quota had remained unchanged. As explained in SC/50/ProgRep Japan, however, the Japanese Fisheries Agency (FAJ) changed the quota period for Dall's porpoise fisheries in 1996. Thus, although statistics in Appendix 3 cover the period from 1 January to 31 December 1997, catches made during this period fall into two periods for the reporting purposes of the FAJ. Catches of Dall's porpoises made between 1 August 1996 and 31 July 1997, for example, were 16,723 (SC/50/ProgRep Japan). Thus, the apparent increase in the harvest of Dall's porpoise in Japanese waters represents a combination of changes in the quota period and inter-annual variation in catch levels.

Brownell asked whether there was any information on the magnitude of catches of Dall's porpoises and other cetaceans in the Japanese drift net fishery operating inside the Exclusive Economic Zone of Russia. Okamoto responded that, at present, no data were available on the number of cetaceans taken in this fishery. The sub-committee encouraged the government of Russia to provide information on the size of bycatches in this fishery.

The sub-committee then discussed, in general terms, the adequacy of the information contained in Appendix 3. Several members noted that the summary was incomplete and both direct and indirect takes of small cetaceans were known to occur in several countries but were not included in this table. Perrin suggested that the table note situations where catches occur, but no quantitative information exists on their magnitude, and that member countries not contributing information to this table be encouraged to do so. The sub-committee agreed, and **recommends** that the Scientific Committee again urges member nations to provide information on bycatch and directed catches.

9. PROGRESS ON PREVIOUS YEAR'S RECOMMENDATIONS

Rojas-Bracho reviewed progress made towards assessment of the conservation status of vaquita in the Upper Gulf of California. The International Committee for the Recovery of the Vaquita will reconvene in October 1998, at which time it will consider the following topics: a temporal assessment of the unusual age structure of samples from bycatches; a spatial analysis of bycatches, incorporating age, sex, date and the geographical boundaries of regulatory areas; a description of fishing grounds and perhaps fishing effort; a review of the most recent estimates of abundance; and initial formulation of a recovery plan, incorporating socio-economic factors.

10. FUTURE PRIORITIES AND DIRECTIONS

In response to a request from the Chairman of the Scientific Committee related to item 6 on the Scientific Committee Agenda, the sub-committee reviewed the way in which it conducts its work, its objectives and priorities. After a wide-ranging discussion, the sub-committee agreed that the current process of setting priority topics for discussion was fundamentally sound. Thus, the sub-committee will continue to identify priority topics that generally involve the assessment of conservation status of particular taxa, where such assessments are useful and appropriate. These topics may focus on methodology for assessing conservation status, on a geographical region, on one or more species, or on a subject matter with relevance to many species (such as interactions with a type of fishery). The topics should be chosen on the basis of one or more stated criteria, for example: (a) recent research progress in a given field, (b) particular concern about conservation status due to levels of directed takes, bycatch or mass mortalities, or (c) the geographical location of the meeting. Once decided, priority topics should not be changed unless there were sound scientific or logistical reasons for such a change. The sub-committee considered that the manner in which it conducts its work was appropriate and should be continued, including proposing priority topics up to three years in advance. However, occasional intersessional meetings may offer a more effective way of dealing with some areas of work and reducing the current backlog.

The sub-committee then reviewed the priority topics for meetings in 1999 and beyond. After considerable discussion, it was agreed to maintain the two priority items identified last year for the 1999 meeting: status of white whales and narwhals, and recent advances in bycatch mitigation measures (specifically acoustic deterrents). The sub-committee proposed a new priority topic for discussion at its meeting in 2000 – a review of the status of freshwater cetaceans (boto, baiji, Indus and Ganges susus, tucuxi and freshwater populations of the Irrawaddy dolphin and finless porpoise), noting that comparison with marine populations of the latter two species may be of value. The sub-committee

Table 1
Priority topics.

Year	Topic	Justification
1999	Status of white whales and narwhals	Magnitude of directed takes; evidence of decline in exploited population; availability of new research results
	Bycatch mitigation measures (acoustic deterrents)	Large amount of new research results
2000	Status of freshwater cetaceans	Poor conservation status and continuing threats
	Bycatch mitigation measures	Large amount of new research results
2001+	Status of Dall's porpoises	Continuing catches; lack of recent assessment
	Systematics and population structure of *Tursiops*	Large amount of new research results
	Status of ziphiids in the Southern Ocean	Lack of previous assessment
	Status of small cetaceans in the Caribbean Sea	Lack of previous assessment; continuing catches and bycatches

agreed to delete the global review of the genus *Lissodelphis* from its list of priority topics for discussion in 2001and beyond, as the primary threat to this taxon (entanglement in high seas driftnets) has been greatly reduced. A review of the status of small cetaceans in the Caribbean region was agreed upon as a replacement priority topic. The schedule for priority topics is given in Table 1.

11. PUBLICATION OF DOCUMENTS

Martin advised the sub-committee that little progress had been made in arranging the publication of a volume incorporating papers on the status of small cetaceans in African coastal waters presented at last year's meeting. It is possible that these papers could be incorporated into the new journal format being considered for IWC publications, either as a special issue or as individual papers. Van Waerebeek remarked that the Secretariat of the Convention on Migratory Species was also considering publication of a special volume that might serve as a repository for these papers.

12. ANY OTHER BUSINESS

There was no other business.

13. ADOPTION OF REPORT

The report was adopted as amended.

REFERENCES

Anon. 1986. First meeting of experts on mortality of marine mammals. Kuwait, 22-23 November 1986. Regional Organisation for he Protection of the Marine Environment, Kuwait.

Aznar, F.J., Raga, J.A., Corcuera, J. and Monzon, F. 1995. Helminths as biological tags for franciscana *Pontoporia blainvillei* (Cetacea, Pontoporiidae) in Argentinian and Uruguayan waters. *Mammalia* 59(3):427-35.

Baldwin, R.M. 1995. Whales and Dolphins of the United Arab Emirates. Emirates Printing Press, P.O Box 5106, Dubai, UAE. 111pp. [Also in Arabic].

Baldwin, R.M. and Cockcroft, V.G. 1997. Are dugongs *Dugong dugon* in the Arabian Gulf safe? *Aquat. Mamm.* 23(2):73-4.

Baldwin, R. and Salm, R. (eds.). 1994. *Whales and Dolphins along the Coast of Oman*. 1st Edn. Robert Baldwin, CPO Seeb, Sultanate of Oman. 65pp.

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.

Chappell, O.P., Leaper, R. and Gordon, J. 1996. Development and performance of an automated harbour porpoise click detector. *Rep. int. Whal. Commn* 46:587-94.

de Silva, P.H.D.H. 1987. Cetaceans (whales, dolphins and porpoises) recorded off Sri Lanka, India, from the Arabian Sea and Gulf, Gulf of Aden and from the Red Sea. *J. Bombay Nat. Hist. Soc.* 84(3):505-25.

Esseen, M. 1996. A survey of the fisheries in the Jubail Marine Wildlife Sanctuary. pp. 479-96. *In:* F. Krupp, A.H. Abuzinada and I.A. Nader (eds.) *A Marine Wildlife Sanctuary for the Arabian Gulf. Environmental Research following the 1991 Gulf War Oil Spill.* Riyadh and Senckenberg Research Institute, Frankfurt am Mein.

Gallagher, M.D. 1991. Collections of skulls of cetacea: Odondoceti from Bahrain,United Arab Emirates and Oman, 1969-1990. *UNEP Mar. Mammal Tech. Rep.* 3:89-97.

Gordon, J., Gillespie, D. and Chapell, O. 1998. Potential uses of automated passive acoustic techniques to determine porpoise distribution and abundance in the Baltic Sea. (Unpublished ms.). 3pp.

International Whaling Commission. 1998. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48: 53-127.

Kemper, C. and Gibbs, S. 1998. Dolphin and sea lion entanglements in tuna farms in South Australia, 1994-1996. (Unpublished ms.). 2pp.

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.

Leatherwood, S. 1986. Whales, dolphins and porpoises of the Indian Ocean Sanctuary: a catalogue of available information. Hubbs Marine Research Center Technical Report 87-197. 206pp.

LeDuc, R.G. and Curry, B.E. 1996. Mitochondrial DNA sequence analysis indicates need for revision of the genus *Tursiops*. Paper SC/48/SM27 presented to IWC Scientific Committee, June 1996, Aberdeen (unpublished). 12pp.

Michel, J., Gundlach, E.R. and Hayes, M.O. 1986. Oil spill contingency planning in the Arabian Gulf. pp. 249-62. *In:* Halwagy *et al.* (eds.) *Marine Environment and Pollution. Proceedings of the Arabian Gulf Conference on Environment and Pollution, Kuwait.*

Perrin, W.F., Donovan, G.P. and Barlow, J. (eds.). 1994. *Reports of the International Whaling Commission, Special Issue 15. Cetaceans and Gillnets.* G.P. Donovan (Series ed.) International Whaling Commission, Cambridge, UK. 629pp.

Preen, A. 1991. Report of the die-off of marine mammals associated with the Gulf War oil spill. Prepared for the National Commission for Wildlife Conservation and Development. (Unpublished ms.). 8pp.

Robineau, D. and Fiquet, P. 1996. The Cetacea of the Jubail Marine Wildlife Sanctuary, Saudi Arabia. pp.438-58. *In:* F. Krupp, A.H. Abuzinada and I.A. Nader (eds.) *A Marine Wildlife Sanctuay for the Arabian Gulf. Environmental Research and Conservation Following the 1991 Gulf War Oil Spill.*

Robineau, D. and Rose, J.M. 1984. Les cétacés de Djibouti. Bilan des connaissances actuelles sur la faune cétologique de la mer Rouge et du Golfe d'Aden. *Bull. Mus. Natn. Hist. Nat., Paris* Sect. A 6((1)):219-49.

Salm, R.V., Jensen, R.A.C. and Papastavrou, V.A. 1993. *Marine fauna of Oman: cetaceans, turtles, seabirds and shallow water corals. A Marine Conservation and Development Report.* IUCN, Gland, Switzerland. 66pp.

Siddeek, S.M. and Baldwin, R.M. 1996. Assessment of the Oman Green Turtle (*Chelonia mydas*) stock using a stage-class matrix model. *J. Herpetol.* 6:1-8.

Van Waerebeek, K., Gallagher, M., Papastavrou, V. and Mustafa Al-Lawati, S. In press. Cranial Evidence of melon-headed whale and rough-toothed dolphin from Oman and the Arabian Sea. *Aquat. Mamm.*

Appendix 1

AGENDA

1. Election of Chairman
2. Adoption of Agenda
3. Appointment of Rapporteurs
4. Review of available documents
5. Review of small cetaceans in the Indian Ocean and Red Sea, with special reference to the Middle East
6. Further consideration of the criteria for assessing the status of harbour porpoise populations
7. Review of other presented information on small cetaceans
8. Takes of small cetaceans in 1997
9. Progress on previous year's recommendations
10. Future priorities and directions
11. Publication of documents
12. Any other business
13. Adoption of Report

Appendix 2

A METHOD FOR ASSESSING THE STATUS OF SMALL CETACEANS RELATIVE TO A CONSERVATION OBJECTIVE OF RESTORING POPULATIONS TO, OR MAINTAINING THEM AT, 80% OR MORE OF THE CARRYING CAPACITY

Paul R. Wade

Paper SC/50/SM12 describes a conservation objective for small cetaceans in the Baltic and North Seas that is 'to restore populations to, or maintain them at, 80% or more of the carrying capacity.' Here it is pointed out that a method exists for calculating a level of anthropogenic mortality to accomplish such an objective (Wade, 1998). This method uses a simulation approach that takes explicit account of uncertainty in estimates of abundance and anthropogenic mortality. The approach is similar to the calculation of the Potential Biological Removal (PBR) level used in the US for assessing the status of marine mammals, and is also similar to the approach used to calculate a mortality limit in SC/50/SM7. Wade (1998) applied the same simulation approach to conservation objectives other than the US goal, one of which is described here. Specifically, a conservation goal (or objective) was described as the:

> *Carrying-capacity goal* - allow a population to recover to, or remain at or above, a specified fraction of its carrying capacity.

A criterion was described for calculating a mortality limit that would identify a level of anthropogenic mortality under which a population should achieve the conservation objective described above:

> *Carrying-capacity criterion* - identify a level of anthropogenic mortality such that a population will recover to, or stay above, a specified percentage of its carrying capacity (K) with 95% probability, as estimated in simulations. This was called 'ML_K', for a mortality limit to achieve a specified percentage of K.

ML_K was calculated as:

$$ML_K = N_{20\%} \cdot \tfrac{1}{2}R_{Max} \cdot F_R,$$

where $N_{20\%}$ is the 20th percentile of an estimate of abundance (assuming log-normal error), R_{Max} is the maximum estimated net productivity rate of the stock, and F_R is a factor that is determined by the conservation goal. In the absence of a population specific estimate for R_{Max}, a default value of 0.04 was recommended by Wade (1998) for odontocetes.

Fig. 8 in Wade (1998) contains results that allow the selection of a value of F_R and indicate a value of 0.4 would achieve a conservation goal of 80%K. The exact value of F_R depends upon the precision, or coeffecient of variation (CV), of the available estimates of abundance and anthropogenic mortality. The value of 0.4 was found to work for a broad range (0.2-0.8) of CVs of the abundance estimate, combined with a mortality CV of 0.3. The value might differ slightly from 0.4 if the actual CVs were far outside this range. Software is available from the author for calculating the value of F_R for any specific combination of CVs.

Wade (1998) discusses potential biases in information on abundance, mortality, R_{Max}, and other parameters, and suggests that where such potential biases are not corrected for, a precautionary approach would be to further reduce the mortality limit. Wade (1998) recommended halving the value of F_R, as this was also shown in simulations to account for plausible levels of potential bias (discussed in the appendix to Wade, 1998). Therefore, in some situations, it might be appropriate to reduce a value such as 0.4 to 0.2 if potential biases exist and a precautionary approach is desired.

To use this method for assessing the status of small cetaceans relative to this conservation goal, knowledge is required of population structure. Obviously, uncertainty often exists in knowledge of the population structure of small cetaceans. However, Perrin and Brownell (1994) concluded that complex population sub-structure has often been found when sufficient data have been available. Identifying plausible stock divisions is important, as Taylor (1996) showed that if two true stocks are incorrectly identified as one stock, the conservation goal may not be achieved if anthropogenic mortality is concentrated in the region of just one of the stocks.

REFERENCES

Perrin, W.F. and Brownell, R.L. 1994. A brief review of stock identity in small marine cetaceans in relation to assessment of driftnet mortality in the North Pacific. *Rep. int. Whal. Commn* (special issue) 15: 393-401.

Taylor, B. 1996. Defining stocks to meet conservation goals. Southwest Fisheries Science Center Administrative Report NOAA-NMFS-LJ-23.

Wade, P.R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. *Mar. Mammal Sci.* 14:1-37.

Appendix 3

SMALL CETACEAN CATCHES 1994-1997

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). Catches are tabled according to the calendar year in which they were taken. All direct and incidental removals (including live captures) are recorded, but not stranded animals.

	1994					1995					1996					1997				
	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live
Species	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.
Argentina																				
Franciscana	-	-	-	+[a]	-	-	-	-	+[a]	-	-	-	-	-	-	-	-	-	-	-
Dusky dolphin	-	-	-	86-136[e]	-	-	-	-	50-100[e]	-	-	-	-	-	-	-	-	-	-	-
Commerson's dolphin	-	-	28[d]	10[b]	-	-	-	91[b]	20[f]	-	-	-	-	-	-	-	-	-	-	-
Peale's dolphin	-	-	3[b]	-	-	-	-	1[b]	-	-	-	-	-	-	-	-	-	-	-	-
Australia																				
Bottlenose dolphin	-	-	11	-	-	-	-	7	-	-	-	-	3	-	-	-	-	14	-	-
Common dolphin (?sp.)	-	-	8	-	-	-	-	1	-	-	1	-	6	-	-	-	-	7	-	-
Irrawaddy dolphin	-	-	-	-	-	-	-	4	-	-	-	-	1	-	-	-	-	-	-	-
Indo-Pacific humpback d.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
Spinner dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
Unidentified dolphin	-	-	11-14	-	-	-	-	18-26	-	-	-	-	12	-	-	-	-	1	-	-
Brazil																				
Killer whale	-	-	-	-	1[f]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
False killer whale	-	-	-	-	-	-	-	-	-	1[f]	-	-	1[v]	-	-	-	-	-	-	-
Spinner dolphin	-	-	1-3[p]	-	-	-	-	1[q]	-	-	-	-	-	-	-	-	-	-	-	-
Dwarf sperm whale	-	-	1[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bottlenose dolphin	-	-	1[a]	-	-	-	-	-	-	-	-	-	1[v]	-	-	-	-	1[s]	-	-
Common dolphin	-	-	3[b]	-	-	-	-	1[g]	-	-	-	-	1[v]	-	-	-	-	1[v]	-	-
Franciscana	-	-	205[e]	157-283[o]	-	-	-	133[h]		-	-		33	413-624	-	-	-	58	-	-
Tucuxi	-	-	33[d]	-	-	2[i]	-	43[j]	-	-	2	-	27	-	-	1	-	80[t]	20-25[u]	-
Spotted dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Atlantic spotted dolphin	-	-	-	-	-	-	-	1[k]	-	-	-	-	1[v]	-	-	-	-	2[s]	-	-
Pantropical spotted d.	-	-	-	-	-	-	-	1[m]	-	-	-	-	-	-	-	-	-	-	-	-
Risso's dolphin	-	-	-	-	-	-	-	1[g]	-	-	-	-	-	-	-	-	-	-	-	-
Rough-toothed dolphins	-	-	-	-	-	-	-	2[l]	-	-	-	-	2	-	-	-	-	2	-	-
Inia geoffrensis	-	-	-	-	-	4[t]	-	22[i]	-	-	11	-	3	-	-	-	-	-	-	-
Burmeister's porpoise	-	-	1[r]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified dolphins	-	-	1[e]	-	-	-	-	5[n]	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified species	-	-	10[v]	-	-	-	-	7[v]	-	-	-	-	18[v]	-	-	-	-	11[v]	-	-
Canada																				
Narwhal	a	-	-	-	-	a	-	-	-	-	a	-	-	-	-	a	-	-	-	-
White whale	a	-	-	-	-	a	-	-	-	-	a	-	-	-	-	a	-	-	-	-
Harbour porpoise	-	-	18[b]	80-120[e]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dall's porpoise	-	-	-	-	-	-	-	1[d]	-	-	-	-	-	-	-	-	-	-	-	-
Long-finned pilot whale	-	-	3[e]	-	-	-	-	9[e]	-	-	-	-	6[e]	-	-	-	-	15[f]	-	-
Atlantic white-sided d.	-	-	-	-	-	-	-	-	-	-	-	-	1[e]	-	-	-	-	-	-	-

cont..

Table 1 continued.

Species	1994					1995					1996					1997				
	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live
	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.
Unidentified dolphin	-	-	1[e]	-	-	-	-	-	-	-	-	-	2[e]	-	-	-	-	-	-	-
Unid./other cetacean	-	-	2[e]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Denmark																				
Harbour porpoise	-	-	-	4,449[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ecuador																				
Bottlenose dolphin	-	-	1[a]	227[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ETP																				
Pacific white-sided d.	-	-	16[a]	d	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bottlenose dolphin	-	-	13[a]	d	-	-	-	48[b]	48[b]	-	-	-	11[c]	11[c]	-	-	-	10[e]	10[e]	-
Pantropical spotted d.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northeastern	-	-	-	935[a]	-	-	-	952[b]	952[b]	-	-	-	818[c]	818[c]	-	-	-	721[e]	721[e]	-
Western-southern	-	-	-	1,226[a]	-	-	-	859[b]	859[b]	-	-	-	545[c]	545[c]	-	-	-	1,044[e]	1,044[e]	-
Coastal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spinner dolphin (? Stock)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eastern	-	-	-	743[a]	-	-	-	654[b]	654[b]	-	-	-	450[c]	450[c]	-	-	-	391[e]	391[e]	-
Whitebelly	-	-	-	619[a]	-	-	-	445[b]	445[b]	-	-	-	447[c]	447[c]	-	-	-	498[e]	498[e]	-
Central	-	-	11[a]	d	-	-	-	17[b]	17[b]	-	-	-	11[c]	11[c]	-	-	-	-	-	-
Striped dolphin	-	-	11[a]	d	-	-	-	34[b]	34[b]	-	-	-	5[c]	5[c]	-	-	-	80[e]	80[e]	-
Common dolphin (?sp.)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Northern	-	-	-	101[a]	-	-	-	9[b]	9[b]	-	-	-	77[c]	77[c]	-	-	-	9[e]	9[e]	-
Central	-	-	-	151[a]	-	-	-	192[b]	192[b]	-	-	-	51[c]	51[c]	-	-	-	114[e]	114[e]	-
Southern	-	-	-	-	-	-	-	-	-	-	-	-	30[c]	30[c]	-	-	-	58[e]	58[e]	-
Melon headed whale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rough-toothed dolphin	-	-	-	-	-	-	-	2[b]	2[b]	-	-	-	-	-	-	-	-	20[e]	20[e]	-
Risso's dolphin	-	-	-	-	-	-	-	1[b]	1[b]	-	-	-	-	-	-	-	-	-	-	-
Whitebelly dolphins	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Short fined pilot whales	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5[e]	5[e]	-
Unspecified dolphins	-	-	237[a]	321	-	-	-	61[b]	61[b]	-	-	-	102[c]	102[c]	-	-	-	55[e]	55[e]	-
Faroes																				
Long-finned pilot whale	1,201[a]	-	-	-	-	228[b]	-	-	-	-	1,524[c]	-	-	-	-	-	-	-	-	-
Atlantic white-sided d.	258[a]	-	-	-	-	151[b]	-	-	-	-	152[c]	-	-	-	-	-	-	-	-	-
Bottlenose dolphin	8[a]	-	-	-	-	-	-	-	-	-	21[c]	-	-	-	-	-	-	-	-	-
Harbour porpoise	-	-	-	-	-	-	-	-	-	-	3[c]	-	-	-	-	-	-	-	-	-
France																				
Long-finned pilot whale	-	-	2	a	-	-	-	2[b]	-	-	-	-	2[bc]	-	-	-	-	3[b]	-	-
White-beaked dolphin	-	-	1	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bottlenose dolphin	-	-	5	a	-	-	-	4[b]	-	-	-	-	1[bc]	-	-	-	-	4[b]	-	-
Striped dolphin	-	-	1	a	-	-	-	1[b]	-	-	-	-	7[bc]	-	-	-	-	11[b]	-	-
Common dolphin (?sp.)	-	-	9	a	-	-	-	9[b]	-	-	-	-	15[bc]	-	-	-	-	182[b]	-	-
Risso's dolphin	-	-	2	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cuvier's beaked whale	-	-	1	a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common porpoise	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8[b]	-	-
Unidentified dolphin	-	-	36	a	-	-	-	2[b]	-	-	-	-	5[bc]	-	-	-	-	72[b]	-	-
Unid./other cetacean	-	-	1	a	-	-	-	-	-	-	-	-	1[bc]	-	-	-	-	-	-	-

cont...

Table 1 continued.

Species	1994					1995					1996					1997				
	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live
	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.
Germany																				
Harbour porpoise	-	-	18	-	-	-	-	8	-	-	-	-	6	-	-	-	-	4	-	-
Long-finned pilot whale	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-
Greenland																				
Narwhal	847[a]	-	-	-	-	461[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
White whale	488[a]	-	-	-	-	606[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Harbour porpoise	1,716[a]	-	-	-	-	1,135[b]	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ireland																				
Common dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4[b]	-	-
Harbour porpoise	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2[a]	-	-
White-sided dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1[a]		
Japan																				
Baird's beaked whale	54	-	-	-	-	54	-	-	-	-	54	-	-	-	-	54	-	-	-	-
Killer whale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	5
False killer whale	-	-	-	-	-	43	-	-	-	6	35	-	-	-	5	28	-	-	-	15
Short-finned pilot whale[a]	196	-	-	-	-	238	-	1	-	1	482	-	-	-	2	347	-	-	-	-
Pacific white-sided d.	-	-	-	-	6	-	-	-	-	2	-	-	2	-	19	-	-	-	-	-
Bottlenose dolphin	310	-	-	-	52	890	-	-	-	85	280	-	-	-	34	299	-	-	-	53
Pantropical spotted d.	449	-	-	-	-	105	-	-	-	-	67	-	-	-	-	23	-	-	-	-
Striped dolphin	535	-	3	-	10	537	-	80	-	2	303	-	-	-	-	602	-	-	-	-
Short-beaked common d.	-	-	1	-	-	-	-	2	-	-	-	-	3	-	-	-	-	-	-	-
Northern right whale d.	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Risso's dolphin	312	-	-	-	-	405	-	7	-	-	369	-	5	-	3	228	-	14	-	-
Dall's porpoise	15,947	-	4	-	-	12,396	-	-	-	-	16,100	-	2	-	-	18,540	-	1	-	-
Finless porpoise	-	-	5	-	-	-	-	7	-	-	-	-	3	-	-	-	-	1	-	-
Unidentified dolphin	-	-	6	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified species	-	-	3	-	-	-	-	-	-	-	-	-	4	-	-	-	-	3	-	-
Korea																				
Baird's beaked whale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1[af]	-	-
Short-finned pilot whale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2[ag]	-	-
Pacific white-sided d.	-	-	-	-	-	-	-	-	-	-	-	-	32[ab]	-	-	-	-	2[ah]	-	-
Common dolphin	-	-	-	-	-	-	-	-	-	-	-	-	13[ac]	-	-	-	-	71[ai]	-	-
Risso's dolphin	-	-	-	-	-	-	-	-	-	-	-	-	45[ad]	-	-	-	-	2[j]	-	-
Harbour porpoise	-	-	-	-	-	-	-	-	-	-	-	-	1[ae]	-	-	-	-	-	-	-
Mexico[a]																				
Vaquita	-	-	-	-	-	-	-	0[e]	-	-	-	-	-	-	-	-	-	1[e]	-	-
Bottlenose dolphin	-	-	-	-	-	-	-	-	-	12[b]	-	-	-	-	12[d]	-	-	-	-	10[d]
Netherlands																				
Long-finned pilot whale	-	-	15	-	-	-	-	-	-	-	-	-	16	-	-	-	-	1	-	-
Atlantic white-sided d.	-	-	90	-	-	-	-	10	-	-	-	-	27	-	-	-	-	43	-	-
Bottlenose dolphin	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common dolphin (?sp.)	-	-	9	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Harbour porpoise	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	4	-	-
Unidentified dolphins	-	-	1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-

cont...

Table 1 continued.

Species	1994					1995					1996					1997				
	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live
	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.
New Zealand																				
Long-finned pilot whale	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	1	-	-
Bottlenose dolphin	-	-	-	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-	-	-
Common dolphin (?sp.)	-	-	9[a]	-	-	-	-	-	-	-	-	-	2[b]	-	-	-	-	4	-	-
Hector's dolphin	-	-	8[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Killer whale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dusky dolphin	-	-	-	-	-	-	-	-	-	-	-	-	1[b]	-	-	-	-	1	-	-
Gray's beaked whale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified dolphin	-	-	2[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Peru																				
Dusky dolphin	-	-	668[a]	1,272[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bottlenose dolphin	-	-	37[a]	42[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Long-beaked common d.	-	-	120[a]	45[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Burmeister's porpoise	-	-	185[a]	224[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unspecified species	-	-	6[a]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Africa																				
Bottlenose dolphin	-	-	48[a]	-	-	-	-	59[c]	-	-	-	-	62[a]	-	-	-	-	50[fg]	-	-
Common dolphin (?sp.)	-	-	115[a]	-	-	-	-	26[d]	-	-	-	-	32[a]	-	-	-	-	90[fg]	-	-
Indo-Pacific humpback d.	-	-	2[a]	-	-	-	-	9[a]	-	-	-	-	4[e]	-	-	-	-	7[fg]	-	-
Heaviside's dolphin	-	-	-	-	-	-	-	1[b]	-	-	-	-	-	-	-	-	-	2[fh]	-	-
Risso's dolphin	-	-	-	-	-	-	-	-	-	-	-	-	1[a]	-	-	-	-	-	-	-
Unidentified dolphins	-	-	-	-	-	-	-	-	-	-	-	-	1[a]	-	-	-	-	-	-	-
Spain																				
Striped dolphin	-	-	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Common dolphin (?sp.)	-	-	16	-	-	-	-	1	-	-	-	-	3	-	-	-	-	3	-	-
Long-finned pilot whale	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cuvier's beaked whale	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
False killer whale	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Harbour porpoise	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Bottlenose dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Unidentified dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
Sweden																				
Harbour porpoise	-	-	25	-	-	-	-	11[a]	53[a]	-	-	-	17[b]	113[e]	-	-	-	8[d]	-	-
UK																				
White-beaked dolphin	-	-	1	-	-	-	-	2[b]	-	-	-	-	-	-	-	-	-	-	-	-
Striped dolphin	-	-	1	-	-	-	-	29[a]	104[h]	-	-	-	-	-	-	-	-	-	-	-
Common dolphin (?sp.)	-	-	9[d]	54[i]	-	-	-	19[f]	61[h]	-	-	-	-	-	-	-	-	6[b]	-	-
Risso's dolphin	-	-	-	-	-	-	-	1[c]	-	-	-	-	2[e]	-	-	-	-	-	-	-
Harbour porpoise	-	-	23[e]	740[g]	-	-	-	19[b]	-	-	-	-	11[j]	-	-	-	-	41[k]	-	-
White-sided dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2[e]	-	-
Bottlenose dolphin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1[e]	-	-

cont..

Table 1 continued.

Species	1994					1995					1996					1997				
	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live	Direct		Indirect		Live
	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.	Rep.	Est. total	Rep.	Est. total	Rep.
USA																				
Baird's beaked whale	-	-	1	11	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-
White whale	-	294-300+[a]	-	-	-	-	225-227[v]	-	-	-	-	395-452[w]	-	-	-	-	303-332[x]	-	-	-
Killer whale	-	-	-	-	-	-	-	1	6	-	-	-	-	-	-	-	-	-	-	-
Dwarf sperm whale	-	-	-	-	-	-	-	1[g]	1[g]	-	-	-	-	-	-	-	-	-	-	-
Long-finned pilot whale	-	-	18[h]	22[h]	-	-	-	21[h]	31[h]	-	-	-	-	-	-	-	-	-	-	-
Short-finned pilot whale	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1[y]	6[y]	-
Pacific white-sided d.	-	-	3	17	-	-	-	1	6	-	-	-	3[u]	25[u]	-	-	-	3[y]	11[y]	-
Atlantic white-sided d.	-	-	12[q]	422[q]	-	-	-	2[r]	80[r]	-	-	-	-	-	-	-	-	-	-	-
Bottlenose dolphin	-	-	16[m]	17[m]	-	-	-	14[n]	22[n]	-	-	-	-	-	-	-	-	-	-	-
Pantropical spotted d.	-	-	28[u]	29[u]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Striped dolphin	-	-	13	19	-	-	-	2[k]	2[k]	-	-	-	-	-	-	-	-	-	-	-
Short-beaked common d.	-	-	26	146	-	-	-	36	231	-	-	-	27[u]	319[u]	-	-	-	18[y]	90[y]	-
Long-beaked common d.	-	-	1	6	-	-	-	6	39	-	-	-	1[u]	12[u]	-	-	-	4[y]	24[y]	-
Common dolphin (?sp.)	-	-	159[i]	257[i]	-	-	-	89[j]	231[j]	-	-	-	-	-	-	-	-	3[y]	11[y]	-
Northern right whale d.	-	-	7	39	-	-	-	15	58	-	-	-	5[u]	27[u]	-	-	-	5[y]	25[y]	-
Risso's dolphin	-	-	2[o]	8[o]	-	-	-	12[p]	47[p]	-	-	-	-	-	-	-	-	3[y]	8[y]	-
Harbour porpoise	-	-	105[b]	2,129[b]	-	-	-	69[f]	1,434[f]	-	-	-	-	-	-	-	-	-	38[z]	-
Dall's porpoise	-	-	9[e]	22[e]	-	-	-	41	131	-	-	-	2[u]	24[u]	-	-	-	4[y]	17[y]	-
Cuvier's beaked whale	-	-	6	34	-	-	-	6	32	-	-	-	-	-	-	-	-	-	-	-
Unidentified dolphins	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unidentified species	-	-	7[s]	22[s]	-	-	-	9[t]	9[t]	-	-	-	-	-	-	-	-	-	-	-

Argentina: (a) SC/46/SM25 estimate, Southern Buenos Aires province. Not monitored in 1994 or 1995 but the estimated effort and catch are probably similar to 1993. (b) Shore-based robalo nets in Tierra del Fuego (Goodall, unpub.). (c) 36 estimated catch in midwater trawling fishery off Patagonia (SC/48/SM22) + 50-100 from other trawls off Patagonia (Crespo, Unpub.). (d) 18 from shore-based robalo nets in Tierra del Fuego (Goodall, unpub.) + 10 from midwater trawls off Patagonia (Crespo, unpub.). (e) 0 estimated catch in midwater trawling fishery off Patagonia (SC/48/SM22) + 50-100 from other trawls off Patagonia (Crespo, unpub.). (f) 20 from shore-based robalo nets in Tierra del Fuego (Goodall, unpub.) + 0 from midwater trawls off Patagonia (Crespo, unpub.).

Brazil: Note: All the information for the 1995 catches was taken from the revised Prog.Rep. Brazil except for the 44 strandings of franciscana in Southern Brazil (pers. commn. M.C.Pinedo). (a) Paraná. (b) 2 killed in southern oceanic fleet gillnets (Secchi *et al.* unpub. data) + 1 caught in Rio Grande do Sul State coast (E. Secchi, pers. commn.). (c) 58 from southern Rio Grande do Sul + 39 from northern Rio Grande do Sul + 2 from Rio de Janeiro + 9 from Paraná + 97 by coastal gillnet boats in Rio Grande do Sul, southern coast (about 25% of fleet) (SC/48/SM12). (d) 13 from Paraná + 16 from Santa Catarina + 4 caught in northern Rio de Janeiro. (e) Caught in nets from Sepetiba Bay, Rio de Janeiro (SC/46/SM10). (f) Caught in a monofilament longline set for tuna and swordfish fisheries in southeastern and southern Brazil (Secchi and Dalla Rosa, unpub. data). (g) Caught in Rio Grande do Sul State coast (E.Secchi, pers. commn.). (h) 10 from Rio Grande port by about 20% of the total coastal gillnet fleet + 4 caught in gillnets set for gadids and sciaenids from northern Rio Grande (May 1995 - April 1996) + 40 caught in gillnets in northern Rio Grande (May 1995 - April 1996) + 1 caught in fishing nets in Pontal do Sul, Paraná + 22 caught in Rio de Janeiro + 12 caught in Cabo de Santa Marta, Santa Catarina State (4 observed + 8 reported by fishermen) + 44 strandings from a long-term monitoring programme in southern Brazil, assumed to be caught in gillnets (M.C. Pinedo). (i) Caught in the Mamirauá system. (j) 8 caught in fishing nets in Pontal do Sul, Paraná + 9 caught in Rio de Janeiro + 2 strandings, 1 with net marks and another with knife cuts + 8 taken in fishing nets + 16 in the Mamirauá system. (k) Stranded with net marks on the body. (l) Taken in fishing nets. (m) Caught in Cabo de Santa Marta, Santa Catarina State. (n) 4 from Rio de Janeiro + 1. (o) Estimate 220-283 Poisson model, 157-230 Geometric model and 199-267 non-parametric model using data of animals caught in coastal gillnets set for sciaenids (78 animals caught from 37 fishing boats taken from a total fleet of about 145 vessels (SC/49/SM37). (p) Taken off the coast of Cabo Frio. (q) Taken off the coast of Rio Grande do Sul (SC/49/SM7). (r) Dalla Rosa (unpub. data). (s) Captured by boats operating from Ubatuba (SC/49/SM7). (t) Northeast 7, Southern/SC 6, Southern/PR 16, Southeast/BA 3, Amazon 36, Rio de Janeiro (UENF) 12. (u) Southern/SC. (v) Caught in Rio de Janeiro (UENF).

Canada: (a) No information. (b) Figure composed of 1 killed in chum salmon gillnet (SC/47/O 6) + 17 killed in Bay of Fundy herring weirs (SC/47/SM18). (c) E.A. Trippel 1995. Harbour porpoise bycatch in the Bay of Fundy gillnet fishery. Project summary, Fisheries and Oceans, Canada, 4pp. (d) SC/48/O 2. (e) SC/49/O 5. (f) Incidentally bycaught in bottom trawls off Nova Scotia. (Hooker, S.K., Baird, R.W. and Showell, M.A., unpub.).

Denmark: (a) Bycatch in turbot and cod fisheries (preliminary estimates).

Ecuador: (a) SC/47/SM38.

ETP: (a) SC/47/SM1. The following catches are included: Mexico 1,472 dolphins (unspecified) (SC/47/ProgRep Mexico), USA 68 pantropical spotted dolphins + 38 spinner dolphins (SC/47/SM4). (b) SC/48/SM4. (c) SC/49/SM4. (d) Included in unspecified dolphins. (e) Background Paper 6, 61st meeting of the IATTC, June 10-12, 1998 - Tuna-Dolphin Investigations.

Faroes: (a) NAMMCO Annual Report 1995: Faroe Islands Progress Report 1994. (b) NAMMCO Annual Report 1996: Faroe Islands Progress Report 1995. (c) NAMMCO Annual Report 1997: Faroe Islands Progress Report1996.

France: (a) No information on the tuna driftnet fishery in 1994. (b) Includes those found stranded with marks indicating that they had been most probably caught in fishing gear. (c) pers. commn. A. Collet.
Greenland: (a) NAMMCO Annual Report 1996: Greenland Prog Rep 1994. (b) NAMMCO Annual Report 1997: Greenland Prog Rep 1995.
Ireland: (a) Bycatch determined from post-mortems. (b) Bycatch of 3 determined from post-mortems + 1 incidentally caught in a pelagic trawl.
Japan: (a) Northern and Southern forms.
Korea: (a) Kyeong-Buk area. (b) 19 coastal drift gillnet, 9 set-net, 3 coastal trap, 1 coastal gillnet. (c) 10 set-net, 3 coastal drift gillnet. (d) 44 set-net, 1 Offshore angling. (e) Set-net. (f) Coastal drift gillnet. (g) Drift gillnet. (h) 1 coastal trap, 1 coastal gillnet. (i) 48 set-net, 9 coastal trap, 8 coastal drift gillnet, 3 offshore drift gillnet, 1 coastal gillnet, 1 drift gillnet, 1 coastal longline. (j) Kyeong-Nam area 1 set-net, Kang-Won area 1 gillnet.
Mexico: (a) See catches taken in the Eastern Tropical Pacific. They are not included here. (b) Permits issued by SEMARNAP. The animals are being kept in captivity at recreational facilities. (c) Two out of three main fishing towns in the Upper Gulf of California (Puerto Peñasco, Sonora and San Felipe, Baja California) were monitored during December, observing 122 gillnet settings. Fishing activities in the Upper Gulf of California were not monitored during other months. There were no other reports from other field researchers working in the area. (d) The animals were live captured at locations in the Gulf of California under permits issued by SEMARNAP. They are being kept in captivity at recreational facilities. (e) Captured in the Gulf of California.
New Zealand: (a) Catch taken during the period April 1994 - March 1995. (b) Pers. commn. M. Donoghue.
Peru: (a) SC/47/SM38. Mixed incidental and directed. Catches are for the period Jan. - Aug. 1994 from Cerro Azul and from shorter surveys throughout the year at 16 other ports and are composed as follows (estimated catch is given first, followed by the observed catch in brackets: dusky dolphin, 1,272 (597) caught in gillnet fishery off Cerro Azul, (71) from 16 other ports; bottlenose dolphin, 42 (17) caught in gillnet fishery off Cerro Azul, (20) from 16 other ports; long beaked common dolphin, 45 (17) caught in gillnet fishery off Cerro Azul, (103) from 16 other ports; Burmeister's porpoise, 224 (91) caught in gillnet fishery off Cerro Azul, (94) from 16 other ports; Unspecified species, from 16 ports other than Cerro Azul.
South Africa: (a) Annual catch of small cetaceans in shark nets (SC/49/SM34). (b) Fishery-related mortalities (excluding live-fishery) (SC/49/SM34). 57 in shark nets + 2 fishery-related mortalities (SC/49/SM34). (c) Figure composed as follows: 25 in shark nets + 1 fishery-related mortality (SC/49/SM34). (d) Figures composed as follows: 3 in shark nets + 1 fishery-related mortality (SC/49/SM34). (e) pers. commn. P. Best. (g) Caught in shark nets. (h) Died in research trawl.
Sweden: (a) SC/48/SM25 bycatch in the Swedish codfish gillnet fishery in ICES Area 4456. Reported catch taken during a total of 95 observer days at sea. (b) The bycatch observer schemes reported 6 harbour porpoises in the Skagerrak Sea and 8 in the Kattegat Sea . An additional 3 animals were collected in the Skagerrak Sea from the driftnet fishery during the satellite telemetry study. (c) Estimate for bycatch in the Swedish Skaggerak Sea cod fish gillnet fishery based on observer scheme data. (d) Two bycaught in Skagerrak Sea mackeral driftnets + 5 bycaught in Skagerrak Sea bottom set gillnets + 1 bycaught in Baltic Sea bottom set gillnet.
UK: (a) Bycatch from Biscay driftnets. (b) Bycatch determined from strandings post-mortems (England and Wales). (c) Bycatch determined from strandings post-mortems (Scotland). (d) 1 observed bycatch from Celtic Sea gillnets + 8 determined from strandings post-mortems (England and Wales). (e) 2 observed bycatch from Celtic Sea gillnets + 21 determined from strandings post-mortems (England and Wales). (f) 17 observed bycatch from Biscay driftnets + 2 determined from strandings post-mortems (England and Wales). (g) From observer programme 1992-1994 and average fishing effort over 1993-94. Estimate of bycatch for a 12 month period between 1993 and 1994. (h) Estimate of bycatch from Biscay driftnets. From observation of 28% of effort for Biscay driftnets only (observed bycatch 17). (i) Estimate of bycatch from Celtic Sea gillnets (observed bycatch 1). (j) 3 from bottom set gillnets + 8 determined from strandings post-mortems (7 from England and Wales + 1 from Scotland). (k) 25 from bottom set gillnets + 16 determined from strandings post-mortems (12 from England and Wales + 4 from Scotland).
USA: Figures for the years 1994-1996 were compiled by Janeen Quintal (except for the white whale figures which were taken from SC/50/ProgRepUSA). 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 unless otherwise indicated. Stranded animals are not included.
The 1997 information was taken from National Progress reports unless otherwise stated.
In the following notes the estimated catch is given, followed by observed catch in brackets
(a) Includes 18+ struck and lost (SC/50/ProgRepUSA). (b) Figure composed as follows: 2100(99) in new England groundfish sink gillnet + 14(1) in California halibut set gillnet + 15(1) in Puget Sound, Washington sockeye salmon drift gillnet. (c) Figure composed as follows: 11(2) in California drift gillnet + (2) in Washington/Oregon/California whiting trawl fishery + 11(5) in Alaska groundfish trawl fishery and Bering Sea/Aleutian Is. (BSA) groundfish trawl and longline fisheries. (d) Including 84 struck and lost. SC/49/ProgRepUSA (e) Including 94-148 struck and lost. SC/49/ProgRepUSA. (f) 1400(43) in New England sink gillnet + 14(0) in California halibut set gillnet + 20(20) in N. Washington marine set gillnet + (6) in Mid-Atlantic coast sink gillnet. (g) New England pelagic drift gillnet. (h) May include some short-finned pilot whales; Atlantic swordfish gillnet and pair trawl fisheries. (i) Figure composed as follows: 163(142) in New England pelagic drift gillnet + 94(17) in California shark/swordfish drift gillnet. (j) Figure composed as follows: 83(82) in New England pelagic drift gillnet + 6(3) in New England pelagic pair trawl + 142(3) in N. Atlantic bottom trawl + (1) in Mid-Atlantic coastal gillnet. (k) New England pelagic drift gillnet. (l) 6(1) in California shark/swordfish drift gillnet + 7(3) in Alaska BSA groundfish trawl and longline fisheries. (m) 13(12) in New England pelagic drift gillnet + 4(3) in New England pelagic pair trawl + (1) in Mid-Atlantic coastal sink gillnet. (n) 5(5) in New England pelagic drift gillnet + 17(9) in New England pelagic pair trawl. (o) 2(1) in New England pelagic drift gillnet + 6 (1) in California shark/swordfish drift gillnet. (p) 4(4) in New England pelagic drift gillnet + 4(2) in New England pelagic pair trawl + 39(6) in California shark/swordfish dirft gillnet. (q) 240(10) in New England groundfish sink gillnet + 182 (2) in N. Atlantic bottom trawl. (r) 80(2) in New England groundfish sink gillnet. (s) 5(4) in New England pelagic drift gillnet + 17(3) in California shark/swordfish drift gillnet. (t) New England pelagic drift gillnet. (u) SC/49/SM2. California swordfish/shark drift gillnet fishery. (v) Includes 38 struck and lost (SC/50/ProgRepUSA). (w) Includes 91-140 struck and lost + 304-312 landed (SC/50/ProgRepUSA). (x) Includes 82-99 struck and lost + 221-233 landed (SC/50/ProgRepUSA). (y) California drift gillnet. SC/50/SM2. (z) California halibut/angel shark set-net. This fishery has not been observed since July of 1994; consequently estimates of harbour porpoise were based on observations during the period Jul. 1990-Jul. 1994. Using mean-per-unit estimation, an estimated 38 harbour porpoise were killed in this fishery during 3,215 effort days in 1997.

Annex J
Report of the Sub-Committee on Whalewatching

Members: Kato (Chair), Addison, Baldwin, Berggren, Carlson, Chen, Childerhouse, Clapham, Clark, Fabbri, Findlay, Goto, Gunnlaugsson, Hakamada, Hatanaka, Kawachi, Kim, Kock, Komatsu, Lawrence, Leaper, Lens, Miyashita, Moronuki, Nakamura, Nishiwaki, Notarbartolo di Sciara, Ohsumi, Papastavrou, Pérez-Cortés, Pinedo, Reijnders, Reilly, Robineau, Rogan, Rojas Bracho, Simmonds, Slooten, Stachowitsch, Swartz, Tanakura, Thiele, Tomita, Van Waerebeek, Walløe, Walters, Yamamura, Zeh.

1. OPENING REMARKS, ELECTION OF CHAIR AND APPOINTMENT OF RAPPORTEURS

Kato was elected Chairman and Findlay was appointed rapporteur.

2. ADOPTION OF AGENDA

The adopted Agenda is given as Appendix 1.

3. REVIEW OF AVAILABLE DOCUMENTS

Documents relevant to items on the Agenda included SC/50/WW1-3; 5-11; SC/50/ProgReps Australia, UK, New Zealand, Japan, Spain and Mexico; and McCauley (1998).

4. ACTION ARISING FROM 1997 MEETING INCLUDING THE COMMISSION'S RESPONSE

No new resolution on whalewatching had been passed at the 1997 Commission meeting and consequently the previous resolution remains. Last year, Carlson offered to submit an updated version of Carlson (1996) to this year's meeting (SC/50/WW9). It was noted that this review was ongoing in that regulations from the Azores and the Code of Conduct from Madagascar had not been incorporated. Given the bulk of this document, individual copies were not distributed and a master copy was circulated for members comment.

5. PRIORITY ITEMS

5.1 Review of guidelines (including management policy on developing tourism industry in the broad sense)

A number of submissions were received from Australia. SC/50/WW1 reported on the management of a developing dwarf minke whale tourism industry in northern Queensland. Government, research and industry were working cooperatively on the management of this largely swim-based industry with research being carried out during all approaches. It was asked if research could be carried out from independent platforms (land, sea, air). Research could be carried out from other vessels or aircraft but their activity was generally undertaken too far from land. Ohsumi, noting there were no tourism activities of diving with whales in Japan, questioned the safety aspect of swim tours. In response, it was noted that clients were linked to the vessel via ropes, thus providing some control by the operator. Information on other swim-based operations on Silver Banks was reported and Findlay provided anecdotal evidence of an aggressive encounter whilst filming right whales in South Africa. Stachowitsch supported the concept of having clients attached to the vessel by holding lines, this was seconded by Slooten. It was suggested that boat- and swim-based whalewatching were significantly different and that this group should review these separately. Swim operations were managed on a case by case basis in Australia. In response to a question regarding guidelines from swim programmes around the world, it was concluded that more detailed information was required.

SC/50/WW2 reported on management of cetacean tourism in Australia and the need for coordinated management between the eight government departments presently responsible. A two-tiered management system was proposed, in which the first tier would set national standards, while the second tier would address issues within this. Consensus had been reached for State and Commonwealth waters and comments were invited from industry NGOs and communities. It was noted that many nations were developing guidelines at a national level, but that situations differed by locality and species and that such differences needed to be considered in national, regional and local guidelines. The difference between the new Australian Draft National Guidelines and the existing legislation was that the National Guidelines would have a punitive aspect. Swartz commented that the experience of the United States is that it is very difficult to enforce legislation and, that consequently, possibly better enforcement arises through aggressive education and awareness campaigns.

SC/50/WW3 reported on the formation of a cetacean tourism industry association in Australia. Slooten suggested that such a body could raise standards of operations by offering training courses. Ohsumi encouraged the formation of such an association and questioned the relationship between the association and recreational boaters. In response it was stated that there was no relationship between the association and recreational boat users.

SC/50/WW5 commented on the whalewatching industry in Australia and the lack of biological research into whalewatching in the region. It was questioned if levies could be better distributed for research. Findlay questioned the two years of comparable aerial survey data from Hervey Bay (1989 and 1990) and it was noted that further comparable survey effort was planned. Ohsumi noted that whalewatching should be developed in close association with research and that in Japan research has increased at various whalewatching sites. This association was seconded by Rogan who suggested that a monitoring aspect be included in the guidelines.

SC/50/WW6 provided a review of management and research of the cetacean tourism industry in New Zealand. The legislation controlling whalewatching in New Zealand is the Marine Mammal Protection Act of 1978 and the Marine Mammal Protection Regulations of 1992, both of which are presently under review. Research into the effects of cetacean tourism activities in New Zealand include studies on the sperm whale, Hector's dolphin and dusky dolphin. Major difficulties encountered were the large number of operators and the lack of pre-industry baseline data.

SC/50/WW7 summarised on the growth of whalewatching in Iceland and noted the lack of regulations in this region.

SC/50/WW8 reported on whalewatching of killer whales at Tysfjord, Norway where operators were subject to voluntary guidelines and that interest in following guidelines was declining. Walløe commented that a recent decline in local herring abundance had resulted in fewer whales for whalewatching. It was questioned if any other information on whalewatching was available from Norway. The operation at Andenes was referred to and Carlson commented that the guidelines from this region were included in SC/50/WW9. It was reported that conflict between whalewatching and hunting was not evident in Norway. In response to a question of whether whaling resulted in fewer whales for whalewatching in Norway, Walløe replied that watching was based on killer and sperm whales and not minke whales. Therefore, there are no direct conflicts in terms of whales avoiding boats or reductions in whale abundance caused by whaling. SC/50/WW8 reported on shore-based theodolite tracking research combined with the use of video. Some members endorsed further development of this research approach.

Simmonds and Slooten proposed that five components raised in last year's meeting be restated in the record of this year's group. These included Permit System, Protective Guidelines, Punitive Aspects, Research and Educational Activities. They asked if the development of scientific guidelines for the evaluation of possible whalewatching impacts could form the basis of an Intersessional Working Group. Moronuki suggested that Permit System and Punitive Aspects were outside the competence of the IWC. Walters asked who Educational Activities were directed at and commented that guidelines have an educational component. Kato noted that education was within the competence of the IWC as referred as a priority item in IWC Resolution 1996-2 (IWC, 1997). Gambell stated that the references to whalewatching education in this resolution did not necessarily apply to the Scientific Committee and that whalewatching education was not within the realms of the Scientific Committee.

A suggestion that these issues be raised in an Intersessional Correspondence Group was endorsed by the sub-committee who recommended that the formation of an Intersessional Correspondence Group on scientific aspects of whalewatching should be investigated. The group will communicate by e-mail and other means on:

(1) scientific protocols for research on the effects of whalewatching on cetaceans;
(2) the scientific basis for management;
(3) research on the effectiveness of management.

Moronuki expressed his concern that the discussions under Item 5.1 were proceeding in a direction which is outside of IWC competence. He noted that the issues of whalewatching should not be handled from the viewpoint of development and analysis of tourism industries, but rather from the point of management of whale resources and providing proper scientific advice for the establishment of guidelines for whalewatching.

5.2 Assessment of short-term reactions

SC/50/WW10 reported on the use of land-based theodolite tracking to monitor the effects of tourism on dusky dolphins at Kaikoura, New Zealand. Dolphins were accompanied by vessels for a high proportion of daylight hours (72%) and almost 10% of approaches violated the regulations. Results suggest that dolphins are more sensitive to disturbance from midday onwards when they appeared to rest. One recommendation for mitigation of disturbance was the establishment of an afternoon period when no commercial approaches would be allowed. It was noted that given that dolphins are generally less active during this period operators may well support this recommendation.

Walters questioned whether there had been a determination of the most suitable size of vessel as related to distance of approaches. It was reported that Kaikoura vessels were initially about 21ft but now dolphin watching operators use vessels of about 25ft and whalewatching operations use vessels of between 30-40ft. Carlson commented that the sizes of whalewatching vessels around the world ranged between kayaks and vessels of over 100ft. It was questioned if blimps had ever been used for whalewatching to which Carlson commented that research had been conducted from a blimp off the coast of New England.

Lawrence queried as to what extent the Kaikoura dusky dolphin watching industry could be allowed to increase, to which it was replied that the industry was presently at its probable maximum given the time that dolphins are subject to boat pressure.

SC/50/WW11 reported on responses of Hector's dolphins to swimmers and boats in New Zealand waters. Whereas swimmers (from shore) elicited weak response from the dolphins, reactions to the boats were stronger. Dolphins were initially attracted to the vessel, but became less interested as the encounter progressed. Dolphins were found to be more tightly bunched when a boat was in the vicinity. The advantage of observers being based on the land was stressed in that no disturbances arise from the monitor platform. Swartz noted that following their initial attraction to vessels, after approximately one hour the dolphins were even less likely to approach a vessel than before the encounter began (~30% compared to 10%), suggesting that dolphins progressively loose interest in vessels. Lawrence seconded the comment of Swartz and noted that dolphin responses to boats within bays or open waters differ.

Findlay reported on shore-based theodolite research on the effects of controlled vessel traffic on southern right whales in South Africa and offered to submit a report of this to a future meeting. Gambell reported the Omani commissioner had requested advice on whale approaches to fishing vessels in Omani waters. It was noted these were probably *Pseudorca crassidens*.

Papastavrou noted that the use of a theodolite in conjunction with video reported in SC/50/WW8 was promising and suggested others adopt this approach. It was suggested that a report be submitted to a future meeting of the Scientific Committee. Walters commented that this was not possible at present as the work was still in progress. The Group held some discussion on the use of the video camera for recording behaviour and it was noted that ideas on

technology could be exchanged through the Correspondence Group.

Kato reported on research of short-term reactions from land on humpback whales off the Bonin Islands, Japan. The report will probably be available at the next meeting.

Clark reported on some results from research projects in Hawaii investigating responses of humpback whales to low-frequency sounds from the Acoustic Thermography of Ocean Climate (ATOC) project and from the US Navy's low frequency active (LFA) sonar system. In 1994 off north Kauai while collecting baseline data prior to any ATOC transmissions, humpbacks were observed responding to vessels. He noted that cow-calf groups consistently responded to the approaches of various types of vessels as the vessels approached to within 100-300m of the whales. Clark suggested that animals were not responding to a particular sound level but rather an acoustic dynamic such as the rate of change of sound level or bearing rate. Van Waerebeek enquired as to the influence of a vessel's sound frequencies on response to which Clark replied that frequency content changes as a function of the vessel's distance from the whales and that there are multiple features in the frequency dynamic that could be cues on vessel proximity. Clark reported that these 1994 results will be published and that preliminary results from 1998 indicate humpback whales show no obvious responses to the ATOC sound. Carlson reported that an increasing number of nations were incorporating approach and departure angle into legislation for behaviour of whalewatching vessels over and above minimum approach distances. The sub-committee thanked Clark for his presentation and encouraged submission of the work to a future Scientific Committee meeting.

Findlay reported on short- and long-term effects of whalewatching on right whales as discussed in the Report on the Workshop on the Comprehensive Assessment of Right Whales (SC/50/Rep4).

5.3 Comparative studies

SC/50/ProgRep UK described two studies being carried out at Aberdeen University. The first is the study reported in SC/50/WW8, while the second is a study on distribution and acoustic behaviour of bottlenose dolphins in an area of intense dolphin watching activity.

5.4 Report from Monkey Mia, Western Australia

Aspects of the dolphin feeding programme at Monkey Mia, Western Australia (Appendix 2) were reported on, including the history of feeding activities, guidelines and feeding regimes and fatalities of dolphins. The sub-committee expressed its appreciation to Australia for submission of this report. Ohsumi noted that generally the feeding of wild animals resulted in the negative aspect of loss of their wild nature. At the same time he suggested that provisioning often results in a decrease in mortality, although at Monkey Mia, mortality trends were increasing as a result of provisioning. It was questioned if contamination of food could be a factor in dolphin deaths. In response it was stated that mortalities had declined since the new feeding regime and that there was no evidence that deaths result from contamination of food sources. Simmonds noted that 10 years after the 1989 mortality event it was gratifying to note that, post-1993, almost all deaths could be ascribed to causes and that none of these causes could be related to the existing feeding regime, and suggested that this was a credit to the existing management regime. Findlay asked whether the results of investigations at Monkey Mia had been incorporated in feeding programmes elsewhere in Australia (for example, Tangalooma). In response it was noted that feeding at Tangalooma was initiated after the Monkey Mia report and that the feeding activities were markedly different. Notarbartolo di Sciara reported that the Monkey Mia example was the only example reviewed at the Montecastello Workshop (IFAW, 1995) where long-term trend could be linked to short-term effects from cetacean tourism activities. This may result from the difficulties of conducting long-term research on the effects of tourism activities on cetaceans and the lack of pre-industry baseline data. Carlson commented that a number of long-term studies were available which could be utilised to monitor long-term effects of whalewatching. It was questioned whether research, and particularly research on biological parameters, were continuing at Monkey Mia to which it was stated a long-term ecological and behavioural study was being undertaken on the bottlenose dolphins of Shark Bay.

5.5 Other information

SC/50/ProgRep Spain noted that a revision of the Decree regulating whalewatching activities in the Canary Islands is in progress to include the introduction of monitor-guides on whalewatching vessels and the use of a 'blue boat' distinctive by the boats that comply with the regulations. It was also reported that a training course for the monitors was carried out in 1997 and another one is programmed for 1998. Some discussion was held regarding approach distance limitations in the region and Carlson noted that although approach distances varied greatly around the world, approach conditions generally did not. Walters noted that this information highlights the need for research on long-term impacts of whalewatching.

SC/50/ProgRepMexico reported that during the last season the ongoing studies of the short and long-term effects of whalewatching in the gray whale breeding lagoons of Mexico had been compromised in one of three sites where research into El Niño conditions was being carried out.

It was noted that the World Marine Mammal Science Conference, Monaco 1998, included workshops on Whalewatching. The minutes of one of these workshops are available on the World Wide Web (*http://office.geog.uvic.ca/dept/whale/wrlmp.html*).

Clark suggested that it would be extremely difficult to design an experiment to adequately assess the long-term impacts of whalewatching but that whalewatching is one area where a common ethic of courtesy to whales can be demonstrated. Carlson recommended a precautionary approach where no data are available. Findlay noted the difficulties that had been experienced in South Africa in designing an experiment to measure long-term effects of whalewatching on right whales. Simmonds suggested that the ongoing studies conducted by Aberdeen University might be useful in this respect.

Kato reported on several research activities on whalewatching being carried out in Japan including work on Bryde's, humpback whales and bottlenose dolphins.

Rojas Bracho suggested that the Group hold some future discussion of which areas would best be suited for a long-term study of the effects of whalewatching on cetaceans. The sub-committee agreed that this would be best achieved through the Intersessional Correspondence Group and initial aspects of discussion could be criteria for selection of such areas.

6. OTHER MATTERS

The sub-committee agreed that all items on this year's Agenda (excluding Monkey Mia) be included as future priorities and that an item on assessment of long-term effects be included as a further future priority.

The sub-committee requests submission of documents on long-term effects of whalewatching.

7. ADOPTION OF REPORT

This report was adopted at 12.45 on 3 May 1998.

REFERENCES

Carlson, C.A. 1996. A review of whale watching guidelines and regulations around the world. Paper SC/48/O 25 presented to IWC Scientific Committee, June 1996, Aberdeen (unpublished). 59pp.

IFAW, 1995. Report on the workshop on the scientific aspects of managing whale watching. Montecastello di Vibio, Italy, 30 March-4 April 1995. 40pp.

International Whaling Commission. 1997. Chairman's Report of the Forty-eighth Annual Meeting. Appendix 2. *Rep. int. Whal. Commn* 47: 48.

McCauley, R.D., Cato, D.H. and Jeffery, A.F. 1998. A study of the impacts of vessel noise on humpback whales in Hervey Bay. (Unpublished ms.).

Appendix 1

AGENDA

1. Opening remarks, election of Chairman and appointment of rapporteurs
2. Adoption of Agenda
3. Review of available documents
4. Action arising from 1997 meeting including Commission's response
5. Priority items
   - 5.1 Review of guidelines (including management policy on developing tourism industry in the broad sense)
   - 5.2 Assessment of short-term reactions
   - 5.3 Comparative studies
   - 5.4 Report from Monkey Mia, Western Australia
   - 5.5 Other information
6. Other matters
7. Publication of documents
8. Adoption of report

Appendix 2

REPORT ON THE DOLPHIN FEEDING PROGRAM AT MONKEY MIA SHARK BAY, WESTERN AUSTRALIA

Milena Rafic

Wildlife Management - Biodiversity Group, Environment Australia, Canberra, ACT

In IWC (1997), it was noted that the dolphin feeding program at Monkey Mia, Western Australia, was the 'only operation for which there was an assessment of a direct adverse impact on juvenile survivorship from a long-term provisioning program'. A report was requested on this program and any associated fatalities that may have occurred there.

History

Feeding dolphins at Monkey Mia beach in Shark Bay, Western Australia began with casual handouts to the dolphins by fishermen in the area. A caravan park was built in 1975, however numbers of visitors remained relatively low at approximately 10,000 a year due to a lack of facilities, difficulty in accessing the area and scarcity of public awareness (Department of Conservation and Land Management and Shire of Shark Bay, 1993). A rapid increase in visitor numbers occurred after improvements in roads to the area and an expansion in facilities and access. Currently visitor numbers are relatively constant at 100,000 per year with peak numbers of 114,000 in 1989 and 102,000 in 1990. The most popular months are in the austral winter period of July to September and visitor surveys show that the majority of visitors are there for the first time; revisits are not common.

Feeding regime and guidelines

In the early days of feeding dolphins, frozen fish was sold to the general public to ensure the public access to a supply of fish and to collect monies to support a foundation for education and dolphin interaction awareness. At this time, the number of fish given out, the number of people offering fish and the quality of fish were not regulated. The dolphins were then visiting the beach on a more regular basis in response to the more continuous supply of fish available year round. In early 1987, Rangers at Monkey Mia stopped buying fish from Perth and were supplied by the local fishermen thus ensuring dolphins were being fed fish from their natural habitat. Researchers from the University of Michigan studying the Monkey Mia dolphins became concerned that abnormal behavioural changes during mating were directly associated with the provisioning of these dolphins (Gales, 1994). In discussions with the Rangers it was agreed to limit the amount of food sold daily to 21-28 kg

in September 1987, down from the previous high of 35kg of fish per day. The total was then again cut down to a maximum of 15kg per day in June 1988. The sale of fish ended in February 1989 to allow the Rangers more control over the feeding. A modified feeding regime was then introduced in September 1994 following the recommendations of the Wilson Report (1994).

Of the total population of 250-300 dolphins that are found offshore in the Shark Bay Marine Park, 5-8 are considered 'regular' visitors to the beach and about another 20 are 'infrequent' visitors. A high juvenile mortality rate for calves born to provisioned females led to a report commissioned by the Department of Conservation and Land Management (CALM) WA. The report, by Dr Barry Wilson, presented in 1994, led to the new feeding regime introduced in that year. Wilson recommended a number of changes to the way dolphins were fed and the following guidelines were introduced in September 1994.

(1) Feeding of calves is banned until they are fully weaned.
(2) No feeding of male dolphins.
(3) Regular feeding times were introduced to avoid the tendency for feeding.
(4) Fresh fish is made available, with frozen fish kept only as a back-up.

The dolphins are fed a maximum of one third of their estimated daily food requirements based on their estimated body weight. The Rangers from CALM regulate the feeding by handing selected people in the designated dolphin interaction area fish to feed the dolphins. Swimming and boating is not allowed in the dolphin interaction area and visitors are advised that if swimming outside the area and approached by dolphins, they are not to attempt to touch or disturb them.

The Wilson Report (1994) noted that researchers found that infant survival rates during 1985-93 were much higher for non-provisioned females than for those females being regularly fed at the beach. This was especially significant for first year calf survival rates, i.e. 67% for calves with non-provisioned mothers and 36% for calves from provisioned females. At the time of the report being written, since provisioning was regulated, only 2 calves from 11 named offspring of the provisioned dolphins survived.

Pollution event

The disappearance of seven of the provisioned dolphins, including 3 calves, over 18 days in early 1989, was believed to be linked to a pollution event involving a contamination of faecal bacteria in the area of the Monkey Mia beach. The area was affected by sewage contamination (Environmental Protection Authority, 1989) and it is possible that the disappearance of the dolphins was directly related to this event but this has remained unproven. The contamination has not recurred and a review and modification of the area's sewage disposal system was undertaken.

Fatalities at Monkey Mia

Researchers attribute at least two deaths indirectly to the provisioning system at Monkey Mia (Wilson, 1994). 'Hobbit', a female calf born to one of the long term provisioned females at Monkey Mia, was small at birth and at three months of age showed a stunted growth rate. She was killed by a shark (19 March 1994) within sight of the Monkey Mia beach while her mother and other group females were interacting with people. Provisioning was held to be a factor in her death for two reasons: her low growth rate was attributed to the poor nutritional quality of food available to her mother; and the protection normally given to calves by their mothers and others in the group was lacking as they were engaged in feeding activities at the beach when Hobbit was by herself at some distance from the beach.

'Finnick', the juvenile male killed by possible shark attack (Table 2) was also born to a long term provisioned female and had been regularly hand fed as he visited the Monkey Mia beach with his mother. He showed markedly different behaviours from that displayed by non-provisioned juvenile male dolphins in the area: i.e. decline of time spent hunting; daylight hours spent at the beach or begging for food handouts from fishermen; no alliances formed with other male dolphins; approaches to boats travelling at speed, and aggressive behaviours to people on the beach and fishermen in the area. In early 1994, his health deteriorated and as tests showed no signs of pathogens, it was concluded that poor nutrition from habituation to hand feeding was a direct cause. He survived a shark attack but was left weak and vulnerable, and later disappeared in May of that year.

It was shortly after these two fatalities that the Wilson Report recommended the change in feeding regime that was instated in September 1994.

Rangers and researchers at Monkey Mia keep records of any deaths or injuries that occur to the Monkey Mia dolphin population. A database kept at CALM lists nine dolphin deaths with causes of death ranging from pneumonia, sting ray barb, shark attack and unknown cause of death. A summary of these deaths follows.

Table 1

Summary of deaths and cause of deaths.

Sex/age	Date of death	Cause of death
Male calf	28 Apr. 1988	Unknown
Male calf	5 Oct. 1988	Acute pneumonia
Male calf	18 Jul. 1989	Unknown
Male	17 Sep. 1989	Unknown
Female	19 May 1992	Unknown
Male	31 Dec. 1992	Stranded and shot
Unknown	10 Sep. 1993	Unknown
Female	27 Jul. 1995	Sting ray barb in heart
Unknown	9 Jul. 1997	Shark attack, bite over genitals

The Wilson Report (1994) lists the deaths of calves born to provisioned dolphins from 1989 to 1994.

Table 2

Deaths of calves born to provisioned dolphins from 1989-1994 from Wilson (1994).

Sex/age	Date of death	Cause of death
Newborn?	Feb. 1990?	At birth? Mother seen heavily pregnant but no calf subsequently seen or recorded
Male calf	Mar. 1990	Unknown
Male calf	Jun. 1991	Unknown
Female calf	Mar. 1992	Shark attack
Male calf	Mar. 1993	Unknown
Female calf	Mar. 1994	Shark attack
Male juvenile	May 1994	Possible shark attack, weak, in poor health, recovering from previous shark attack
Male calf	Jul. 1994	Unknown

Officers from CALM and researchers stationed at Monkey Mia were contacted about information on any fatalities after the last database entry (9 July 1997) but no information was available.

REFERENCES

Department of Conservation and Land Management, W.A. and Shire of Shark Bay. 1993. Draft Management Plan, Monkey Mia Reserve.

Environmental Protection Authority. 1989. Disappearance of dolphins at Monkey Mia. *EPA Bulletin* 381.

Gales, N.J. 1994. A Report to the Monkey Mia Reserve Management Committee: Recommendations for a Feeding Strategy for the Dolphins of Monkey Mia, Shark Bay.

International Whaling Commission. 1997. Report of the Scientific Committee. Annex Q. *Rep. int. Whal. Commn* 47: 255.

Wilson, B. 1994. *Review of the Dolphin Management at Monkey Mia*. Murex Consultants, Pty Ltd. (Unpublished).

Annex K
Summary of Information from Progress Reports

This Annex summarises information presented in National Progress Reports. For further information (including the addresses 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						
Southern right whale	Callosity	Southern Australia	~ 100	to be comp.	>350	S. Burnell, Eubalaena PL
			70	to be comp.	?	J. Bannister, WA Museum
Humpback whale	Fluke	Area IV	212	to be comp.	648[1]	C. and M. Jenner, Centre for Whale Research
	Fluke	Area V	321	Y	1600	PWF
	Lateral body	Area V	47	Y		PWF
	Fluke, lat. body	Area V	79	to be comp.	?	D. Paton, NSW NPWS
	-	Group IV, Perth coast	1997	-	-	J. Bannister, WA Museum
Indo-Pacific hump-backed dolphin	Dorsal fin	Moreton Bay, QLD	~25	N	50	P. Corkeron, JCU
Bottlenose dolphin	Dorsal fin	Moreton Bay, QLD	Many	Y	>350	P. Corkeron, JCU
	Signature whistle	Port Phillip Bay	1997	-	-	C. Scarpaci, RMIT
Killer whale	Dorsal fin	Macquarie Is., TAS	2	N	10	M. Morrice, Univ. of Tasmania
Brazil						
Bottlenose dolphin	Dorsal fin	Patos Lagoon	-	-	-	E. Secchi, MORG
	Dorsal fin	Southern coast	15	Y	26	P. Flores, IWC, Brazil
	Dorsal fin	Southern coast	12	Y	12	I. Moreno, GEMARS
	Dorsal fin	Southern coast	-	-	-	P. Simão-Lopes, UFSC
Humpback whale	Fluke	S.Shetland Is.	Summer	-	45-50	E. Secchi, MORG
	Fluke	Group A	125	Y	475	A. Freitas, M. Engel, IBAMA
	Fluke	Group A	5	Y	5	M.S. Reis, MAMA
Tucuxí	Dorsal fin	S. Catarina	37	Y	40	P. Flores, IWC, Brazil
	Dorsal fin	S. Catarina	-	-	-	P. Simão-Lopes, UFSC
	Dorsal fin	Cananéia		-	-	M.C. Oliveira Santos, USP
	Dorsal fin	Bahia	-	Y	15	M.S. Reis, MAMA
Southern right whale	Head	Southern coast	8	Y	68	J. Palazzo, IWC, Brazil
France						
Humpback whale	Flukes	N. Caledonia	1997: 35 new	Y	140	C. Garrigue, OCNC
	Flukes	Madagascar	1997: 63	Y	66	M. Vely, TOMS
Ireland						
Bottlenose dolphin		Shannon Estuary	1997		>100	UCC, IWDG, NP and WS
Japan						
Bryde's whale	Dorsal fin	Kochi	32	Y	-	WATB cooperative programme
Mexico						
Blue whale	Dorsal fin	Baja California waters/North Pacific	?	Y	<250	D. Gendron, CICIMAR
Sperm whale	Fluke	Baja California waters	?	Y	30	D. Gendron, CICIMAR
Gray whale	Mid-dorsal right side	Eastern San Ignacio lagoon	526	In process	526	J. Urban R., UABCS
Humpback whale	Fluke	North Pacific	?	Ongoing		L. Medrano, FC-UNAM
Bottlenose dolphin	Dorsal fin	Gulf of California	50	In process	<120	H. Pérez-Cortés, INPA
New Zealand						
Hector's dolphin	Fin and body scars	East coast South Is.	1984-1997	Y	467	Otago University
	Fin and body scars	West coast, South Is.	1994-1997	Y	238	Otago University
Bottlenose dolphin	Fin and body scars	Doubtful Sound	1990-1998	Y	97	Otago University
Sperm whale	Fluke	Kaikoura	1990-1998	Y	136	Otago University
Dusky dolphin	Dorsal fin	Kaikoura	1997 (2,000-2,500)	Y	510	T. Markowitz, Texas A&M
Norway						
Killer whale	-	North Norway	1997 autumn	-	-	UITØ - NFH
Sweden						
Bottlenose dolphins	-	Western Australia	1997	-	-	Stockholm University
Bottlenose and hump-backed dolphins	-	Tanzania	1997	-	-	Stockholm University
Sperm whales	-	Norway	1997	-	-	E. Lettevall, Kristineberg Marine Research Station
UK						
Bottlenose dolphins	Skin lesions	Moray Firth, Scotland	1997-8	-	-	AU, SMRU
	-	Cardigan Bay	1997-8	-	-	AU, CCW
USA						
Gray whales	-	Washington coast, Vancouver Island	May-Nov. 1997	123(?)	-	M. Gosho

[1] Figures for 1990-95 – there are still 121 photographs from 1996 and 212 from 1997 to be matched/checked for resightings and added to the catalogue.

ARTIFICIAL MARKING DATA.

Species	Tag type	No. branded	Location	Brand no.	Contact
Australia					
Bottlenose dolphin	Freeze brand	5 (including 1 rebranded)	Mandurah, WA	Rebrand 17, then 20, 21, 22,23	CALM, WA
Bottlenose dolphin	Freeze brand	5	Moreton Bay, QLD		P Corkeron, JCU
Brazil					
Boto	Freeze brand	27	-	-	V.M.F. da Silva/INPA
Tucuxi	Freeze brand	2	-	-	V.M.F. da Silva/INPA
Japan					
Baird's beaked whales	Artificial	4	-	-	T. Iwasaki, NRIFS
Striped dolphins	Dart-tag	14 + 2	-	-	Iwasaki, Kishiro, Miyashita, NRIFS
Dall's porpoise	Dart-tag	2	-	-	Iwasaki, Kishiro, Miyashita, NRIFS
UK					
Boto	Freeze brand	35	-	-	-
Tucuxi	Freeze brand	1	-	-	-

TELEMETRY DATA.

Species	Tag type	No. successfully deployed	Maximum time transmitting	Contact person/institute
Australia				
Bottlenose dolphin	radio (archival)	0	Attachment unsuccessful	P. Berggren, Monkey Mia Dolphin Research Group
Bottlenose dolphin	satellite	1	5 months	P. Corkeron, JCU
Bottlenose dolphin	VHF	4	2 months	P. Corkeron, JCU
Brazil				
Boto	VHF-radios	9	13 months	A. Martin, SMRU, UK and V.M.F. da Silva, INPA
Denmark				
Narwhal	Satellite	5	-	R. Ditz, DMU
Pilot whale	Telemetry	-	-	M.-P. Heide-Jørgensen, GN
Harbour porpoise	Satellite	4	14 - 41 days	J. Teilmann, CSC
Harbour porpoise	T/D recorder	2	-	J. Teilmann, CSC
Norway				
White whale	Satellite	3	3 months maximum	C. Lydersen, NP
Sweden				
Harbour porpoise	Satellite	2	10 days	E. Lettevall, Kristineberg Marine Research Station
UK				
White whale	Satellite	-	-	SMRU
Boto	VHF	-	-	SMRU
USA				
Dall's porpoise	VHF + suction cup	3	5 days	B. Hanson

BIOPSY SAMPLES.

Species	Area/stock	Calendar year/ season/no. collected	Archived (Y/N)	No. analysed	Total holdings	Contact person/institute
Australia						
Indo-Pacific hump-backed dolphin	Northwest WA	In progress	?	?	?	P. Hale, Univ. of Queensland
Bottlenose dolphin	Shark Bay, WA	79	Y	30%	79	M. Kruetzen, B Sherwin, Univ. of New South Wales
Bottlenose dolphin	NSW coast	3	?	?	n/a	G Dutton, Univ. of Sydney
Brazil						
Humpback whale	Group A	12	Y	0	12	Projeto Baleia Jubarte
Boto	Mamirauá	27	Y	0	-	INPA
Tucuxi	Central Amazon	2	Y	0	-	INPA
Denmark						
Minke whale	Greenland	-	Y	65	65	GN
Fin whale	Greenland	-	Y	4	4	GN
Japan						
'True' blue whale	Antarctic	5	Y	0	5	NRIFS
Pygmy blue whale	S. Pacific	18	Y	0	18	NRIFS
	Antarctic	1	Y	0	1	NRIFS
Sei whale	Antarctic	3	Y	0	3	NRIFS
Bryde's whale	S. Pacific	9	Y	0	9	NRIFS
Humpback whale	S. Pacific	2	Y	0	2	NRIFS
	Antarctic	10	Y	0	10	NRIFS

cont...

Biopsy samples (continued).

Species	Area/stock	Calendar year/ season/no. collected	Archived (Y/N)	No. analysed	Total holdings	Contact person/institute
Japan (cont.)						
Southern right whale	Antarctic	5	Y	0	5	NRIFS
Sperm whale	S. Pacific	3	Y	0	3	NRIFS
Pygmy sperm whale	S. Pacific	1	Y	0	1	NRIFS
Dall's porpoise (*dalli*-type)	N. Pacific	1	Y	0	1	NRIFS
Short-beaked common dolphin	N. Pacific	3	Y	0	3	NRIFS
	Antarctic	3	Y	0	3	NRIFS
Delphinus sp.	N. Pacific	5	Y	0	5	NRIFS
Striped dolphin	N. Pacific	44	Y	0	44	NRIFS
Spotted dolphin	N. Pacific	4	Y	0	4	NRIFS
Bottlenose dolphin	N. Pacific	13	Y	0	13	NRIFS
	S. Pacific	10	Y	0	10	NRIFS
Southern right whale dolphin	S. Pacific	2	Y	0	2	NRIFS
Killer whale	Antarctic	3	Y	0	3	NRIFS
Mexico						
Gray whale	Eastern	55	Y	0		J. Urbán R., UABCS
Humpback whale	Mexican Pacific[1]	>100	Y (1998 pending)	~200 (none of 1998)	>500	Facultad de Ciencias, UNAM
New Zealand						
Dusky dolphin	Kaikoura	181	Y	65	181	Auckland University
Hector's dolphin	New Zealand	54	Y	nil	54	Auckland University[2]
Humpback whale	Mexican Pacific	>100	Y (up to 1997)	~200 (none of 1998)	>500	Facultad de Ciencias, UNAM
Norway						
White whale	Svalbard	1997/8	N	7	-	C. Lydersen, Norwegian Polar Institute, Tromsø, Norway
USA						
Gray whale	Washington State + Vancouver Is.	May-Nov. 1997	Y	9	-	M. Gosho

[1] The collection effort is ongoing at the time of report so data are only approximate.

[2] The samples were collected in Jan. 1998 and will be extracted for total genomic DNA this year. There will not be sufficient material left for archiving of tissue.

SAMPLES FROM DIRECTED CATCHES OR BYCATCHES.

Species	Area/stock	Calendar year/season total	Archived (Y/N)	Tissue type(s)	Contact person/institute
Australia					
Bottlenose dolphin	South Australia	1	Y	Stomach	C. Kemper, SA Museum
Common dolphin	South Australia	3	Y	Genetic, toxin, reproductive, stomach	C. Kemper, SA Museum
Brazil					
Minke whale	Eastern N. Atlantic	Whaling season period	Y	Gonads	A. Langguth, A.Lucema, GEMMAR/UFPB
Franciscana	Southern RS	29	Y	-	E. Secchi, MORG
	Southern RS	9	Y	Blubber, liver, muscle, kidneys, gonads	I. Moreno, GEMARS
	Southern PR	11	Y	Gonads, parasites, intestines, eyes, skin, skeletons, blubber	F. Rosas, CEM/UFPR
Tucuxi	Southern PR	18	Y	Gonads, parasites, intestines, eyes, skin, skeletons, blubber	F. Rosas, CEM/UFPR
	Bahia	4	Y	Blood, blubber	M.S. Reis, MAMA
	Bahia	6	Y	Tissue for DNA	E.C. Aroucha, GECET
	Amazon	36	Y	Skull, teeth, skin, stomach contents	V.M.F. da Silva, INPA
Stenella sp.	Bahia	1	Y	Tissue for DNA	E.C. Aroucha, GECET
Denmark					
Minke whale	Greenland	3	Y	3 incomplete stomach samples	GN
Long-finned pilot whale	Skagerrak (North Sea)	20	Y	7 full autopsy	ZM, FSM
Harbour porpoise	Danish waters	>47	Y	Full autopsy	DFU
Germany					
Harbour porpoise	Baltic Sea Schleswig-Holstein	3	Y	All organs, central nervous system, skeletal system	U. Siebert
Harbour porpoise	Baltic Sea Meckl.-Prepom.	1	Y	Skull	H. Benke
Ireland					
Common dolphin	NE Atlantic	1	Y	Skin, blubber etc	UCC

cont...

Samples from directed catches or bycatches (continued).

Species	Area/stock	Calendar year/season total	Archived (Y/N)	Tissue type(s)	Contact person/institute
Japan					
Striped dolphin	N. Pacific	494	Y	Tooth, skin, muscle, ovary, uterine horn, testis, epididymis	NRIFS
Spotted dolphin	N. Pacific	4	Y	As above	NRIFS
Bottlenose dolphin	N. Pacific	306	Y	As above	NRIFS
Risso's dolphin	N. Pacific	107	Y	As above plus liver	NRIFS
Short-finned pilot whale (northern form)	N. Pacific	50	Y	As above plus liver, vertebral epiphysis	NRIFS
Short-finned pilot whale (southern form)	N. Pacific	252	Y	As above	NFRIS
False killer whale	N. Pacific	25	Y	Tooth, skin, muscle, ovary, uterine horn, testis, epididymis	NRIFS
Baird's beaked whale	N. Pacific	54	Y	As above plus liver, vertebral epididymis	NRIFS
Minke whale	N. Pacific	2	Y	Ovary, uterine horn, testis, epididymis	NRIFS
New Zealand					
Hector's dolphin	New Zealand coastal	25[1]	Y	Skin, blubber, organs	F. Pichler, Univ. of Auckland
Norway					
Minke whale	NE Atlantic	1997 - 502	Y	Muscle	T. Haug, NIFA, Tromsø, Norway
Minke whale	NE Atlantic	1997 - 60	Y	Kidney, liver, skin, blubber, testicles/ovaries	T. Haug, NIFA, Tromsø, Norway
Minke whale	NE Atlantic	1997 - 60	-	Stomach contents	T. Haug, NIFA, Tromsø, Norway
Sweden					
Harbour porpoise	Skagerrak/Kattegat Seas	1997 - 7	Y	Skin, blubber, muscle, brain, kidney, liver, stomach, testicles/ovaries, skeleton	SU or NRM
	Baltic Sea	1997 - 1	Y		
UK					
Harbour porpoise	Around UK	21	Y	Skin, blubber, etc	SMRU

[1](New Zealand): Mostly genetic material from historical collections.

SAMPLES FROM STRANDED ANIMALS.

Species	Area/Stock	Calendar year/season total	Archived (Y/N)	Tissue type(s)	Contact person/institute
Australia					
Pygmy right whale	VIC	1	?	Blubber	G. Dutton, Sydney University
Minke whale	QLD	1	Y	*	G. Byron, Dept. of Environment, Qld
Bryde's whale	VIC	1	?	Blubber	G. Dutton, Sydney University
Blue whale	VIC	1	?	Blubber	G. Dutton, Sydney University
Humpback whale	Area IV	1	?	Skin	P. Hale, Queensland University
		1	Y	Blubber	D. Mell, WA CALM
	Area V	1	N	Larynx	M. Noad, Sydney Univerity
Sperm whale	SA	2	Y	Genetic	C. Kemper, SA Museum
Pygmy sperm whale	QLD	3	Y	*	G. Byron, Dept. of Environment, Qld
	VIC	1	Y	Teeth, stomach contents	J. Dixon, Museum of Victoria
		1	?	Blubber	G. Dutton, Sydney University
	NSW	1	?	Blubber	G. Dutton, Sydney University
Straptoothed whale	SA	2	Y	Genetic, toxin, reproductive, stomach	C. Kemper, SA Museum
	NSW	1	?	Blubber	G. Dutton, Sydney University
Hector's beaked whale	TAS	1	Y	**	K. Evans, Tasmania University
Cuvier's beaked whale	VIC	1	?	Blubber	G. Dutton, Sydney University
Southern bottlenose whale	VIC	1	?	Blubber	G. Dutton, Sydney University
Indo-Pacific hump-backed dolphin	QLD	1	Y	*	G. Byron, Dept. of Environment, Qld
Bottlenose dolphin	SA	8	Y	Genetic, toxin, reproductive, stomach	C. Kemper, SA Museum
	QLD	4	Y	*	G. Byron, Dept. of Environment, Qld
	WA	4	?	Skin	P. Hale, Queensland University
		3	Y	Blubber	D. Mell, WA CALM
	NSW	1	?	Blubber	G. Dutton, Sydney University
	TAS	6	Y	**	K. Evans, Tasmania University
Pantropical spotted dolphin	WA	1	?	Skin	P. Hale, Queensland University
Pantropical spotted dolphin	NSW	1	?	Blubber	G. Dutton, Sydney University
Common dolphin	SA	10	Y	Genetic, toxin, reproductive, stomach	C. Kemper, SA Museum
	VIC	1	Y	Skull	J. Dixon, Museum of Victoria
	NSW	2	?	Blubber, reproductive/blubber	G. Dutton, Sydney University

cont...

Samples from stranded animals (continued).

Species	Area/Stock	Calendar year/season total	Archived (Y/N)	Tissue type(s)	Contact person/institute
Australia (cont.)					
Melon-headed whale	QLD	2	Y	*	G. Byron, Dept. of Environment, Qld
Pygmy killer whale	NSW	1	?	Blubber	G. Dutton, Sydney University
False killer whale	NSW	1	?	Blubber	G. Dutton, Sydney University
Killer whale	WA	1	?	Skin	P. Hale, Queensland University
	VIC	1	?	Blubber	G. Dutton, Sydney University
Long finned pilot whale	VIC	2	Y	Teeth/teeth and ribs	J. Dixon, Museum of Victoria
Irrawaddy dolphin	QLD	1	Y	*	G. Byron, Dept. of Environment, Qld
Spectacled porpoise	SA	1	Y	Genetic, toxin, reproductive, stomach	C. Kemper, SA Museum
	TAS	1	Y	**	K. Evans, Tasmania University
Brazil					
Tucuxi	Northeast	1997	Y	Blubber, lung, kidney, spleen, gonads, liver, stomach, intestine, endoparasites	LABOMAR/UFC
	Southeast	11	Y	Skull, muscle, blubber, gonads	M.C. Oliveira Santos, USP
	Southeast	4	Y	Skull, skeleton, teeth, gonads, stomach, tissues for DNA and pollution	A. Zerbini, USP
	Southern	3	Y	Skeleton, gonads	LAMAQ/UFSC
	Southern	4	Y	Skin, blubber, muscle	P. Flores, IWC, Brazil
	Southern	12	Y	Gonads, parasites, intestine, eyes, skin, skeleton, blubber	F. Rosas, CEM/UFPR
	Amazon	1	Y	Skull, teeth, tissue	V.M.F da Silva, INPA
Rough toothed dolphin	Northeast	1997	Y	Blubber, heart, lung, kidney, spleen, liver, gonads, endoparasites	LABOMAR/UFC
	Southern RS	1	Y	Skull, post-cranial, gonads	M.C. Pinedo, FURG
	Southern RS	1	Y	Muscle	I. Moreno, GEMARS
Bottlenose dolphin	Northeast	1997	Y	Gonads	LABOMAR/UFC
	Southeast	5	Y	Skull, muscle	M.C. Oliveira Santos, USP
	Southern	1	Y	Skeleton	LAMAQ/UFSC
	Southern RS	3	Y	Skull, skin, muscle	M.C. Pinedo, FURG
	Southern RS	5	Y	Blubber, liver, gonads, muscle	I. Moreno, GEMARS
Sperm whale	Northeast	1997	Y	Ectoparasites	LABOMAR/UFC
	Northeast	1998:1	Y	Skeleton	GEMMAR/UFPB
Humpback whale	Northeast	1997	Y	Baleen	LABOMAR/UFC
Franciscana	Southeast	2	Y	Skull, muscle	M.C. Oliveira Santos, USP
	Southeast	1	Y	Teeth, gonads, stomach, tissues for DNA and pollution	A. Zerbini, USP
	Southern	1	Y	Skeleton, gonads	LAMAQ/UFSC
	Southern	2	Y	Gonads, parasites, intestine, eyes, skin, skeleton, blubber	F. Rosas, CEM/UFPR
	Southern RS	40	Y	Teeth	M.C. Pinedo, FURG
	Southern RS	39	Y	Blubber, liver, kidney, gonads, muscle	I. Moreno, GEMARS
Common dolphin	Southeast	2	Y	Skull, muscle	M.C. Oliveira Santos, USP
	Southern	1	Y	Skull, parasites	M.C. Pinedo, FURG
Spotted dolphin	Southeast	2	Y	Skull	M.C. Oliveira Santos, USP
	St. Catarina	3	Y	Skull	LAMAQ/UFSC
	Northeast	1997:1	Y	Skeleton	GEMMAR/UFPB
Stenella spp.	Southern	2	Y	Muscle	I. Moreno, GEMARS
Spinner dolphin	Northeast	1997:1	Y	Skeleton	GEMMAR/UFPB
Fraser's dolphin	Southern RS	4	Y	Skull, stomach contents, foetus	M.C.Pinedo, FURG
	Southern RS	11	Y	Blubber, liver, gonads, muscle	I. Moreno, GEMARS
Minke whale	Southeast	1	Y	Skull, muscle	M.C. Oliveira Santos, USP
	Southern	1	Y	Blubber, muscle	I. Moreno, GEMARS
Pygmy sperm whale	Northeast	1998:1	Y	Skeleton, heat, genitals, liver	GEMMAR/UFPB
Humpback whale	Northeast	1998:1	Y	Skeleton	GEMMAR/UFPB
Balaenopterid	Southeast	1	Y	Tissue for DNA	A. Zerbini, USP
Denmark					
Sperm whale	N. Atlantic	13	Y	Skin, blubber, muscle, liver	ZM/FSM
Striped dolphin	North Sea	1	Y	Skin, blubber, muscle, liver	ZM
Harbour porpoise	Danish waters	>20	Y	Full autopsy	DFU
France					
Delphinids	Atlantic	1997:107	Y	Teeth	A. Collet, CRMM
Delphinids	Atlantic	1997:25	Y	Various tissues	A. Collet, CRMM

cont...

Samples from stranded animals (continued).

Species	Area/Stock	Calendar year/season total	Archived (Y/N)	Tissue type(s)	Contact person/institute
France (cont.)					
Common porpoise	Atlantic	1997:4	Y	Various tissues	A. Collet, CRMM
Common porpoise	Atlantic	1997:2	Y	Teeth	A. Collet, CRMM
Fin whale	Atlantic	1997:1	Y	Various tissues	A. Collet, CRMM
Bottlenose dolphin	Mediterranean	1997:3	Y	Skin, liver, kidney etc	D. Viale, LEMUC
Striped dolphin	Mediterranean	1997:3	Y	Skin, liver, kidney etc	D. Viale, LEMUC
Striped dolphin	Mediterranean	1997:18	Y	Skin, liver, kidney etc	H. Augier, GECEM
Fin whale	Mediterranean	1997:1	Y	Skin, muscle, liver etc	D. Viale, LEMUC
Germany					
Harbour porpoise	North Sea - Schleswig-Holstein	46	20	Tissues for histopathology, toxicology, genetics	U. Siebert
	North Sea - Lower Saxony	8	Y	Lung, liver, stomach	M. Stede
	Baltic Sea	3	N	-	U. Siebert
	Baltic Sea	6	5	Skeleton, various tissues	H. Benke
Sperm whale	North Sea	2	Y	Skeleton, various tissues	M. Stede
White-beaked dolphin	North Sea	1	Y	Skeleton	U. Siebert
Ireland					
Harbour porpoise	NE Atlantic	10	Y	Skin blubber, etc	UCC
Common dolphin	NE Atlantic	7	Y	Skin blubber, etc	UCC
Striped dolphin	NE Atlantic	3	Y	Skin blubber, etc	UCC
White-sided dolphin	NE Atlantic	3	Y	Skin blubber, etc	UCC
Pilot whale	NE Atlantic	1	Y	Skin blubber, etc	UCC
Bottlenose dolphin	NE Atlantic	1	Y	Teeth, skin	UCC
Minke whale	NE Atlantic	1	Y	Skin blubber, etc	UCC
Japan					
Mesoplodon sp.	-	2	-	Tissue	-
Mexico					
Gray whale	Eastern	3	Y	Skin, blubber	Jorge Urbán R., UABCS
Netherlands					
Harbour porpoise	North Sea	1997	Y	Liver, blubber	NMN
Sperm whale	North Sea	1997	Y	Liver, blubber	NMN
White-beaked dolphin	North Sea	1997	Y	Liver, blubber	NMN
New Zealand					
Dusky dolphin	-	6	Y	Skin, blubber, blood, gonads, all organs, skeleton	P. Duigan, Massey University
Common dolphin	-	3	Y	Skeleton	A. van Helden, MONZ
Bottlenose dolphin	-	1	Y	Skeleton	A. van Helden, MONZ
Hectors dolphin	-	38[1]	Y	Skeleton	A. van Helden, MONZ
Pygmy sperm whale	-	6	Y	Skeleton, blubber, skin	A. van Helden, MONZ
Cuvier's beaked whale	-	4	Y	Skeleton, blubber, skin, some organs	A. van Helden, MONZ
Pilot whale	-	23	Y	Blubber, skin, some organs, skeleton	A. van Helden, MONZ
Minke whale	-	2	Y	Blubber, skin, some organs, skeleton	A. van Helden, MONZ
Bryde's whale	-	2	Y	Blubber, skin	A. van Helden, MONZ
Pygmy right whale	-	1	Y	Blubber, skin	A. van Helden, MONZ
Gray's beaked whale	-	15	Y	Blubber, skin	University of Auckland
Straptoothed whale	-	2	Y	Blubber, skin	University of Auckland
Southern bottlenose whale	-	1	Y	Blubber, skin	University of Auckland
Cuvier's beaked whale	-	1	Y	Blubber, skin	University of Auckland
Spain					
Common dolphin	NE Atlantic	1997	Y	Skin, blubber, muscle	S. Lens, IEO
Common dolphin	Mediterranean	1997	Y	Full necropsy	E. Fernández, CREMA
Common dolphin	Canary Islands	1997	Y	Full necropsy	A. Fernández, VULP
Striped dolphin	Mediterranean	1997	Y	Full necropsy	E. Fernández, CREMA and J.M. Farré, CRAM
Bottlenose dolphin	NE Atlantic	1997	Y	Skin, blubber, muscle	S. Lens, IEO and J.M. Farré, CRAM
Risso's dolphin	Mediterranean	1997	Y	Full necropsy	E. Fernández, CREMA and J.M. Farré, CRAM
Striped dolphin	Canary Islands	1997	Y	Full necropsy	A. Fernández, VULP
Spotted dolphin	Canary Islands	1997	Y	Full necropsy	A. Fernández, VULP
Bottlenose dolphin	Canary Islands	1997	Y	Full necropsy	A. Fernández, VULP
Cuvier's beaked whale	Mediterranean Sea	1997	Y	Full necropsy	E. Fernández, CREMA
Long-finned pilot whale	NE Atlantic	1997	Y	Skin, blubber, muscle	S. Lens, IEO
Short-finned pilot whale	Canary Islands	1997	Y	Full necropsy	A. Fernández, VULP
Sperm whale	Canary Islands	1997	Y	Full necropsy	A. Fernández, VULP
Sweden					
Harbour porpoise	Skagerrak/Kattegat Seas	1997:4	Y	Skin, blubber, etc	Stockholm University
Harbour porpoise	Skagerrak/Kattegat Seas	1997:14	Y	Teeth, dorsal fin	Stockholm University or NRM

cont...

Samples from stranded animals (continued).

Species	Area/Stock	Calendar year/season total	Archived (Y/N)	Tissue type (s)	Contact person/institute
Sweden (cont.)					
White beaked dolphin	Skagerrak Sea	1997:2	Y	Skin, blubber, muscle, brain, kidney, liver, stomach, etc	Stockholm University and NRM
Sperm whale	Lofoten	1997	Y	Teeth, blubber	GU
UK					
-	Around UK	61	Y	Skin, blubber, etc	Institute of Zoology
-	Around UK	75	Y	Skin, blubber, etc	Scottish Agricultural College

Australia: A range of tissues were collected: for toxic contaminants: blubber, muscle, kidney and liver; for genetics: skin, liver, muscle, kidney, blood; for reproductive: ovaries, uterus, mammary glands, testes. Skeletal material (skull and/or postcranial) was collected for all specimens lodged with SA Museum.

* For each specimen: heart, lungs, liver, kidney, blubber, skin, intestine, brain, eyes, skeleton and intestine were collected (+ reproductive organs of some).

** For each specimen: liver, stomach/small intestine/large intestine, reproductive organs, lung, heart, muscle, skin and blubber were collected. Plus teeth, skull, kidney, spleen, internal parasites, mammary glands, colonial algae, skeleton and posterior vertebra of some.

[1] Mostly genetic material extracted from historical collections.

STATISTICS FOR LARGE CETACEANS: DIRECT CATCHES (COMMERCIAL, ABORIGINAL AND SCIENTIFIC PERMITS) FOR THE CALENDAR YEAR 1997 OR SEASON 1997/98.

Species	Type of catch	Area/stock	Males	Females	Total landed	Struck and lost
Denmark						
Fin whale	Aboriginal	West Greenland	5	5	10	2
Minke whale	Aboriginal	West Greenland	42	99	146[1]	2
Minke whale	Aboriginal	East Greenland	1	10	11	3
Japan						
Minke whale	Special Permit	N. Pacific	87	13	100	-
Minke whale	Special Permit	Antarctic	279	159	438	-
Minke whale	Commercial	NE Atlantic (EB, EC, EN, ES) and C. Atlantic (CM)	-	-	503	-
USA						
Bowhead whale	Aboriginal	Bering-Chukchi-Beaufort Seas	-	-	48	18
White whale	Aboriginal	Beaufort Sea	-	-	43	26-30
		Chukchi Sea	-	-	8	2
		E. Bering Sea	-	-	124-136	19-32
		Bristol Bay	-	-	11	0
		Cook Inlet stock	-	-	35	35

[1]Includes animals of unknown sex.

OTHER NON-NATURAL MORTALITES FOR THE CALENDAR YEAR 1997 OR THE SEASON 1997/98 (LARGE CETACEANS).

Species	Area/stock	Males	Females	Total	Cause	Methodology
Brazil						
Southern right	Group A	?	?	1 (calf)	Entanglement	Reported by fishermen
France						
Minke whale	Atlantic	?	?	1	Stranding - bycatch indicating marks	-
Japan						
Minke	Aomori	?	?	1	Trap net	Reported by fishermen or fishery cooperative unions
	Toyama	?	?	1	Trap net	As above
	Ishikawa	?	?	4	Trap net	As above
	Mie	?	?	1	Trap net	As above
	Wakayama	?	?	6	Trap net	As above
	Kochi	?	?	11	Trap net	As above
	Nagasaki	?	?	3	Trap net	As above
Fin whale	Aomori	?	?	1	Trap net	As above
Humpback	Wakayama	?	?	1	Trap net	As above
Korea						
Minke whale	Kyeong-Nam	?	?	2	Entanglement	-
		?	?	1	Entanglement	-
	Pusan	?	?	1	Entanglement	-
	Kyeong-Buk	?	?	49	Entanglement	-
	Kang-Won	?	?	25	Entanglement	-
New Zealand						
Bryde's whale	Hauraki Gulf	1	0	1	Entangled in mussel farm ropes	Examination of beach-cast animal
UK						
Minke whale	Lewis (Western Isles)	?	?	1	Entanglement	-

LARGE CETACEANS: EARLIER YEARS' STATISTICS.

Year	Species	Area/stock	Incidental mortality: Reported	Incidental mortality: Est. total	Source
1996	**Korea**				
	Minke whale	Kyeong-Nam	2	-	Coastal trap
			1	-	Set trap
		Kyeong-Buk	44	-	Coastal trap
			5	-	Offshore trap
			16	-	Set-net
			33	-	Coastal drift gillnet
			5	-	Offshore drift gillnet
			3	-	Coastal gillnet
			1	-	Offshore trawl
		Kang-Won	14	-	Set-net
			2	-	Coastal drift gillnet
			2	-	Coastal gillnet

STATISTICS FOR SMALL CETACEANS FOR THE CALENDAR YEAR 1997.

Species	Area/stock	Directed Catch: Reported	Directed Catch: Est. Total	Incidental Mortality: Reported	Incidental Mortality: Est. Total	Live-capture: Source	Live-capture: Reported
Australia							
Indo-Pacific hump-backed dolphin	QLD	0	0	2	?	Gillnet	0
				4	?	Shark meshing	0
Bottlenose dolphin	SA	0	0	1	?	?	0
	QLD	0	0	5	?	Gillnet	0
		0	0	5	?	Shark meshing	
	WA	0	0	2	?	Hook ingested	0
	NSW	0	0	1	?	Shark meshing	0
Spinner dolphin	QLD	0	0	1	?	Gillnet	0
		0	0	2	?	Shark meshing	0
Common dolphin	SA	0	0	3	?	?	0
	QLD	0	0	4	?	Shark meshing	0
Unidentified Delphinid sp.	SE Australia	0	0	1	?	Shark meshing	0
Brazil							
Tucuxi	Northeast	0	0	7	-	Gillnet	0
	Southern, SC	0	0	6	20-25	Gillnet	0
	Southern , PR	0	0	16	-	Gillnet	0
	Southeast, BA	1	-	3	-	Gillnet	0
	Amazon	0	0	36	-	-	0
Rough-toothed dolphin	Northeast	0	0	2	-	Trawl net	0
Spotted dolphin	Southeast, SP	0	0	1	-	Drift net	0
Franciscana	Southern, RS, PR	0	0	47	-	Gillnet	0
France							
Common dolphin	Atlantic	-	-	182	-	Strandings - bycatch marks	-
Striped dolphin	Atlantic	-	-	11	-	As above	-
Bottlenose dolphin	Atlantic	-	-	4	-	As above	-
Long-finned pilot whale	Atlantic	-	-	3	-	As above	-
Delphinids spp	Atlantic	-	-	72	-	As above	-
Harbour porpoise	Atlantic	-	-	8	-	As above	-
Germany							
Harbour porpoise	Baltic Sea	0	0	4	?	Gillnet	0
Ireland							
Harbour porpoise	-	0	0	2	-	-	-
Common dolphin	-	0	0	3	-	-	-
Common dolphin	-	0	0	1	-	Pelagic trawl	-
Japan							
Dall's porpoise – *dalli*-type	Hokkaido	999	-	0	-	Hand harpoon	0
	Iwate	7,433	-	0	-	Hand harpoon	0
	Aomori	2	-	0	-	Hand harpoon	0
	Miyagi	99	-	0	-	Hand harpoon	0
	-	0	-	1	-	Salmon driftnet_	0
Dall's porpoise – *truei*-type	Hokkaido	31	-	0	-	Hand harpoon	0
	Iwate	9,976	-	0	-	Hand harpoon	0
Finless porpoise	Aichi	0	-	1	-	Trap net	0
Striped dolphin	Wakayama	57	-	0		Hand harpoon	0
	Wakayama	545	-	0	-	Driving	0
Spotted dolphin	Wakayama	23	-	0	-	Hand harpoon	0
Bottlenose dolphin	Wakayama	57	-	0	-	Hand harpoon	0
	Okinawa	8	-	0	-	Hand harpoon	0
	Wakayama	234	-	0	-	Driving	53

cont...

Statistics for small cetaceans for the calendar year 1997 (continued).

		Directed Catch		Incidental Mortality		Live-capture	
Species	Area/stock	Reported	Est. Total	Reported	Est. Total	Source	Reported
Japan (cont.)							
Risso's dolphin	Wakayama	20	-	0	-	Small-type whaling	0
	Wakayama	148	-	0	-	Hand harpoon	0
	Wakayama	60	-	0	-	Driving	0
	Kochi	0	-	14	-	Trap net	0
Short-finned pilot whale – Northern form	Miyagi	50	-	0	-	Small-type whaling	0
Short-finned pilot whale – Southern form	Chiba	5	-	0	-	Small-type whaling	0
	Wakayama	22	-	0	-	As above	0
	Okinawa	66	-	0	-	Hand harpoon	0
	Wakayama	204	-	0	-	Driving	0
Killer whale	Okinawa	1	-	0	-	Hand harpoon	0
	Wakayama	0	-	0	-	Driving	5
False killer whale	Okinawa	3	-	0	-	Hand harpoon	0
	Wakayama	25	-	0	-	Driving	15
Baird's beaked whale	Hokkaido	1	-	0	-	Small-type whaling	0
	Miyagi	26	-	0	-	As above	0
	Chiba	27	-	0	-	As above	0
Unidentified cetacean	Hokkaido	0	-	1	-	Trap net	0
	Hokkaido	0	-	2	-	Large mesh driftnet[2]	0
Korea							
Baird's beaked whale	Kyeong-Buk	-	-	1	-	Gillnet	-
Risso's dolphin	Kyeong-Nam	-	-	1	-	Set-net	-
	Kang-Won	-	-	1	-	Gillnet	-
Short-finned pilot whale	Kyeong-Buk	-	-	2	-	Drift gillnet	-
Pacific white-sided dolphin	Kyeong-Buk	-	-	1	-	Coastal trap	-
	Kyeong-Buk	-	-	1	-	Coastal gillnet	-
Common dolphin	Kyeong-Buk	-	-	48	-	Set-net	-
		-	-	9	-	Coastal trap	-
		-	-	8	-	Coastal drift gillnet	-
		-	-	3	-	Offshore drift gillnet	-
		-	-	1	-	Coastal gillnet	-
		-	-	1	-	Drift gillnet	-
		-	-	1	-	Coastal longline	-
Mexico							
Vaquita	Gulf of California	0	0	1	?	-	0
Bottlenose dolphin	Gulf of California	0	0	0	0	-	10
Netherlands							
White-sided dolphin	SW Ireland	-	-	43	-	Mid-water trawl	-
Long-finned pilot whale	SW Ireland	-	-	1	-	Mid-water trawl	-
Harbour porpoise	SW Ireland	-	-	4	-	Mid-water trawl	-
New Zealand							
Hector's dolphin	East coast – South Island	0	0	2	?	Gillnet/inshore trawl	0
Common dolphin	NZ coastal	0	0	4	?	Inshore trawl	0
Pilot whale	NZ coastal	0	0	1	?	Mid-water trawl	0
Dolphin sp.	NZ coastal	0	0	1	?	Mid-water trawl	0
Dusky dolphin	NZ coastal	0	0	1	?	Mid-water trawl	0
Spain							
Common dolphin	NW Spanish coast	-	-	3	-	Pair trawl	-
Bottlenose dolphin	East Central Atlantic	-	-	1	-	Trawl	-
Unidentified dolphin	Bay of Biscay	-	-	3	-	Pair trawl	-
Sweden							
Harbour porpoise	Skagerrak Sea	-	-	2	-	Mackerel driftnets	-
		-	-	5	-	Bottom set gillnet	-
	Baltic Sea	-	-	1	-	Bottom set gillnet	-
UK							
Harbour porpoise	-	-	-	25	-	Bottom set gillnets	-
				16		[3]-	
Common dolphin	-	-	-	6	-	-	-
White-sided dolphin	-	-	-	2	-	-	-
Bottlenose dolphin	-	-	-	1	-	-	-

[1] Taken by research vessel outside the Japanese FZ.
[2] Taken by commercial fishing vessels within the Japanese FZ.
[3] Bycatch related mortality determined from strandings post-mortems.

SMALL CETACEANS: EARLIER YEARS' STATISTICS

Species	Year	Area/stock	Landed	Struck and lost
USA				
White whale[1]	1994	Beaufort Sea	62	1+[2]
		Chukchi Sea	63	3+
		E. Bering Sea	110-116	9
		Kuskokwim Delta	6	1+
		Bristol Bay	16	2
		Cook Inlet	19	2
	1995	Beaufort Sea	44	-
		Chukchi Sea	37	6
		E. Bering Sea	48-50	6
		Kuskokwim Delta	2	-
		Bristol Bay	6	4
		Cook Inlet	50	22
	1996	Beaufort Sea	22	18
		Chukchi Sea	118	7
		E. Bering Sea	96-103	16
		Kuskokwim Delta	2	0
		Bristol Bay	17-18	1
		Cook Inlet	49	49-98

[1] Subsistence harvest estimates by calendar year.
[2] + indicates lower bound.

Appendix 1

CONTACTS FOR FURTHER INFORMATION

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Annex L
Furthering Scientific Cooperation Between ASCOBANS and the IWC

Peter J.H. Reijnders

ASCOBANS Observer at the 50th Annual Meeting of the Scientific Committee of the IWC

and

Greg Donovan

IWC Observer at the ASCOBANS 2nd Meeting of Parties

In recent years, the IWC Scientific Committee has spent considerable effort in examining the status of harbour porpoise stocks in the North Atlantic (IWC, 1996; 1997; 1998). This work is ongoing (see Annex I). In response to a Commission initiative, it has also dedicated effort into addressing issues related to environmental factors and cetaceans. In particular it held a Workshop in Bergen in 1995 to address the issue of chemical pollutants and cetaceans. In response to the recommendations of that Workshop, the Committee has developed a research programme to examine cause-effect relationships between pollutants and cetacean health. In that proposal, endorsed by the Commission last year, the need for co-operation with other organisations, including ASCOBANS was highlighted.

As observers at each other's meetings, we have noted that there is considerable mutual interest in these subjects. This became explicit at the 4th Meeting (1997) of the Advisory Committee of ASCOBANS, where these two subjects were identified as of mutual interest and the work of the IWC Scientific Committee was extensively referred to. This was also the case in the Report of the Working Group on Scientific Matters which met at the 2nd Meeting of Parties to ASCOBANS. At that meeting, ASCOBANS adopted two Resolutions pertaining to these issues of mutual interest as follows.

A resolution relating to the status of North Atlantic harbour porpoises drew in part on the Scientific Committee's work on this subject and in effect endorsed the longer-term approach identified by the Committee last year (IWC, 1998).

A resolution relating to pollutant matters strongly endorsed the IWC research programme on pollutants, and indeed all the recommendations of the Bergen Workshop. It was agreed that the ASCOBANS Parties and the Advisory Committee should consider ways to facilitate the development and execution of the Programme, which addresses that issue in harbour porpoises, in co-operation with the IWC and others.

The Advisory Committee, at its 5th Meeting in Hel (Poland) held immediately prior to the Scientific Committee meeting, agreed that close co-operation with the IWC would be of mutual benefit. It was recommended that the Advisory Committee liaise with the Scientific Committee on scientific issues of mutual interest. This is comparable to the Scientific Committee's request for co-operation in the pollution research programme.

We therefore believe that it would be extremely useful for the IWC Scientific Committee to welcome this request by ASCOBANS for co-operation, by developing mechanisms for co-operation between the two organisations at the scientific level, while recognising that they are responsible for managing different groups of cetacean species.

One way in which this can be done is to encourage co-operation in the holding of joint working groups or workshops on scientific matters of mutual interest. For example, ASCOBANS, particularly through the efforts of its Advisory Committee Chairman, is playing an important role in helping to organise the Workshop to develop further the IWC pollution research programme to be held in Barcelona in the Autumn of this year (Annex H).

Similarly, it seems sensible to further the scientific work on the status of harbour porpoises in the North Atlantic, by holding the joint working group meeting suggested in Annex I, recognising that this meeting will be discussing scientific and not direct management issues.

We suggest that the Scientific Committee might like to formally endorse this approach.

REFERENCES

International Whaling Commission. 1996. Report of the Scientific Committee. *Rep. int. Whal. Commn* 46:49-236.

International Whaling Commission. 1997. Report of the Scientific Committee. *Rep. int. Whal. Commn* 47:59-257.

International Whaling Commission. 1998. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48:53-127.

Annex M
Revised Rules of Procedure of the Scientific Committee

The DUTIES of the Scientific Committee, as set out in the Convention, can be seen as a progression from the scientific investigation of whales and their environment, leading to assessment of the status of the whale stocks and the impact of catches upon them, and finally the provision of management advice on the regulation of whaling. This role can be defined in the following terms for the Scientific Committee to:

Encourage and initiate scientific studies related to whales and whaling [Convention Article IV.1(a)]
Investigate the trend and condition of whale stocks, and the effects of whaling on them [Article IV.1 (b)]
Develop measures for the conservation and utilisation of whale resources [Article IV.1 (c)]

In addition to activities associated with meeting the above duties, additional specific FUNCTIONS of the Scientific Committee associated with these activities are to:

Advise on the regulation of whaling [Convention Article V. 2 (b)]
Review and comment on Special Permits issued for scientific research [Schedule paragraph 30]
Review research programmes of Contracting Governments and other bodies [Rule of Procedure M.4]
Publish reports of its activities and findings [Convention Article IV.2]

SPECIFIC TOPICS of current concern are:

Comprehensive Assessment of whale stocks [RIWC 34:30]
Implementation of the RMP [RIWC 45:43]
Assessment of stocks subject to aboriginal subsistence whaling [Schedule paragraph 13(b)]
Development of the AWMP [RIWC 45:42-3]
Effects of environmental change on cetaceans [RIWC 43:39-40; 44:35; 45:49]
Scientific aspects of whale sanctuaries [RIWC 33:21-2; 45:63]
Scientific aspects of small cetaceans [RIWC 41:48; 42:48; 43:51; 45:41]
Scientific aspects of whalewatching [RIWC 45:49-50]

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. The Secretary of the Commission and relevant members of the Secretariat shall be ex officio non-voting members of the Scientific Committee.
2. The Scientific Committee recognises that representatives of Inter-Governmental Organisations with particular relevance to the work of the Scientific Committee may also participate as non-voting members, subject to the agreement of the Chairman of the Committee acting according to such policy as the Commission may decide.
3. Further to paragraph 2 above, the World Conservation Union (IUCN) shall have similar status in the Scientific Committee.
4. Non-member governments may be represented by observers at meetings of the Scientific Committee, subject to the arrangements given in Rule C.1(a) of the Commission's Rules of Procedure.
5. Any other international organisation sending an accredited observer to a meeting of the Commission may nominate a scientifically qualified observer to be present at meetings of the Scientific Committee. Any such nomination must reach the Secretary not less than 60 days before the start of the meeting in question and must specify the scientific qualifications and relevant experience of the nominee. The Chairman of the Scientific Committee shall decide upon the acceptability of any nomination but may reject it only after consultation with the Chairman and Vice-Chairman of the Commission. Observers admitted under this rule shall not participate in discussions but the papers and documents of the Scientific Committee shall be made available to them at the same time as to members of the Committee.
6. The Chairman of the Committee, acting according to such policy as the Commission or the Scientific Committee may decide, may invite qualified scientists not nominated by a Commissioner to participate by invitation or otherwise in committee meetings as non-voting contributors. They may present and discuss documents and papers for consideration by the Scientific Committee, participate on sub-committees, and they shall receive all Committee documents and papers.
   (a) Convenors will submit suggestions for Invited Participants (including the period of time they would like them to attend) to the Chairman (copied to the Secretariat) not less than four months before the meeting in question. The Convenors will base their suggestions on the priorities and initial agenda identified by the Committee and Commission at the previous meeting. The Chairman may also consider offers from suitably qualified scientists to contribute to priority items on the Committee's agenda if they submit such an offer to the Secretariat not less than four months before the meeting in question, providing information on the contribution they believe that they can make. Within two weeks of this, the Chairman, in consultation with the Convenors and Secretariat, will develop a list of invitees.
   (b) The Secretary will then promptly issue a letter of provisional invitation to those potential Invited

Participants suggested by the Chairman and Convenors. That letter will state that there may be financial support available. Invitees who wish to be considered for travel and subsistence will be asked to submit an estimated airfare (incl. travel to and from the airport) to the Secretariat, within 2 weeks. Under certain circumstances (e.g. the absence of a potential participant from their institute), the Secretariat will determine the likely airfare.

(c) At least three months before the meeting, the Secretariat will supply the Chairman with a list of participants and the estimated expenditure for each, based on (1) the estimated airfare, (2) the period of time the Chairman has indicated the Invited Participants should be present and (3) a daily subsistence rate based on the actual cost of the hotel deemed most suitable by the Secretary and Chairman*, plus an appropriate daily allowance. [*Footnote: Invited participants who choose to stay at a cheaper hotel will receive the actual rate for their hotel plus the same daily allowance].

(d) The Chairman will review the estimated total cost for all suggested participants against the money available in the Commission's budget. Should there be insufficient funds, the Chairman, in consultation with the Secretariat and Convenors where necessary, will decide on the basis of the identified priorities, which participants should be offered financial support and the period of the meeting for which that support will be provided. Scientists not supported for the full period, may, with the agreement of the Chairman, attend the remainder of the meeting at their own expense.

(e) At least two months before the meeting, the Secretary will send out formal invitations to all the selected scientists, in accordance with the Commission's Guidelines (IWC, 1997), indicating where appropriate that financial support will be given and the nature of that support.

(f) In exceptional circumstances, the Chairman, in consultation with the Convenors and Secretariat, may waive the above time restrictions.

(g) The letter of invitation to Invited Participants will include the following ideas:

Under the Committee's Rules of Procedure, Invited Participants may present and discuss papers, and participate in meetings (including those of subgroups). They are entitled to receive all Committee documents and papers. They may participate fully in discussions pertaining to their area of expertise. However, discussions of Scientific Committee procedures and policies are in principle limited to Committee members nominated by member governments. Such issues will be identified by the Chairman of the Committee during discussions. Invited Participants are also urged to use their discretion as regards their involvement in the formulation of potentially controversial recommendations to the Commission; the Chairman may at his/her discretion rule them out of order.

7. A small number of interested local scientists may be permitted to observe at meetings of the Scientific Committee on application to, and at the discretion of, the Chairman. Such scientists should be connected with the local Universities, other scientific institutions or organisations, and should provide the Chairman with a note of their scientific qualifications and relevant experience at the time of their application.

B. Agenda

1. The initial agenda for the Committee meeting of the following year shall be developed by the Committee prior to adjournment each year. The agenda should identify, as far as possible, key issues to be discussed at the next meeting and specific papers on issues should be requested by the Committee as appropriate.
2. The provisional agenda for the Committee meeting shall be circulated for comment 60 days prior to the Annual Meeting of the Committee. Comments will normally be considered for incorporation into the draft agenda presented to the opening plenary only if received by the Chairman 21 days prior to the beginning of the Annual Meeting.

C. Organisation

1. The Scientific Committee shall include standing sub-committees and working groups by area or species, or other subject, and a standing sub-committee on small cetaceans. The Committee shall decide at each meeting on sub-committees for the coming year.
2. The sub-committees and working groups shall prepare the basic documents on the identification, status and trends of stocks, including biological parameters, and related matters as necessary, for the early consideration of the full Committee.
3. The sub-committees, except for the sub-committee on small cetaceans, shall concentrate their efforts on stocks of large cetaceans, particularly those which are currently exploited or for which exploitation is under consideration, or for which there is concern over their status, but they may examine matters relevant to all cetaceans where appropriate.
4. The Chairman may appoint other sub-committees as appropriate.
5. The Committee shall elect from among its members a Chairman and Vice-Chairman 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-Chairman shall act for the Chairman in his/her absence.

D. Meetings

1. Meetings of the Scientific Committee as used in these rules include all meetings of subgroups of the Committee, e.g. sub-committees, working groups, workshops, etc.
2. The Scientific Committee shall meet prior to the Annual Meeting of the Commission. Special meetings of the Scientific Committee or its subgroups may be held as agreed by the Commission or the Chairman of the Commission.
3. The Scientific Committee will organise its work in accordance with a schedule determined by the Chairman with the advice of a group comprising sub-committee/working group chairmen and relevant members of the Secretariat.

E. Scientific Papers and Documents

The following documents and papers will be considered by the Scientific Committee for discussion and inclusion in its report to the Commission:

1. Progress Reports. Each nation having information on the biology of cetaceans, cetacean research, the taking of

cetaceans, or other matters it deems appropriate should prepare a brief progress report following the format agreed by the Committee.
2. Special Reports. The Committee may request special reports as necessary on matters to be considered by the Committee for the following year.
3. Sub-committee Reports. Reports of the sub-committees or working groups shall be included as annexes to the Report to the Commission. Recommendations contained therein shall be subject to modification by the full Committee before inclusion in its Report.
4. Scientific and Working Papers.
   (a) Any scientist may submit a scientific paper for consideration by the Committee in accordance with guidelines established by the Secretariat with the concurrence of the Committee. Papers published elsewhere may be distributed to Committee members for information as relevant to specific topics under consideration.
   (b) Scientific papers will be considered for discussion and inclusion in the papers of the Committee only if the paper is received by the Secretariat on or by the first day of the annual Committee meeting, intersessional meeting or any sub-group. Exceptions to this rule can be granted by the Chairman of the Committee where there are exceptional extenuating circumstances.
   (c) Working papers will be distributed for discussion only if prior permission is given by the Chairman of the Committee or relevant sub-group. They will be archived only if they are appended to the meeting report.
   (d) The Scientific Committee may receive and consider unpublished scientific documents from non-members of the Committee (including observers) and may invite them to introduce their documents at a meeting of the Committee provided that they are received under the same conditions (with regard to timing etc.) that apply to members.
5. Publication of Scientific Papers and Reports
   (a) Scientific papers and reports considered by the Committee that are not already published shall be included in the Commission's archives in the form in which they were considered by the Committee or its sub-committees.
   (b) Reports of the meetings of the Scientific Committee shall be available outside the Commission after distribution to the Commission. They are strictly confidential prior to that time. In particular, the Report of the Annual Meeting of the Scientific Committee shall be available at the time of the opening Plenary of the Commission meeting.
      (i) Reports of intersessional Workshops or Special Committee Meetings are considered confidential until they have been distributed to the full Committee, Commissioners and Contracting Governments.
      (ii) Reports of intersessional Steering Groups or Sub-committees are considered confidential until they have been discussed by the Scientific Committee, normally at an Annual Meeting.

The Scientific Committee should identify the category of any intersessional meetings at the time they are recommended.

6. Scientific papers and reports (revised as necessary) may be considered for publication by the Commission. Papers shall be subject to peer review before publication. Papers submitted shall follow the Guidelines for Authors published by the Commission.

F. Review of Scientific Permits

1. When proposed scientific permits are sent to the Secretariat before they are issued by national governments the Scientific Committee shall review the scientific aspects of the proposed research at its annual meeting, or during a special meeting called for that purpose and comment on them to the Commission.
2. The review process shall take into account guidelines issued by the Commission.
3. The proposed permits and supporting documents should include specifics as to the objectives of the research, number, sex, size, and stock of the animals to be taken, opportunities for participation in the research by scientists of other nations, and the possible effect on conservation of the stock resulting from granting the permits.
4. Preliminary results of any research resulting from the permits should be made available for the next meeting of the Scientific Committee as part of the national progress report or as a special report, paper or series of papers.

G. Financial Support for Research Proposals

1. The Scientific Committee shall identify research needs.
2. It shall consider unsolicited research proposals seeking financial support from the Commission to address these needs. A sub-committee shall be established to review and rank research proposals received four months in advance of the Annual Meeting and shall make recommendations to the full Committee.
3. The Scientific Committee shall recommend in priority order those research proposals for Commission financial support as it judges best meet its objectives.

H. Availability of data

The Scientific Committee shall work with the Secretariat to ensure that catch and scientific data that the Commission holds are archived and accessible using modern computer data handling techniques. Access to such data shall be subject to the following rules:

1. Information identified in Section VI of the Schedule that shall be notified or forwarded to the IWC or other body designated under Article VII of the Convention.

This information is available on request through the Secretariat to any interested persons with a legitimate claim relative to the aims and purposes of the Convention.[1]

2. Information and reports provided where possible under Section VI of the Schedule.

When such information is forwarded to the IWC a covering letter should make it clear that the information or report is being made available, and it should identify the pertinent Schedule paragraph under which the information or report is being submitted.

Information made available to the IWC under this provision is accessible to accredited persons as defined below, and additionally to other interested persons subject to the agreement of the government submitting the information or report.

Such information already held by the Commission is not regarded as having been forwarded until such clarification of its status is received from the government concerned.

[1] The Government of Norway notes that for reasons of domestic legislation it is only able to agree that data it provides under this paragraph are made available to accredited persons.

3. Information neither required nor requested under the Schedule but which has been or might be made available to the Commission on a voluntary basis.

This information is of a substantially different status from the previous two types. It can be further divided into two categories:

(a) Information collected under International Schemes.
  (i) Data from the IWC sponsored projects.
  (ii) Data from the International Marking Scheme.
  (iii) Data obtained from international collaborative activities which are offered by the sponsors and accepted as contributions to the Comprehensive Assessment, or proposed by the Scientific Committee itself.
  (iv) Information collected as the result of IWC sponsored activities and/or on a collaborative basis with other organisations, governments, institutions or individuals is available within those contributing bodies either immediately, or, after mutual agreement between the IWC and the relevant body/person, after a suitable time interval to allow 'first use' rights to the primary contributors.

(b) Information collected under national programmes, or other than in (a).
  (i) Information in this category is likely to be provided by governments under special conditions and would hence be subject to some degree of restriction of access. This information can only be held under the following conditions.
  (ii) A minimum level of access should be that such data could be used by accredited persons during the Scientific Committee meetings using validated techniques or methods agreed by the Scientific Committee. After the meeting, at the request of the Scientific Committee, such data could be accessed by the Secretariat for use with previously specified techniques or validated programs. Information thus made available to accredited persons should not be passed on to third parties but governments might be asked to consider making such records more widely available or accessible.
  (iii) The restrictions should be specified at the time the information is provided and these should be the only restrictions.
  (iv) Restrictions on access should not discriminate amongst accredited persons.
  (v) All information held should be documented (i.e. described) so that accredited persons know what is held, along with stated restrictions on the access to it and the procedures needed to obtain permission for access.

Accredited persons

Accredited persons are those scientists defined under sections A.1, 2, 3 and 6 of the Rules of Procedure of the Scientific Committee. Invited Participants are also considered as 'accredited' during the intersessional period following the meeting which they attend.

REFERENCE

International Whaling Commission. 1997. Chairman's Report of the Forty-Eighth Annual Meeting. *Rep. int. Whal. Commn* 47:17-55.

Annex N
The Revised Management Procedure (RMP) for Baleen Whales[1]

(Superscript numbers refer to the appended annotations)

1. DEFINITIONS

Regions are non-overlapping major ocean areas. For species found in or migrating to higher latitudes, these will normally be the Arctic and adjacent waters, the North Atlantic and adjacent waters, the North Pacific and adjacent waters, and the Southern Hemisphere. For species confined to lower latitudes, the *Regions* will normally be the Atlantic, Pacific and Indian Oceans. *Regions* can be combined for species where the interchange is not negligible.

Small Areas are disjoint areas small enough to contain whales from only one biological stock, or be such that if whales from different biological stocks are present in the *Small Area*, catching operations would not be able to harvest them in proportions substantially[2] different to their proportions in the *Small Area*.

Medium Areas[3] correspond to known or suspected ranges of distinct biological stocks.

Large Areas[4] coincide with *Regions*, unless evidence exists to support the selection of one or more areas smaller than a *Region* which fully covers the range of some biological stocks of a species and definitely excludes whales from all other biological stocks of that species in the *Region*.

Residual Areas[5] are all geographical areas in a *Region* which are outside any *Small Areas*. *Medium Areas* comprise unions of *Small* and, where identified, *Residual Areas*. *Large Areas* comprise unions of *Medium* and, where identified, *Residual Areas*.

Combination Areas are disjoint unions of *Small Areas* to which the *Catch Limit Algorithm* is applied when *Catch-cascading* is used.

Management Area is a generic term denoting a *Small, Medium, Large, Residual* or *Combination Area*.

Catch Limit Algorithm is the process (described in Section 4) that is used to calculate a catch limit for a *Management Area*.

Years[6] are consecutive periods of 12 months used for the compilation of time series of catches and abundance data for application of the *Catch Limit Algorithm*.[6A] Neither this definition, nor any statement following, should be construed as precluding the possibility of a regulation that a catch limit calculated in such an application may be taken only during a certain part of the *Year*.

Catch-cascading[7] is the process by which a catch limit calculated for a *Combination Area* is distributed among the *Small Areas* that make up the *Combination Area* in proportion to the calculated relative abundances in those *Small Areas*. When *Catch-cascading* occurs, the relative abundances for *Small Areas* within the *Combination Area* shall normally be calculated from the same estimates of absolute abundance as were used for the application of the *Catch Limit Algorithm* to the *Combination Area*. The calculated relative abundance in a *Small Area* shall be an appropriate form of weighted average of the available abundance indices for that *Small Area*, with the statistically appropriate weighting, except that each estimate shall also be further weighted by the factor 0.9^n, where n is the number of years that have elapsed between the *Year* to which the estimate refers and the *Year* of the *Catch Limit Calculation*.

Catch-capping[8] is the process by which *Catch Limits* calculated for *Small Areas* are adjusted by reference to those calculated for either *Medium* or *Large Areas* containing those *Small Areas*. It consists of the following rules. If the sum of the catch limits calculated for those *Small Areas* that make up a *Medium* (or *Large*) *Area* exceeds the catch limit calculated for the *Medium* (or *Large*) *Area*, then both the *Small* and *Medium* (or *Large*) Area catch limits shall apply in such a way that the maximum catch allowed in each *Small Area* is the appropriate *Small Area* catch limit and the maximum catch allowed in the *Medium* (or *Large) Area* is the *Medium* (or *Large*) *Area* catch limit. This definition does not preclude the possibility of applying *Catch-capping* to overlapping *Medium Areas*.

An *Implementation* involves the designation of the *Management Areas* and their boundaries and the selection of *Catch-cascading* and/or *Catch-capping* options for a particular species and *Region*. These designations and/or selections may be changed in a subsequent *Implementation Review*.

A *Catch Limit Calculation* is the process by which catch limits for a species in a *Region* are calculated for all *Small* (and where appropriate *Medium* or *Large*) *Areas* within that *Region*, as specified in Sections 3.3, 3.4 and 3.5, by application of the *Catch Limit Algorithm* as described in Section 4. This algorithm uses historic catch data and estimates of absolute abundance for each *Management Area* that meet the requirements of Section 3.2.

2. IMPLEMENTATIONS AND IMPLEMENTATION REVIEWS

Implementations and *Implementation Reviews* are conducted by the Scientific Committee on a *Regional* basis. They involve the delineation of *Small Areas* and, where appropriate, *Medium* and *Large Areas*. A selection between possible options for *Catch-cascading* and/or *Catch-capping* is made during an *Implementation (Review)*, which includes the designation of *Combination Areas* as may be appropriate. This process is described as an *Implementation*

on the first occasion it takes place for a species in a *Region*; subsequent revisions are termed *Implementation Reviews*.[9] An *Implementation (Review)* shall take account of the available biological and operational data, including in particular those data pertaining to stock-identity. An *Implementation (Review)* is conducted by species or other suitable taxonomic unit below the species level[10]. Such taxonomic units should be treated separately for the purpose of *Catch Limit Calculations* (see Section 3) where the extent of geographical separation is sufficient to make this feasible. In the following text, 'species' should be taken to refer to taxonomic units below the species level where appropriate.

3. CATCH LIMIT CALCULATIONS

3.1 Scope and period of validity

Catch limits pertain to the first *Year* commencing after their calculation by the Scientific Committee, and for each of the following four *Years*[11]. A catch limit is calculated for each *Small Area* in a *Region* for each of these five *Years*. The five catch limits calculated for each *Management Area* shall be equal, except where adjustments are made under the phaseout rule specified in section 3.4. A *Catch Limit Calculation* involves the (re)calculation of catch limits for all *Small Areas* and, where appropriate, *Medium* or *Large Areas* in the *Region*. At the request of the Commission, the first of these catch limits calculated may alternatively refer to the *Year* in which the calculation takes place, and for each of the following four *Years*.

Where appropriate, a carry-over provision may be attached to the set of five catch limits calculated for a *Small Area*, and shall operate as follows. Where a catch limit for a *Small Area* is not reached in any one *Year*, the shortfall may be added to the catch limit for the same *Small Area* in any of the remaining years of validity of the *Catch Limit Calculation*. Any unused carry-over remaining at the end of the fifth *Year* of validity of the *Catch Limit Calculation*, or at the beginning of the first *Year* of validity of a new *Catch Limit Calculation*, whichever is the sooner, lapses.[11A]

3.2 Data requirements[12]

3.2.1 Catch history

Time series of catches by sex shall be compiled for each of the *Management Areas* specified within the region, using the best available information. These catch histories shall cover a period beginning not later than the *Year* of the first recorded or estimated[13] catch and ending with the *Year* preceding the first *Year* for which catch limits are to be calculated.[14]

If there are catches known to have occurred in the *Region*, but the *Small Area* in which they were taken is not known, they shall be assigned to the *Small Area* in which they are considered most likely to have been taken. *Pro rata* allocations are allowed. Where the sex ratio of catches is not accurately known, the best available estimate of the sex ratio shall be used to divide the catches; in the absence of any information, a 50:50 sex ratio shall be assumed. Unspecified catches of whales shall be allocated to species using the best available information on the species composition of the catch.[15] Known or estimated numbers of whales struck and lost shall be added to the catches. If the timing of catches is uncertain, they shall be assigned to *Years* according to the best available information. No catches known to have occurred in the *Region* shall be omitted from the *Catch Limit Calculation* on grounds of uncertainty over their location, timing, sex ratio or other details. All known removals[16] from a *Region* shall be included in the catch series.

3.2.2 Absolute abundance estimates

Absolute abundance data to be used in the calculation of catch limits shall have been obtained by direct methods[17], such as sightings surveys, and collected and analysed using methods approved by the Scientific Committee. *Management Areas* to which the *Catch Limit Algorithm* is applied should normally be surveyed at intervals not exceeding six years. The methods shall be such as to provide estimates of whale abundance that have acceptable levels of bias and precision. They shall also permit estimation of the variance of each estimate and of their variance-covariance matrix, or alternative variance-related statistics where appropriate.

Data for any sightings survey[18] to be used to calculate abundance estimates for the purposes of conducting a *Catch Limit Calculation* shall be documented and provided to the Secretariat in computer readable data files before a specified time in advance of the Scientific Committee meeting during which the data are to be used. All such data should be archived by the Secretariat in an appropriate database such that abundance estimates can be calculated for any specified *Small Area*. Data should be in a fully disaggregated form so that estimates can be recalculated appropriately if the boundaries of *Management Areas* are altered. Once lodged with the Secretariat, these data shall be available to accredited scientists as defined in the Scientific Committee's Rules of Procedure.

Estimates of absolute abundance are required for each *Management Area* to which the *Catch Limit Algorithm* is to be applied under the procedures described in Section 3.3[19]. For each such *Management Area*, a time series of absolute abundance estimates shall be calculated, along with an estimate of their variance-covariance matrix, or alternative variance-related statistics where appropriate. The approximate distributional properties of the abundance estimates shall also be determined. Care should be taken to avoid substantially underestimating the variance (or alternative variance-related statistic) of each abundance estimate used for input into the *Catch Limit Algorithm*.[20]

The absolute abundance estimate for a given *Year* should ideally be calculated from data collected in that *Year*. Data collected in different *Years* may be used, for example to account for parts of the area that were not covered in that *Year*, to pool results from surveys conducted over consecutive or nearly consecutive *Years* in order to reduce variance, or to provide estimates of calibration factors, provided that appropriate statistical methods are used[21].

Data from surveys conducted in different *Years* or at different times of year may only contribute to a single abundance estimate if adequate precautions are taken to avoid substantial double counting of whales due to migration or other factors. In the calculation of an absolute abundance estimate for a *Management Area* in a given *Year*, parts of the Area for which there are no absolute abundance estimates available at any time meeting the above specifications shall be treated as having an absolute abundance of zero.

The absolute abundance estimates should pertain to the total number of whales aged one year and above in the *Management Area*, regardless of any size limits that may be in force or the selectivity or otherwise of any past or present exploitation[22]. Animals aged less than one year shall be excluded where possible.

3.3 Options for determination of catch limits

Catch limits shall always be set at the *Small Area* level and they shall be set for each *Small Area* in a *Region*. In addition, where *Catch-capping* is invoked at the *Medium* or *Large*

Area level, corresponding catch limits will be set for those *Medium* or *Large Areas*. Catch limits for all *Residual Areas* within a *Region* shall be set at zero.

Catch limits for the total number of whales that may be taken in a season in each *Small Area* will be calculated by:

(a) application of the *Catch Limit Algorithm* to the *Small Areas* or, where appropriate, to *Combination Areas*, in which case *Catch-cascading* occurs; and
(b) where appropriate, by adjustment of the *Small Area* catch limits calculated, with or without *Catch-cascading*, under (a) by either

(1) application of the *Catch Limit Algorithm* to one or more of the *Medium Areas*, followed by *Catch-capping* of the *Small Area* catch limits; or
(2) application of the *Catch Limit Algorithm* to one or more of the *Large Areas*, followed by *Catch-capping* of the *Small Area* catch limits.

Catch limits for the total number of whales that may be taken in a *Year* in *Medium* or *Large Areas*, as required when *Catch-capping* is invoked, will be calculated by application of the *Catch Limit Algorithm* to those *Medium* or *Large Areas*.

The decision for any particular species or *Region* on whether or not *Catch-capping* is to be applied, and if so whether it should be applied at the *Medium* or *Large Area* level, and whether or not *Small Areas* are to be combined for the purposes of *Catch-cascading*, will be made on the basis of biological evidence available to the Scientific Committee, and, where necessary, the results of computer simulation trials[23] conducted by the Scientific Committee. Where computer simulation trials are carried out, they shall, as far as possible, encompass the full range of plausible hypotheses (regarding, for example, stock identity) consistent with existing biological data.

3.4 Phase-out rule

The catch limits for a *Small Area* calculated under Section 3.3 shall be adjusted downwards when the time series of absolute abundance estimates used for the application of the *Catch Limit Algorithm* to the *Small Area* (or, if *Catch-cascading* has been applied, to the *Combination Area* containing it) does not include an absolute abundance estimate pertaining to a *Year* not more than eight years[24] prior to the *Year* to which the catch limit pertains. Under these circumstances, the catch limit for the *Small Area* shall be reduced by 20% of the unadjusted catch limit for that *Small Area* and *Year* for each year in excess of eight years that has or will have elapsed since the *Year* of the most recent such abundance estimate[25]. This rule shall also be invoked in a *Small Area* included in a *Combination Area* for *Catch-cascading* if the data used for the derivation of absolute abundance estimates for input to the *Catch Limit Algorithm* do not contain any survey effort in that *Small Area* within this eight year period.

3.5 Adjustments for recent sex ratios in the catch

If the proportion, P_f, of female whales in the total catch taken from a *Small Area* in the most recent five *Years* prior to the *Catch Limit Calculation* for which the catch data are available exceeds 50%, the catch limits for the *Small Area* calculated according to the procedure described in sections 3.3 and 3.4 shall be adjusted downwards by the ratio $0.5/P_f$.[26] However, should the Scientific Committee decide it to be more appropriate, this adjustment ratio shall be determined from the proportion of females in the total catch taken from a union of *Small Areas*, and applied to the catch limit for each *Small Area* in the union. Further, the sex ratio adjustment shall be waived if the Scientific Committee agrees that the catches taken in the most recent five *Years* for which the catch data are available are too few to provide a useful indication of the expected future sex ratio of the catch.

4. CATCH LIMIT ALGORITHM

The nominal catch limit for a *Management Area* shall be calculated using the algorithm defined below if at least one estimate of absolute abundance as defined in Section 3.2 is available for the *Area* in question. Otherwise, the nominal catch limit for the *Management Area* shall be zero.

4.1 Input data

The input data for application of the *Catch Limit Algorithm* for any *Management Area* shall include the time series of annual catches as detailed in Section 3.2.1 and the time series of absolute abundance estimates, along with their variance-covariance matrix or other appropriate variance-related statistics and a specification of the distributional form of the absolute abundance estimates, as specified in Section 3.2.2.

4.2 Population model

The following population dynamics model[27] shall be used:

$$P_0 = P_T/D_T$$
$$P_{t+1} = P_t - C_t + 1.4184\,\mu P_t(1 - (P_t/P_0)^2)(0 \leq t < T)$$

where:

P_t is the population size in numbers at the beginning of *Year* t;
C_t is the catch in numbers in *Year* t;
D_T is the ratio of the population size at the beginning of *Year* T to the population size at the beginning of *Year* zero, known as the stock depletion;
Year zero is the first *Year* of the catch series used in the *Catch Limit Calculation* (as specified in Section 3.2.1);
Year T is the first year for which a catch limit is to be calculated in the current *Catch Limit Calculation*;
μ is the productivity parameter[28].

Provided there have been at least some catches, the population dynamics model is fully determined when the catch series and the values of D_T and μ are specified. If there have been no catches, a nominal catch of one whale in *Year* zero is assumed.

4.3 Fitting of the model

The annual absolute abundance estimate (if there is one) for each *Year* t, is assumed to have expectation bP_t where b is the bias parameter. The joint likelihood function of the parameters b, D_T and μ is determined using the absolute abundance estimates, the variance-covariance matrix of the absolute abundance estimates (or alternative variance-related statistics where appropriate) and information on their distributional form.

Unless there are specific indications to the contrary[29], the absolute abundance estimates shall be assumed to be lognormally distributed with a variance-covariance matrix of the log estimates to be estimated from the data using methods judged appropriate by the Scientific Committee. In this case, the formula for the likelihood is:

$$\text{Likelihood}\ (D_T, \mu, b) \propto \exp[-\tfrac{1}{2}(\mathbf{a} - \mathbf{p} - \beta\mathbf{1})'\, H\, (\mathbf{a} - \mathbf{p} - \beta\mathbf{1})]$$

where:

a is the vector of logarithms of estimates of absolute abundance by season;
p is the vector of logarithms of the modelled annual population sizes: $p_t = \log(P_t)$;
β is the logarithm of the bias parameter: $\beta = \log(b)$;
1 is a vector of ones;
H is the information matrix of the **a** vector. If H is non-singular, $H = V^{-1}$ where V is the variance-covariance matrix of the components of **a**.

The stock depletion parameter D_T is assigned a prior probability distribution[30] that is uniform from zero to one, and zero outside this range.

The productivity parameter μ is assigned a prior probability distribution[30] that is uniform from zero to 0.05, and zero outside this range.

The bias parameter b is assigned a prior probability distribution[30] that is uniform from zero to 5/3, and zero outside this range.

The above three prior distributions are treated as independent and combined accordingly to determine the joint prior distribution of the parameters D_T, μ and b.

The joint 'posterior' distribution of the parameters D_T, μ and b is defined as follows:

Posterior $(D_T, \mu, b) \propto$ Prior (D_T, μ, b). Likelihood $(D_T, \mu, b)^s$

where s, the scale parameter, is set equal to 1/16. The presence of the scale parameter represents an intended deviation from a strictly Bayesian approach.

4.4 The Catch Control Law

The internal catch limit, L_T, is the following function of D_T, μ and P_T:

$$L_T = \begin{cases} 3\mu(D_T - 0.54)P_T & \text{if } D_T > 0.54 \\ 0 & \text{if } D_T \leq 0.54 \end{cases}$$

The marginal posterior distribution of L_T is obtained by integration of the joint posterior distribution of (D_T, μ, b). This requires that, for each value of L_T , the joint posterior distribution of (D_T, μ, b) is to be integrated over the subset of parameter space that corresponds to that value of L_T . The nominal catch limit is equal to the lower [**to be added**] percentile of the marginal posterior distribution of L_T.[31]

4.5 Computation

All steps in the above algorithm for the calculation of the nominal catch limit shall be performed using a computer program validated by the IWC Secretariat and with sufficient numerical accuracy that the calculated nominal catch limit is numerically accurate to within one whale.

ANNOTATIONS TO THE REVISED MANAGEMENT PROCEDURE FOR BALEEN WHALES

(1) The trials carried out to date have largely been based on simulated management of baleen whales with breeding grounds in lower latitudes and feeding grounds in higher latitudes, and with whaling operations and abundance surveys restricted to higher latitudes. Thus, while the species may be distributed over an entire *Region* as defined here, most data will pertain only to a restricted part of the *Region*. While it is believed that the framework for calculation of catch limits specified here will be sufficiently flexible for management of species in *Regions* not directly matching the conditions simulated so far, this needs to be affirmed by the additional simulation trials required before implementation of the RMP in such cases. This would be especially important in the case of humpback or right whales, for which there is a possibility of whaling in the breeding grounds, on feeding grounds and on migrations between these in the one year.

The development of the RMP has been a long and difficult task, involving a wide range of scientific and technical issues and a thorough and extensive testing process. The Scientific Committee has recommended a protocol for evaluating amendments to the RMP which is given in IWC (1994a, pp.47-8).

1. Definitions

(2) The judgement on whether or not differences in proportions may be substantial will, in the first place, be based on estimates of movements and rates of mixing, and on relevant operational factors. Where the size of a proposed *Small Area* is such that potential differences in the proportions might be substantial, its acceptability will be judged on the basis of the risk of inadvertent depletion of some of the stocks in the *Region*, as estimated from suitable simulation trials. Conducting such simulation trials will be a normal part of the initial implementation of the RMP to a *Region* and species. Additional trials may also be necessary where it is proposed to increase the size of existing *Small Areas*.

(3) *Medium Areas* play a secondary role in the RMP, in that they are used only when *Catch-capping* is applied; it is not necessary for application of the RMP for any *Medium Areas* to be defined. In cases where *Medium Areas* can be identified with some confidence, so that *Medium Areas* approximate to ranges of actual stocks, *Catch-capping* is most appropriately carried out at the *Medium Area* level, rather than at a *Large Area* level.

See also annotation 8.

(4) As indicated, normally *Large Areas* will coincide with *Regions*. An example of when a *Large Area* may be smaller than a *Region* is the case in which there is a geographically isolated stock of whales within the *Region* which does not mix with other whale stocks within the *Region*.

(5) Normally, in cases where the whales migrate to higher latitudes, these *Residual Areas* will be confined to lower latitude areas within a region. In such cases, they will normally also be unsurveyed, and so will be assigned an absolute abundance of zero. As indicated in Section 3.3, catch limits are set at zero for *Residual Areas*.

(6) A *Year* is normally a calendar year for Northern Hemisphere *Regions* and split-years (for example, July 1-June 30) for Southern Hemisphere *Regions*. Where possible, a *Year* should be compatible with the whaling season established in terms of the definition in the Schedule.

(6A) The provision is to make allowance for the fact that mixing between different stocks in a *Small Area* may change during a Year, so the catches from that *Small Area* may be restricted at certain times in the interests of reducing their impact on one of these stocks.

(7) Where *Small Areas* identified in a region are also quite small in size, it is likely that the absolute abundance estimates for these *Small Areas* will have large variances associated with them. On the other hand, estimates of absolute abundance for some combinations of these *Small Areas* may have considerably greater precision. Provided sufficient evidence exists to warrant combining some *Small Areas*, the process of *Catch-cascading* can be used to take advantage of this greater precision. In calculating the relative

abundances in the *Small Areas* making up a *Combination Area*, a weighted average of past abundance indices for those *Small Areas* is used. The additional factor of 0.9^n is included to downweight abundance data from *Years* separated by n years from the *Year* of the *Catch Limit Calculation*. Criteria for deciding whether or not *Catch-cascading* should be applied are given in Section 3.3.

An example of the calculation involved is as follows. If the absolute abundance estimates are treated as being lognormally distributed, then the relative abundance for a *Small Area* would normally be calculated using the following formula.

Let:
$\mathbf{a}$ = vector of log abundance estimates in the *Small Area;*
t_i = difference between the current *Year* and the *Year* of the ith estimate;
F = information matrix of $\mathbf{a}$.
If F is non-singular, $F = V^{-1}$ where V is the variance-covariance matrix of $\mathbf{a}$. G is the matrix such that

$$G_{ij} = F_{ij}\,(0.9)^{-(t_i + t_j)/2}$$

The relative abundance in the *Small Area* is given by:

$$\exp\left[\left(\sum_i \sum_j a_i G_{ij}\right) / \left(\sum_i \sum_j G_{ij}\right)\right]$$

(8) *Catch-capping* is a process designed to ensure that catch limits calculated individually for some *Small Areas* are not inappropriately large, as is possible in some cases of uncertain stock identity. As indicated in Section 3.3, whether or not *Catch-capping* is invoked in the *Catch Limit Calculation* for a species in a particular *Region* will depend on examination of available data and possibly simulation trials for that species and *Region*. *Catch-capping*, if it is invoked, will be carried out at the *Medium* or *Large Area* level depending on the degree of certainty existing about the identification of *Medium Areas*. Where that degree of certainty is relatively high, *Catch-capping* should be carried out at the *Medium Area* level. Where no *Medium Areas* are identified for a species and region, *Catch-capping* should be carried out at the *Large Area* level, if invoked. Where *Medium Areas* are identified, but only tentatively, the decision as to whether any *Catch-capping* should be carried out at the *Medium* or *Large Area* level should be determined from results of appropriate simulation trials.

Catch-capping can be applied together with *Catch-cascading*. In this case, after the *Small Area* catch limits have been calculated under *Catch-cascading*, the capping option is invoked.

2. Implementations and Implementation Reviews

(9) An *Implementation* is required before the *Catch Limit Algorithm* can be applied to a new species and *Region* for the first time. An *Implementation Review* for a species and *Region* should normally be scheduled no later than five years since the completion of the previous *Implementation (Review)*. In some cases an *Implementation (Review)* may require the specification and running of further *Implementation Simulation Trials*, especially when major changes to *Management Area* boundaries or the selection of different options for *Catch-capping* and/or *Catch-cascading* than those currently used is contemplated. In such cases the *Implementation Review* would probably not be completed at a single meeting. In the meantime, *Catch Limit Calculations* continue to be based on the existing *Management Areas* and options.

In some cases, it may be appropriate to carry out an *Implementation Review* earlier than 5 years after the previous *Implementation (Review)*. This would be warranted, for example, if important new evidence on stock identity becomes available, if major advances are made in methodology of calculating absolute abundance estimates, if major changes occur in the areas covered by the abundance surveys, or if other evidence becomes available to the Scientific Committee suggesting that the premises on which the previous *Implementation (Review)* was conducted are no longer appropriate.

Implementation Simulation Trials involve identifying the range of plausible hypotheses relevant to recommending an *Implementation* or *Implementation Review* and formulating simulation models which conform with these hypotheses. Computer simulations are used to evaluate the effect under these models of applying the CLA to designated *Management Areas* with various *Catch-cascading* and/or *Catch-capping* options. If none of the options tried produces satisfactory performance on conservation criteria across the range of hypotheses it may be that *Management Areas* are inappropriately defined. If the range of plausible hypotheses is very broad, it may be that additional information is required to narrow the range of plausible hypotheses before application of the RMP can be recommended. Further explanation is given in IWC (1995, p.117-19).

(10) Normally, *Implementation (Reviews)* will be carried out at the species level. However, if sub-species, varieties or different morphological forms of baleen whales exist in a *Region* such that they can be identified in catches and separate absolute abundance estimates can be obtained for them, then *Implementation (Reviews)* should be conducted separately, provided the degree of geographical separation is sufficient to allow this.

3. Catch Limit Calculations

3.1 Scope and period of validity

(11) To provide an uninterrupted series of catch limits, a new *Catch Limit Calculation* will normally be required not more than five years after the preceding one. However, a *Catch Limit Calculation* should be carried out sooner than this if a new abundance estimate meeting the requirements of Section 3.2.2 becomes available. Even if no new abundance estimate has become available, it could be necessary to carry out the new *Catch Limit Calculation* up to one year before the expiry of the current five-*Year* series of catch limits, to ensure timely availability of the resulting figures. In the event of difficulties of finalising the analysis of new abundance data in time to be used in the *Catch Limit Calculation* for the next five-*Year* period, the *Catch Limit Calculation* shall nevertheless be carried out with the existing agreed data.

(11A) The following example explains how this provision operates. Suppose that a *Catch Limit Calculation* yields a set of five annual catch limits of 500 whales for a *Small Area*. Suppose also that the catch taken in Year 1 amounts to 400 whales. Then, up to 600 whales may be taken from the same *Small Area* in Year 2. If the catch taken in Year 2 amounts to, say, only 480 whales, then up to 620 whales may be taken in Year 3. If the catch taken in Year 3 amounts to 550 whales, then up to 570 whales may be taken in Year 4. The provision thus affects the way the RMP *Catch Limits* are applied, but not the *Catch Limits* themselves. Simulation studies of the effects of this provision on the performance of the *Catch Limit Algorithm* are reported in IWC (1989).

3.2 Data requirements

(12) In addition to the requirements outlined in Section 3.2, data and methods for analysing them that are used in the application of the RMP should meet the minimum standards described in IWC (1994).

3.2.1 CATCH HISTORY

(13) For stocks for which exploitation started relatively recently, the catch history over the entire period of exploitation will be well known. For other stocks, however, where exploitation has extended over many years and possibly intermittently over centuries, records for early catches may be incomplete, or gaps may exist. The intent here is that the catch histories for use with the RMP should extend as far back as possible. Where there are no gaps in a long historical record of catches, the catch series used in *Catch Limit Calculations* shall start in the first season for which the catch has been recorded or estimated sufficiently reliably. Where there are gaps, or there is major uncertainty about the early catch history, selection of this first *Year* will be made on a case by case basis.

The RMP has been demonstrated to be robust to considerable uncertainties in catch histories in single stock robustness trials (Adams, 1982, p.272).

(14) In the event of catch data for the most recent years not yet being available, input to the *Catch Limit Algorithm* shall assume that the catches taken are equal to the limits set for those *Years*.

(15) Where the information is insufficient to allocate catches to species sufficiently reliably, the potential consequences of incorrect allocations may need to be examined by simulation trials.

(16) The population model used in the *Catch Limit Algorithm* (see Section 4) effectively assumes that all whales that die from causes other than those resulting from natural mortality are included in the catch history. Thus, known or estimated 'indirect' catches, e.g. whales killed through entanglement in fishing gear (including those that subsequently strand), should also be included in the catch history, in addition to whales caught or struck and lost in direct whaling operations. On the other hand, stranding is assumed to be part of the process of natural mortality, and numbers of whales stranded due to natural causes should not be included in the catch history.

3.2.2 ABSOLUTE ABUNDANCE ESTIMATES

(17) In the early stages of development of the RMP, it was envisaged that absolute abundance estimates, relative abundance indices, or both could be used. The difficulty with use of relative abundance indices that are collected as part of or associated with catching operations of the type carried out prior to the development of the RMP, is that the precise relationship between the index and the true absolute abundance is rarely known. These issues were discussed at the CPUE workshop, at which the types of information necessary to clarify this relationship were also identified (IWC, 1998). As this relationship has remained unresolved, the possible use of such data was dropped for the present. Possible use of relative abundance indices other than those associated with catching operations was not investigated during development of the RMP.

Note that the above does not preclude the use of estimates of relative abundance during *Catch-Cascading* (see annotation 7) or in analysing abundance data collected in different *Years* (see Section 3.2 and annotation 21).

In some circumstances, the best available estimates of absolute abundance may come from mark-recapture analyses, e.g. those resulting from photo-identification studies. The properties of such estimates, and the implications of these with respect to possible uncertain stock identity and migration patterns need to be evaluated before estimates of abundance based on them may be used when implementing the RMP for a particular species and *Region*. Until this is done, sightings surveys or other direct methods of estimation with similar statistical properties remain the primary tools for obtaining suitable estimates of absolute abundance for *Catch Limit Calculations*.

(18) The types of data that are required fall into two categories: data necessary for standard analyses (e.g. sightings effort data and sightings records) and ancillary data (as appropriate according to the analyses to be carried out, e.g. dive-time records) (IWC, 1994a, p.44-5).

(19) In the simulation trials of the RMP carried out so far, it has been assumed that absolute abundance estimates are available for effectively all the *Management Areas* within the *Region* being assessed. As indicated later in Section 3.2, *Management Areas* for which no suitable estimates of absolute abundance are available are treated as having an absolute abundance of zero. This, along with the possible application of *Catch-capping* described in Section 3.3, makes adequate provision for cases where surveys have not been conducted for some parts of the range in the *Region* being assessed, provided the unsurveyed area does not form too large a proportion of that range.

(20) This is because trials have shown adverse behaviour when there is a high probability of substantial underestimation of the variance. This can occur even when the variance estimator is statistically unbiased, but has a high variance. Estimators for the variance (or alternative variance related statistics) should take into account, to the extent possible, all sources of observation error, and should not themselves have such high variance that there is a serious risk of markedly overestimating the precision of an abundance estimate. These remarks do not apply to zero abundance estimates, which should be handled in the way described in annotation 29 unless a more appropriate alternative method is available. Simulation trials have shown that process error additional variance may need to be taken into account when the observation error is low and the process error this is high. Some examples in this regard may be found in IWC (1994b):

Note:

Observation error is the sampling error arising from the survey methods and design. The level of observation error is inversely related to the amount of survey effort, provided that the survey is well designed.

additional variance reflects the extent to which abundance estimates from repeat surveys of the same area in successive years will vary more than would be expected on the basis of the observation error alone, for example due to variations in the numbers of whales moving into or out of the survey area.

(21) Statistical methods to be used in the calculation of absolute abundance estimates from data collected in different years shall ensure, *inter alia*, that (i) no piece of data receives undue weight; (ii) the absolute abundance estimate is referred to the most appropriate *Year*; (iii) the data contributing to an absolute abundance estimate for any *Management Area* in a given *Year* shall normally all have been collected within a ten year period, and where possible not more than five years earlier or later than the *Year* to which the abundance estimate refers; and (iv) in the case of a *Small Area* or a *Combination Area*, except for contributions to calibration factors, data collected in a *Year* other than that to which the estimate refers shall not contribute disproportionately to the abundance estimate. A

contribution to the abundance estimate of more than 50% would normally be considered disproportionate. For some stocks of whales currently at low levels of abundance, it may be necessary to pool data over a period longer than ten years in order to obtain reliable estimates of some calibration factors. It is possible that in the future, appropriate alternative statistical methods may be developed for calculating time series of absolute abundance estimates in which data from all *Years* are analysed together, e.g. methods based on generalised linear models (Cooke, 1993; IWC, 1994c, pp.93-94). For such methods, the above requirements may need revision.

(22) In the simulation trials conducted so far, it has been assumed that estimates of absolute abundance correspond to whales of all ages from one year upwards.

3.3 Options for determination of catch limits

(23) The Committee has recommended that suitable case-specific simulation trials be carried out prior to the initial implementation of the RMP for each species and *Region*. These have been termed *Implementation Simulation Trials*, to distinguish them from the more generic robustness trials used during the development of the RMP.

Where simulation trials are used during implementation to evaluate the appropriateness or otherwise of *Catch-cascading* and/or *Catch-capping*, and in the latter case whether at the *Medium* or *Large Area* level, judgements will be based on comparisons of performance of the different options against a base case where catch limits are calculated and set by *Small Area* only. The addition of *Catch-capping* to other options leads to the setting of catch limits lower than or equal to those which would be set in the absence of *Catch-capping*. Where the performance of suitable simulation trials of the base case option for setting catch limits is satisfactory in terms of statistics related to lowest and final depletion levels, it would not normally be judged necessary to invoke *Catch-capping* ('depletion' is defined in Section 4.2). However, where the performance of the base case option is judged unsatisfactory in terms of the depletion statistics, and this is rectified when one of the *Catch-capping* options is used, *Catch-capping* at the relevant level shall be invoked.

Catch-cascading normally leads to higher catch limits than the base case option. Accordingly, *Catch-cascading* may only be invoked when simulation trials show that it does not lead to unsatisfactory performance on depletion statistics related to lowest and final depletions.

Examples of examination of these issues in the context of potential implementation of the RMP to Southern Hemisphere and North Atlantic minke whales are given in Annexes E and F of the 1992 Report of the Scientific Committee (IWC, 1993a; b).

3.4 Phaseout rule

(24) Discussion of issues relating to the selection of this time period is recorded in IWC, 1994a, p.48 (Item 9).

(25) This provision will ensure that the catch limit will be reduced linearly to zero in five years. All five catch limits, including phaseout adjustments, are to be calculated at the time of the *Catch Limit Calculation*. This allows prior warning to the Commission and member governments that future phaseouts will occur within five years unless new abundance estimates meeting the requirements of Section 3.2 become available and a *Catch Limit Calculation* is performed.

3.5 Adjustments for recent sex ratios in the catch

(26) An example may help clarify this formulation. Suppose that in the 5 years prior to the *Catch limit calculation*, during which the annual catch limit was 100 whales, the total catch from the *Small Area* comprised 200 males and 300 females, i.e. $P_f = 300/(200+300) = 0.6$. Suppose also that prior to the sex ratio adjustment, the annual catch limit indicated by the *Catch Limit Algorithm* for each of the next five years is 132 whales. The adjusted catch limit is then:

$$132 \times 0.5/P_F = 132 \times 0.5/0.6 = 110 \text{ whales per annum}$$

Note that the aim of the *Catch limit algorithm* in setting the pre-adjustment catch limit is that this comprise equal numbers (66 in this case) of males and females. The intent of the adjustment is that no more than 66 females will be caught: if the female proportion remains at 0.6, this will be achieved exactly by the adjustment process because $0.6 \times 110 = 66$.

4. Catch Limit Algorithm

4.2 Population model

(27) The population dynamics model used here has the form of a discrete time version of the Pella-Tomlinson model. Neither the form of model used, nor its parameter values, are meant to give an accurate representation of the population dynamics of baleen whales. Rather, it is a model which, when used as an integral part of the *Catch Limit Algorithm*, has been demonstrated to allow robust calculation of catch limits.

(28) The parameter μ is related to the MSY rate. For the population model used, MSYR = 0.9456μ.

4.3 Fitting of the model

(29) An example where the lognormal assumption cannot be used is when the estimate of absolute abundance is zero. Zero estimates of absolute abundance arise when no sightings of the target species are made on primary effort during a survey of an area. This should not be a frequent occurrence, but such estimates should not be ignored when they do occur.

Although several factors contribute to the variance of an estimate of absolute abundance, the variance is dominated by the variance in the number seen when the number of sightings is very low. The variance of the number of sightings will be at least as high as the variance of a random variable with a Poisson distribution with expectation equal to the expectation of the number of sightings. The number of sightings refers to the number of schools or groups, rather than to individual animals.

The expected number of sightings, $E(n)$, is proportional to the true absolute abundance, P:

$$E(N) = P/\propto$$

The parameter $\propto$ represents the estimate of absolute abundance that would have been obtained had there been exactly one sighting. This will be a function of the survey effort, the size of the area, and survey parameters that may need to be estimated by adopting values from similar surveys. Ignoring the variance of $\propto$, the likelihood of the zero estimate of absolute abundance is the following function of the true absolute abundance:

$$L(P) = \exp(-P/\propto)$$

Since the only covariance between the absolute abundance estimate and other absolute abundance estimates is that due to the $\propto$ parameter, whose variance is being ignored, the joint likelihood function of the zero estimate of absolute abundance and the remaining estimates is taken to be the product of the respective likelihood functions.

The information about the zero estimate of absolute abundance that needs to be supplied to the *Catch Limit Algorithm* is: (i) the *Year* of the zero estimate; (ii) the fact that it is a zero estimate; and (iii) the value of the a parameter. The computer program implementing the *Catch Limit Algorithm* that has been validated by the IWC Secretariat has the facility to handle zero estimates of absolute abundance in this manner. *P* is identified with the simulated population size generated by the *Catch Limit Algorithm's* internal calculations.

Since the treatment above ignores some contributions to the variance of a zero estimate of absolute abundance, it assigns more weight to a zero estimate than is strictly warranted.

(30) Despite their appearance, the prior distributions assumed here are not standard Bayesian priors on the selected parameters reflecting prior beliefs about the likely distribution of the corresponding biological parameters. The procedure adopted here is Bayes-like, rather than strictly Bayes. The distributions and ranges were selected to provide 'optimum' performance in relation to a set of agreed performance statistics in simulation trials. If likely ranges and distributions of the corresponding biological parameters change from current perceptions, the appropriate way to take account of these changed perceptions is to revise the simulation trials, and if appropriate change the tuning (IWC, 1992b, p.55) of the procedure, rather than altering the 'priors'.

4.4 The Catch Control Law

(31) This percentile was arrived at by a process detailed in IWC, 1994a, p.153-167 [**update reference when available**] to implement the Commission's choice (IWC, 1992a, pp.47-8) of a 0.72 tuning level.

REFERENCES

Adams, J. 1982. History and function of the Alaska Eskimo Whaling Commission. pp. 9-13. *In:* T.F. Albert, J.J. Kelley and R. Dronenburg (eds.) *Proceedings of the First Conference on the Biology of the Bowhead Whale,* Balaena mysticetus*: Population Assessment.* Alaska Eskimo Whaling Commission, Barrow, Alaska. viii+252pp.

Cooke, J. 1993. A maximum-likelihood approach to fitting population trajectories to sightings data. Paper SC/F92/Mg8 presented to the Special Meeting of the Scientific Committee on the Revised Management Procedure, March 1992 (unpublished).

International Whaling Commission. 1989. Report of the Comprehensive Assessment Workshop on Catch Per Unit Effort (CPUE), Reykjavik, 16-20 March 1987. *Rep. int. Whal. Commn* (special issue) 11:15-20.

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. Report of the Scientific Committee. *Rep. int. Whal. Commn* 42:51-86.

International Whaling Commission. 1993a. Report of the Scientific Committee, Annex E. Report of the sub-committee on Southern Hemisphere baleen whales. *Rep. int. Whal. Commn* 43:104-14.

International Whaling Commission. 1993b. Report of the Scientific Committee, Annex F. Report of the sub-committee on North Atlantic baleen whales. *Rep. int. Whal. Commn* 43:115-29.

International Whaling Commission. 1994a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 44:41-201.

International Whaling Commission. 1994b. Report of the Scientific Committee, Annex D. Report of the sub-committee on management procedures. *Rep. int. Whal. Commn* 44:74-92.

International Whaling Commission. 1994c. Report of the Scientific Committee, Annex E. Report of the sub-committee on Southern Hemisphere baleen whales. *Rep. int. Whal. Commn* 44:93-107.

International Whaling Commission. 1995. Report of the Scientific Committee, Annex D. Report of the sub-committee on management procedures. *Rep. int. Whal. Commn* 45:104-19.

International Whaling Commission. 1998. Report of the Scientific Committee. *Rep. int. Whal. Commn* 48:53-127.

Sakshaug, E., Bjorge, A., Gulliksen, B., Loeng, H. and Mehlum, F. 1994. Structure, biomass distribution, and energetics of the pelagic ecosystem in the Barents Sea: A synopsis. *Polar Biol.* 14:405-11.

Annex O
Recommendations on Management Issues Arising out of the Right Whale Workshop

The Committee endorsed the Workshop recommendations that require management action. These measures attempt to reduce or eliminate non-natural mortality of right whales and disturbance to their habitat. These are particularly important for those stocks for which the Committee has expressed concern over their status.

Mortality

The Workshop had identified ship strikes and incidental entanglements in fishing gear as the most significant cause of human-induced mortality of right whales.

With respect to ship strikes (see SC/50/Rep4, item 12.3.3), given the serious concern over the status of western North Atlantic right whales (see SC/50/Rep4, item 11), the Committee **strongly recommends** that the Commission makes every effort to encourage the adoption by relevant governments of the specific recommendations for this area given in Appendix I.

In more general terms the Committee **recommends** that the Commission:

(1) urges its member nations to
  (a) initiate or expand preventative measures including Notices to Mariners, notifications on charts and informational brochures to other areas where right whales and high levels of shipping overlap, and
  (b) develop mitigating options, areas to be avoided, early warning systems, sonar detection of whales, acoustic deterrents, and the shifting of shipping lanes and reductions in ship speed;
(2) seek cooperation from the International Maritime Organisation to provide protection for right whales, including but not limited to mandatory ship reporting and ship routing, especially where commercial vessels are entering calving, breeding or feeding areas.

With respect to entanglements (see SC/50/Rep4, item 12.3.2), the Committee **recommends** the Commission urges member governments to ensure that:

(1) research continues on methods to reduce right whale entanglements in fishing gear;
(2) entanglement rates and the success of steps to reduce entanglement are determined and monitored (e.g. through periodic analysis of scarring rates and levels of severe entanglement in photo-identification databases);
(3) if the above monitoring indicates that protective measures are insufficient, they are upgraded as appropriate;
(4) disentanglement programmes (including training from experienced persons) are established where appropriate;
(5) consideration is given to the prohibition of any gear that might entangle right whales in high use habitats, and especially in calving, breeding or feeding areas and sanctuaries.

Disturbance and habitat issues

The Committee **recommends** that the Commission urges local, regional and national authorities responsible for right whale habitat to develop contingency plans for oil and chemical spills, where these do not exist (see SC/50/Rep4, item 12.3.1).

The Workshop had also made specific recommendations on habitat related issues that require management action by individual governments (see SC/50/Rep4, item 12.3.5). The Committee **recommends** that the Commission ask the relevant governments to take the necessary action as follows.

(1) *Gull harassment:* Kelp gull harassment of right whales off Peninsula Valdés, Argentina (Rowntree *et al.*, 1998a; b) has grown substantially worse in parallel with increasing areas of open waste disposal sites and a concomitant growth in gull populations. Avoidance reactions of the whales significantly impact their behaviour and perhaps their distribution (Rowntree *et al.*, 1998b). The Committee **recommends** that these disposal sites be aggressively regulated.
(2) *Monitoring human activities:* Recognising that the entire known breeding population of New Zealand sub-Antarctic southern right whale concentrates in a very small area, and that adverse effects of human-related activities could potentially have a serious impact on this recovering population, the Committee **recommends** that any existing or proposed human-related activities in the New Zealand sub-Antarctic (e.g. whalewatching, oil or gas exploration, vessel traffic and fishing operations) be carefully evaluated and monitored for any potential negative effects.

Facilitation of research

The Committee **recommends** that the Commission urges member governments to provide funding for the research items it has identified (see SC/50/Rep4, item 15). In addition the Committee draws attention to the following **recommendations** that require action but not funding *per se*.

Sample collection

The Workshop had made a number of research recommendations with respect to the collection of biopsy samples. The Committee **recommends** that the Commission

urges member governments to facilitate the issue of national permits to collect sufficient biopsy samples from adult and calf right whales to address the research recommendations identified in SC/50/Rep4 (items 7 and 9).

Sample transfer
The Workshop **recommends** that IWC member nations should be asked to facilitate transfer of skin/blubber biopsy samples between research institutions in different countries to assist collaborative analyses, and that the IWC Secretariat approaches the CITES Secretariat to determine the best way to facilitate the exchange of such material.

Necropsies
The Workshop had noted the need for detailed necropsies of right whales, particularly for those populations for which there is concern over their status. The Committee **recommends** that the Commission requests that member governments ensure that appropriate programmes are initiated and, where necessary, permits granted to enable this work to take place (see SC/50/Rep4, item 9.1.3).

Surveys in territorial waters
The Workshop had identified the need for a further research cruise to assess the abundance of right whales in the western North Pacific. The Committee **recommends** that the Committee requests the Commission to urge relevant member nations to co-operate in this exercise and in particular that the Russian Federation is urged to grant permission for vessels to survey within 12 n.miles of Okhotsk Sea coast (see item 10.2).

Whalewatching
The Workshop had endorsed the IWC's general principles for whalewatching (IWC, 1997, p.105). The Committee **recommends** that these be applied to all whalewatching activities involving right whales. It was agreed that it was critical to: (1) manage the development of new and fledgling whalewatching operations to minimise the risk of adverse affects; and (2) take appropriate regulatory measures in areas where directed research demonstrates negative impacts on whales from established whalewatching activities.

Special protected areas
The Workshop had agreed that special protected areas provide a framework for the implementation of site-specific regulations for whalewatching and that such areas are important in conserving coastal habitats. The Committee therefore **recommends** that studies be undertaken to assess the need for the establishment of special protected areas in areas of known right whale concentration (e.g. the central-south coast of Santa Catarina, Brazil).

Appendix 1

SPECIFIC RECOMMENDATIONS FOR REDUCING SHIP STRIKES (SEE ITEM 12.3.3 AND ITEM 14 OF SC/50/REP4)

1. Western North Atlantic

Southeast USA
Calving right whales give birth and over-winter in the coastal waters between Savannah, Georgia (GA) and West Palm Beach, Florida (FL). The primary aggregation occurs along 80 n.miles of coastline between Sapelo Island, GA and St Augustine, FL. Most sightings of right whales occur west of 81°00'W (Knowlton *et al.*, 1992; Slay *et al.*, 1998). Three major shipping channels serve three commercial ports and two military bases located within this area of aggregation. These are the Brunswick Harbor entrance (Brunswick, GA), the St Marys River entrance (Fernandina Beach, FL) and the St. Johns River entrance (Jacksonville, FL).

The Committee **recommends** that these three channels be extended due east, from their respective sea-buoys, to 81°00'W. During the calving season (December to March), all vessels greater than 25m in length, using these channels, should travel the entire length of the channels. All vessels greater than 25m in length should operate at less than 10 knots (or minimum safe steerage) while in the federally designated critical habitat. The Committee further **recommends** that a mandatory ship reporting system be implemented to acquire information on the numbers of vessels transiting this area.

Bay of Fundy
Right whales are present in the Bay of Fundy from June to November, with a peak in August and September. In recent years, mother-calf pairs, juveniles and adults identified in the Bay represent some two-thirds of the catalogued population. The aggregation of right whales overlaps with the outbound shipping lane from Saint John, New Brunswick, and the inbound vessels lane for ports in Maine and New Brunswick. These lanes are monitored by a Vessel Traffic System. Since 1992, there have been three mortalities from ship collisions in the Bay of Fundy (Slay *et al.*, 1998).

To reduce the potential for ship/whale collisions, the Committee **recommends** that the shipping lanes be narrowed and moved about 10km to the east away from right whale aggregations.

Roseway Basin
Roseway Basin is an offshore feeding habitat which has been observed with high numbers of right whales from July to September. Although no shipping lanes transit the area and no mortalities have been documented, ship traffic has been observed transiting this habitat.

The Committee **recommends** that this high-use area be designated as an area to be avoided by shipping.

Great South Channel
Right whales are present in high numbers in this offshore area from April to June. Shipping traffic to/from Boston Harbor use the shipping lanes in the Great South Channel. Other Gulf of Maine shipping traffic traverses the entire breadth of the Great South Channel. Little is known about the level of ship traffic and how it overlaps with right whale habitat use.

The Committee **recommends** that a mandatory ship reporting system be implemented to acquire information on the numbers of vessels transiting this area and to provide

these ships with information and information on real time sighting locations obtained of right whales observed from aerial surveys.

Cape Cod Bay
Right whales are present in limited numbers in this area from December to May. An unknown level of vessel traffic transits through this high-use area.

The Committee **recommends** that a mandatory ship reporting system be implemented to acquire information on the numbers of vessels transiting this area and to provide these vessels with information on right whale sighting locations obtained from aerial and shipboard surveys.

High speed ferries
The Workshop expressed serious concern over the proposed use of large (>100') high speed (>30 knots) ferries transiting right whale migration corridors and habitat. The Committee **recommends** consideration of ship/whale collision risks in permit review.

2. Other areas

The Committee agreed that many of the problems faced by North Atlantic right whales with regard to ship traffic either currently or potentially exist in other parts of the world where right whales concentrate.

For areas where there is information on right whale distribution and densities, or critical habitats have been defined, the control of shipping activity should be investigated. This may include:

(a) moving shipping lanes to areas of lower right whale densities;
(b) slowing ship speeds;
(c) educating mariners on right whale distribution and vulnerability;
(d) assessing regions where there is increased potential for whale/ship interaction with increasing or expanding right whale populations.

REFERENCES

International Whaling Commission. 1997. Report of the Scientific Committee. *Rep. int. Whal. Commn* 47:59-257.

Knowlton, A.R., Sigurjónsson, J., Ciano, J.N. and Kraus, S.D. 1992. Long-distance movements of North Atlantic right whales (*Eubalaena glacialis*). *Mar. Mammal Sci.* 8(4):397-405.

Rowntree, V.J., McGuiness, P., Marshall, K., Payne, R., Sironi, M. and Sefer, J. 1998a. Increased harassment of right whales (*Eubalaena australis*) by kelp gulls (*Larus dominicanus*) at Península Valdés, Argentina. *Mar. Mammal Sci.* 14(1):99-115.

Rowntree, V.J., Payne, R.S. and Schell, D.M. 1998b. Changing patterns of habitat use by southern right whales (*Eubalaena australis*) identified on the nursery ground at Península Valdés, Argentina. Paper SC/M98/RW13 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

Slay, C.K., Kraus, S.D., Hamilton, P.K., Knowlton, A.R. and Conger, L.A. 1998. Early warning system 1994-1997. Aerial surveys to reduce ship/shale collisions in the North Atlantic right whale calving ground. Paper SC/M98/RW6 presented to the IWC Special Meeting of the Scientific Committee towards a Comprehensive Assessment of Right Whales Worldwide, 16-25 March, Cape Town, South Africa.

Annex P
Proposal for Developing a Cooperative Research Programme to Address Critical Research Needs for the Greenland Stocks

The sub-committee on Aboriginal Subsistence Whaling (Annex I) had noted with great concern that it has never been able to provide satisfactory scientific advice on either the fin or minke whales off West Greenland. The reason that satisfactory advice cannot be given is the lack of requisite data, particularly on stock structure and abundance. That sub-committee had recognised that the logistical difficulties of obtaining the necessary information are enormous, both in terms of the physical environment (including weather conditions) and the level of resources required. However it believed that it was unacceptable to merely continue to provide less than satisfactory advice and make general recommendations for further work.

Similarly, the Standing Working Group on the Development of the AWMP (Annex F) had agreed that providing advice on the Greenlandic fisheries was a matter of the highest priority. It agreed that given our present state of knowledge, developing a *Strike Limit Algorithm* for the Greenland Fisheries that would fulfil all the Commission's objectives will be an extremely difficult, if not impossible task.

Born noted that research directed at obtaining a better understanding stock structure by using a variety of techniques has been initiated this year in co-operation with Norwegian scientists. He added that a survey for the purpose of estimating abundance of cetacean stocks off Greenland was planned within the next five years. The Committee welcomed the Greenland research initiative.

Taking into account its discussions on priorities for the Commission's work (Plenary Item 6), the Committee therefore, agreed to establish a Working Group, in collaboration with Greenlandic scientists, to determine a *costed* research programme that will enable the Committee to provide satisfactory advice to the Commission as soon as possible. At a minimum this programme should address questions of stock identity and abundance. The programme should include representatives of the AWMP in which group the important relationship between data requirements and management procedures has already been stressed. Noting that the Greenlandic scientists are currently designing a research programme, the Committee agreed to establish an Intersessional Correspondence Group (convened by Born) to assist in this process. Noting the full workload of the SWG on the AWMP and the fact that the sub-committee on aboriginal subsistence whaling does not need to carry out a major reassessment next year, the Committee agrees that consideration of the Greenlandic research programme should be accorded high priority status in the work of that sub-committee next year.

Annex Q
Report of the *Ad hoc* Working Group on Future SOWER Planning

Members: Baker, Bannister, Best, Borchers, Butterworth, Clark, Donovan, Ensor, Findlay, Kasuya, Kato (Convenor), Moronuki, Nishiwaki, Pastene, Perrin, Pinedo, Tomita, Thiele, Van Waerebeek.

1. BACKGROUND

Kato explained that the group had been formed to produce a plan for the future of both the Antarctic and blue whale components of the SOWER cruise programme, given that (a) the Scientific Committee had recommended that such planning should take into consideration collaboration with GLOBEC and CCAMLR, and (b) that there had been three years of blue whale cruises, and an assessment of progress to date would be timely.

2. ELECTION OF CHAIRMAN AND RAPPORTEUR

Kato was elected Chairman and Best agreed to act as rapporteur.

3. ADOPTION OF AGENDA

The Agenda was adopted unchanged.

4. BLUE WHALE PROJECT

4.1 Brief review of progress on discrimination between two subspecies[1]

4.1.1 Acoustic

The sounds recorded on the 1997/98 SOWER Antarctic cruise still had to be analysed, and the group felt that until the working group under Clark had reported to the sub-committee on Other Great Whales (Annex E, Appendix 2) it was premature to comment on acoustic results to date. It was, however, possible that the existing coverage of 'true' blue whale vocalisations might be more limited in quantity and area coverage than that from 'pygmy' blue whales.

4.1.2 Video-sequence

Results from the first two cruises had been summarised in SC/50/CAWS1. The technique looked promising, but to date, the material from true blue whales was much less than that from pygmy blue whales (although some 27mins was available from the 1997/98 Antarctic SOWER cruise – as well as another 180mins from putative pygmy blue whales off Chile on the 1997 SOWER cruise).

4.1.3 Biopsy

Material had been collected from 3 true blue and 3 pygmy blue whales on the SOWER Antarctic cruise in 1997/98, and from 18 pygmy blue and 1 undetermined blue whale on the 1997 SOWER cruise off Chile. The group felt unable to reach a conclusion on the status of the genetic discrimination between true blue and pygmy blue whales without first checking on the state of analysis of existing samples, including 'voucher' material from known true blue and pygmy blue whales. It agreed to recommend that a report summarising the situation, including the need for further material, should be prepared in time for the next planning meeting.

4.1.4 Photographs

The group noted that these had been collected mainly for the purposes of individual identification, but that the frames taken included some suitable for investigating morphological differences between true and pygmy blue whales (i.e. blowhole and rostrum shape). No analyses of these photographs had been undertaken yet (nor of existing video material which had also been taken for the purposes of documenting possible morphological differences between the two forms). The group recommended that Kato investigate the possibility of analysing this material, which is held in Japan. Thiele volunteered to inspect the photo-identification pictures for photographic quality and distinctiveness.

Although photogrammetry of body proportions had originally been proposed as a means of discriminating between true and pygmy blue whales, based on relative lengths of the tail section of the body, photogrammetry had proved impracticable because of behavioural problems. On the other hand, the photographic and video material could provide data on pigmentation patterns, in which some differences had been described between the two forms in the literature.

4.1.5 Other morphology

Differences in baleen shape had also been described between pygmy blue and true blue whales. Although it could not be used under field conditions, it could be useful in attributing an isolated plate to one or other form, so increasing the number of voucher specimens for genetics.

[1] Note that use of 'true' and 'pygmy' throughout this report refers to putative not confirmed identifications.

4.1.6 Other techniques
The group proposed that dive time experiments should continue. Even if the likelihood of being able to discriminate between true blue and pygmy blue whales might be low, the data might be useful for modelling sightability.

4.2 Necessity for further data and analyses for discrimination purposes

Apart from the need for more samples from true blue whales, the group felt that some progress had been made in developing means of discriminating between true and pygmy blue whales, notably in the fields of acoustics and genetics. However these did not help identification in real time.

The group supported the sub-committee's recommendation that a report be prepared documenting the criteria used on each of the three blue whale cruises to discriminate between the two forms (Annex E, item 9.1.2). However, it urged that the report should be prepared in time for the planning meeting for the 1998/99 cruise. The quantity of high resolution video records of surfacings of both putative forms now available should make it possible for topmen to be interrogated on the characters they use to distinguish between the forms, while viewing tapes of blue whales. This could be used (a) to develop a better understanding of criteria used, (b) to assess or evaluate topmen for accuracy and/or consistency, or (c) for training.

4.3 Next research objective for the blue whale project

Donovan reviewed the terms of reference of the present cruise programme. They were originally (IWC, 1995a):

(a) to refine estimates of abundance of true blue whales in the feeding areas;
(b) to evaluate the potential for competition for krill between (true) blue whales, other baleen whales and other high-level predators;
(c) to determine the distribution of breeding areas and whether animals that utilise a particular low-latitudinal breeding area utilise a particular feeding area in the Southern Ocean.

The group noted that (a) was still the main objective. Item (c) might become more important in due course, but (b) had previously been agreed not to be feasible, at least in the foreseeable future (IWC, 1995b; 1996 and Annex E).

4.4 Action arising

It was felt that more material was needed from known 'true' blue whales for discrimination purposes.

Before deciding on lines of possible future research on blue whales, a table was prepared (by Ensor, Donovan and Findlay) for subsequent presentation to the sub-committee, of the acoustic, genetic, morphological and behavioural data collected on the three blue whale cruises to date, whether it had been analysed, and how useful the results were in discriminating between true and pygmy blue whales. A revised tabulation will be available for discussion at the planning meeting.

5. ANTARCTIC CRUISE

5.1 Review of remaining areas in the third circumpolar coverage

The following regions of the Antarctic still remain to be covered by the SOWER cruise programme:

Sector A - 10 degree sector between 60° and 70°W,
Sector B - 30 degree sector between 110° and 140°W,
Sector C - 30 degree sector between 170°W and 160°E (including the Ross Sea), and
Sector D - 50 degree sector between 80° and 130°E.

The group was reminded that coverage of Area VW when last surveyed (1991/92) had been incomplete. It noted that the survey had not extended up to 60°S, and that this should be added to the area coverage.

5.2 Report from SOWER 2000 Planning Group

5.2.1 GLOBEC
The GLOBEC small-scale process study was now planned for the 2000/2001 Antarctic summer season. The research area would be in the vicinity of the Antarctic Peninsula. The SWG on Environmental Concerns had recommended that a joint survey between IWC and GLOBEC should be conducted at this time and place.

5.2.2 CCAMLR
The CCAMLR synoptic krill survey was planned for the 1999/2000 Antarctic summer season, and the research area would be in the vicinity of the Antarctic Peninsula.

5.2.3 Australian national survey
A fine-scale krill survey incorporating cetacean sightings was planned for the 1999/2000 Antarctic summer season; the research area would be in Area IV (between longitudes 70° and 80°E). The Australian pelagic monitoring programme will continue to run annual surveys on ANARE voyages from 1998/99.

5.3 Scheduling

The working group considered the future schedule of the SOWER Antarctic cruises, given that (a) one season would be utilised for a collaborative survey with GLOBEC, (b) part of another season might be spent working with CCAMLR, (c) the third circumpolar survey should be completed within five years, (d) conflict of interest with the JARPA programme should be avoided if possible, and (e) it was likely that only two research vessels would be available for the SOWER programme.

The working group decided that:

(a) Sector A should be reserved for the GLOBEC and CCAMLR surveys, with the intention that during one of these programmes, a dedicated line transect survey of the area would be possible.
(b) Sector B could be adequately surveyed with two vessels in one season under existing coverage.
(c) Area VW should be added to the missing sectors because of the incomplete coverage of the northern stratum during the last survey, as Sector E. This effectively joins sectors C and D into one very large unit, C+D+E, which (if the timetable was to be adhered to) would have to be surveyed in three years. This would be difficult with two vessels if the existing coverage was maintained. It was therefore proposed that, unless a third vessel becomes available, coverage of this large sector would be reduced so that it could be completed in three years. One of these

years should be reserved for sector C, which poses special problems because of the extended latitudinal coverage required if the Ross Sea was to be adequately surveyed. As the advantages of having three vessels would be especially great in this sector, it was also decided that the survey of sector C should be carried out later in the time series rather than earlier, to give time for negotiations over the provision of an extra vessel.

With these provisos, the following schedule was proposed:

(a) Because JARPA will be taking place in Area V in 1998/99, it is proposed that the opportunity be taken to survey Sector D in 1998/99, starting from the western edge.
(b) Sector B will be surveyed the following year, in 1999/2000.
(c) An effort should be made to survey the 10° sector in Sector A in conjunction with GLOBEC 2000, i.e. in 2000/2100.
(d) After the GLOBEC collaborative project in 2000/2001, the circumpolar surveys will resume in the remainder of C+D+E. Since access to the Ross Sea cannot be guaranteed every year, an attempt to survey sector C should be made in 2001/2002. If access is impossible, the survey that year can be switched to Sector E.
(e) If Sector C is surveyed successfully in 2001/2002, Sector E will be surveyed in 2002/2003. If not, a second attempt will be made to survey Sector C.

6. PLAN FOR THE 1998/99 CRUISE

6.1 Blue whale cruise

The group agreed that, in the absence of a separate, dedicated, blue whale cruise in lower latitudes in 1998/99, a major component of the SOWER Antarctic cruise should involve research on blue whales. This is compatible with the finding that more information is needed from true blue whales for discrimination between them and pygmy blue whales. As the total number of research days available in 1998/99 would be 47 and recent Antarctic SOWER cruises had operated with only 35 days, it was proposed that 12 days would be reserved for blue whale research. A final decision on how this time would be allocated during the cruise was left to the planning meeting.

Nishiwaki informed the group that during early December 1997, JARPA survey vessels had encountered a concentration of blue whales at approximately 61°S, 65°E; 13 schools of 20 blue whales were seen in one day (with another 29 unidentified baleen whales).

Blue whale sightings between 30° and 130°E longitude during the IDCR cruises were extracted from the IWC Database. There had been 33 sightings totalling 91 animals in that region. Of them, 23 (69 animals) were in the vicinity of the ice edge between 45° and 75°E. This concentration is just outside the western border of Area IV, so the cruise design should take into account the possibility of a starting position in the southeastern corner of Area III. One option might be that the 'blue whale' element of the cruise would take place there, as a distinct segment of the cruise. If no blue whales were found, however, the main survey would resume until a concentration of blue whales was encountered.

6.2 Antarctic cruise

6.2.1 Japanese proposal (SC/50/CAWS3)

Given the discussions above, the proposal had been withdrawn.

6.2.2 Alternative proposal

The group recommended that as much as possible of Area IV should be surveyed in 1998/99, starting at 80°E and surveying eastwards. The objective would be to survey as far as 120°E.

6.3 Logistics

6.3.1 Brief review of recommendations from last year's SOWER cruises

(a) 1997-98 SOWER blue whale cruise (SC/50/Rep2)
  - Accepted: Recommendations 5 (subject to funding) ; 6; 13
  - Referred to the Planning Meeting: 1-4; 7-12
(b) 1997-98 SOWER Antarctic cruise (SC/50/Rep1)
  - Accepted: Recommendation 3
  - Referred to Planning Meeting: 4-14; 17-20
  - Other action: 2 (Reilly/Thiele/Secretariat, to act); 15 (Institute of Cetacean Research to act); 21 (Clark to act)

6.3.2 Number and identity of vessels offered, length of cruise

The *Shonan Maru* and *Shonan Maru No. 2* would be offered, as last year. The length of the cruise (from home port to home port) would be 60 days, of which an estimated 13 days would be spent in transit between the home port and the research area.

6.3.3 Research area

The systematic sighting surveys for minke whales would take place in Area IV. Survey would commence at 80°E and would extend as far east as possible, up to approximately 120°E, and from the ice edge to 60°S.

6.3.4 Survey methodology and experiments

The same survey methods and sightings experiments would be carried out as last year, with the provisos that (a) survey coverage per day might have to be adjusted to achieve better longitudinal coverage, and (b) observer searching behaviour in IO mode might have to be changed if the data are to be used to estimate $g(0)$. Details would be discussed at the planning meeting.

For the acoustic studies, it was agreed that at least 60 sonobuoys would be needed for the cruise (19 remained from the last cruise). Clark recommended that re-useable sonobuoys be considered as an option and offered to investigate the availability of such equipment. The group recommended that the use of acoustics to locate blue whale concentrations should also be investigated.

6.3.5 Time allocation and survey methodology for blue whale research

Twelve days have been provisionally allocated for this research, the final details and timing of which will be discussed at the planning meeting.

6.3.6 Possible participants

Kato announced that a total of four researchers would be accommodated on each vessel, as last year. Ensor stated that he would probably be available to act as cruise-leader if required. The group agreed to recommend his leadership.

The group further recommended that the positions of researchers be advertised as usual, and the final choice of participants would be made at the planning meeting.

Table 1

Proposed budget for 1998-99 SOWER Antarctic cruise. (All amounts in pounds sterling). (a) Personnel; (b) Other.

(a) Personnel	Grant	Travel	Ship	Land	Ins.	Bank	Total
Cruiseleader	8,200	1,500	950	520	200	100	11,470
Senior scientist	6,400	1,500	950	520	200	100	9,670
Researcher × 4	20,000	6,000	3,800	2,080	800	400	33,080
Japan A	0	1,500	0	520	200	100	2,320
Japan B	0	0	0	520	200	100	820
Sub total	34,600	10,500	5,700	4,160	1,600	800	57,360

(b) Other	£
Planning Meeting(Tokyo)	
Travel (8 × 1000)	8,000
Subsistence (8 × 6 @ 100)	4,800
Incidentals	100
Airport transport/tax	300
Sub total	13,200
Equipment	
Airfreight of Equipment (computers and sonobuoys)	2,000
Communications	1,500
Photo-identification film	130
Photo processing	70
Purchase of new computer	2,000
Software development and data acquisition interface	1,500
Printer cartridges, disks	50
Hire of directional sonobuoy receiver	1,000
Purchase of *Paxarms* biopsy darts and charges	200
Meeting room hire	100
2 × Annual Reports	250
Sub total	8,800
Cruiseleaders attendance at Scientific Committee Meeting	
Travel	1,400
Subsistence (6 × 90)	540
Incidentals	60
Sub total	2,000
Total	81,360

6.3.7 Planning meeting

It is intended to hold a planning meeting in Tokyo, possibly in early October. It was stressed, however, that it would be desirable to schedule the meeting as early as possible. The group recommended that the duration of the meeting be five days, if possible, with one day reserved for topmen briefing and interrogation about true blue whale/pygmy blue whale differentiation, and another day for track design and acoustic experiment design. Besides the cruise-leader and relevant crew members, the meeting should include the Steering Group (Bannister, Best, Brownell, Kato) together with Clark, Ljungblad, a representative from the IWC Secretariat, and a sightings survey specialist.

6.3.8 Responsible persons in home ports

It was recommended the cruise would begin in Cape Town, South Africa, and end in Hobart, Tasmania. The meeting nominated Best as the responsible person in Cape Town. The responsible person in Hobart was to be nominated.

6.3.9 Budgets

A preliminary budget was prepared (Table 1).

7. OTHER MATTERS

Information on the position of the ice edge will be required during the cruise. Reilly offered to relay such data to the vessels.

REFERENCES

International Whaling Commission. 1995a. Report of the Scientific Committee. *Rep. int. Whal. Commn* 45:53-103.

International Whaling Commission. 1995b. Report of the Steering Committee for research related to conservation of large baleen whales in the southern oceans. Paper SC/47/Rep1 presented to the IWC Scientific Committee, May 1995 (unpublished). 17pp.

International Whaling Commission. 1996. Report of the Scientific Committee. *Rep. int. Whal. Commn* 46:49-236.

Annex R
A Full Description of the Standard BALEEN II Model and Some Variants Thereof

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ABSTRACT

A full mathematical description of the BALEEN II population dynamics model is provided. The specifications required for alternative parameterisations of this model and to initiate projections when the population is not at its pre-exploitation equilibrium are also listed. Some new insights into the implications of different definitions for the yield curve are provided.

INTRODUCTION

The Hitter-Fitter package (de la Mare, 1989; Punt and Butterworth, 1991; de la Mare and Cooke, 1992; Punt, 1996) has been used in the assessments of a number of whale stocks (e.g. IWC, 1991a; b; Butterworth and Punt, 1992a). The BALEEN II population dynamics model underlying this package is age- and sex-structured, and can take age-specific recruitment and maturation ogives into account. Both maximum likelihood (e.g. Butterworth and Punt, 1992a) and Bayesian estimators (e.g. Givens *et al.*, 1993; 1995) have been used to estimate the parameters of this population model.

This paper provides a full description of the BALEEN II population dynamics model[1]. It also describes the implementation details of a subset of the various possible parameterisations of the model (primarily those related to the assessment of the Bering-Chukchi-Beaufort (B-C-B) Seas stock of bowhead whales), provides full specifications for the case in which the population projection does not start at pre-exploitation equilibrium, lists the specifications of the output from the model, and contrasts a variety of ways of defining *MSYL* and *MSYR* in terms of population components other than that from which harvests are removed (i.e. other than the 'recruited'[2] component of the population as modelled).

THE BALEEN II POPULATION DYNAMICS MODEL

Basic dynamics

BALEEN II is age- and sex-structured, and considers animals as being either 'recruited' or 'unrecruited'. It assumes that all whaling takes place at the start of the year, and that all animals are 'recruited' (and have reached the age at first parturition) by age $x - 1$. The dynamics of the population are assumed to be governed by the equations:

$$N^s_{t+1,a} = \begin{cases} 0.5\,\alpha^s_0\, P^{\mathrm{M,f}}_{t+1}\, f_{t+1} & \text{if } a = 0 \\ N^s_{t,a-1}(1-F^s_{\mathrm{r},t,a-1})S^s_{a-1} & \\ \quad + U^s_{t,a-1}(1-F^s_{\mathrm{u},t})\,S^s_{a-1}\,\delta^s_a & \text{if } 1 \le a \le x-1 \\ N^s_{t,x}(1-F^s_{\mathrm{r},t,x})S^s_x & \\ \quad + N^s_{t,x-1}(1-F^s_{\mathrm{r},t,x-1})S^s_{x-1} & \text{if } a = x \end{cases} \quad (1)$$

$$U^s_{t+1,a} = \begin{cases} 0.5(1-\alpha^s_0)P^{\mathrm{M,f}}_{t+1}\, f_{t+1} & \text{if } a = 0 \\ U^s_{t,a-1}(1-F^s_{\mathrm{u},t})\,S^s_{a-1}(1-\delta^s_a) & \text{if } 1 \le a \le x-2 \end{cases} \quad (2)$$

where

$N^s_{t,a}$ is the number of 'recruited' animals of age a and sex s (m/f) at the start of year t,

$U^s_{t,a}$ is the number of 'unrecruited' animals of age a and sex s at the start of year t,

δ^s_a is the proportion of 'unrecruited' animals of sex s and age a-1 which recruit at age a,

S^s_a is the annual survival rate of animals of sex s and age a, and is equal to $\exp(-M^s_a)$

where M^s_a is the instantaneous rate of natural mortality on animals of sex s and age a,

$F^s_{\mathrm{r},t,a}$ is the exploitation rate on 'recruited' animals of sex s and age a during year t,

$F^s_{\mathrm{u},t}$ is the exploitation rate (uniform over age) on 'unrecruited' animals of sex s during year t,

α^s_a is the proportion of animals of sex s and age a which would be 'recruited' if the population were at pre-exploitation equilibrium,

$P^{\mathrm{M,f}}_t$ is the number of females that have reached the age at first parturition by the start of year t,

f_t is pregnancy rate (number of calves per 'mature' female) during year t (note that Equations (1) and (2) assume an equal male : female sex ratio at birth), and

x is the maximum (lumped) age-class.

Note that in the interests of generalisation, f_t is defined as in Punt (1996), which differs from convention in some earlier papers (de la Mare, 1989; Punt and Butterworth, 1991; de la

[1] W.K. de la Mare wrote the core code for BALEEN II for the Hitter-Fitter package.

[2] 'Recruited' and 'unrecruited' are placed in quotes because there are cases in which some of the catch is taken from the 'unrecruited' component of the population because the catch exceeds the size of the 'recruited' component of the population.

Mare and Cooke, 1992) in that it applies to both sexes born rather than to females only. Note also that the convention of referring to $P_t^{M,f}$ as the 'mature' female component of the population is used here, although it actually refers to animals no younger than their true age-at-maturity plus the gestation period, which is assumed to be one year. The survival rate S is assumed to depend on sex and age but to be independent of time. Punt (1996) provides a description of an extension to the BALEEN II model that allows for the possibility of density-dependent natural mortality and Punt and Butterworth (1996) include assessments of the B-C-B bowhead stock under the assumption that density-dependence impacts natural mortality rather than fecundity.

The possibility that age 0 animals (calves) are 'recruited' is allowed. However, for most applications (including the assessment of the B-C-B bowhead stock), the value of α_0^s is set equal to zero[3]. The values of $U_{t,x-1}^s$ and $U_{t,x}^s$ are not defined by Equation (2) because it is assumed that all animals of ages x-1 and x are 'recruited' (i.e. $\alpha_{x-1}^s = \alpha_x^s = 1$).

Density dependence

Density dependence on fecundity can be modelled by writing the pregnancy rate, f_t, as follows:

$$f_t = \max\left(f_{eq}\left[1 + A\left\{1 - \left(P_t^D / K_t^D\right)^z\right\}\right], 0\right) \tag{3}$$

where f_{eq} is the pregnancy rate at the pre-exploitation equilibrium, $f(0)$[4]:

$$f(F) = 2\left\{\sum_{a=\text{mat}_{\min}}^{x} \beta_a\left[\tilde{N}_a^f(F) + \tilde{U}_a^f(F)\right]\right\}^{-1} \tag{4}$$

A is the resilience parameter:

$$A = \frac{f_{\max} - f_{eq}}{f_{eq}} \tag{5}$$

$f_{\max}$ is the maximum (theoretical) pregnancy rate,

z is the degree of compensation,

P_t^D is the size, at the start of year t, of the component of the population to which density dependence is functionally related (either total (1+) population size, P_t^{1+}, 'recruited' population size[5], P_t^E, or the number of females that have reached the age at first parturition $P_t^{M,f}$:

$$P_t^{1+} = \sum_s \sum_{a=1}^{x} \left(N_{t,a}^s + U_{t,a}^s\right) \tag{6a}$$

$$P_t^E = \sum_s \sum_{a=1}^{x} N_{t,a}^s \tag{6b}$$

$$P_t^{M,s} = \sum_{a=\text{mat}_{\min}}^{x} \beta_a (N_{t,a}^s + U_{t,a}^s) \tag{6c}$$

$\text{mat}_{\min}$ is the lowest age that a female can reach first parturition (constrained to be at least 2),

β_a is the fraction of females of age a which have reached the age at first parturition,

K_t^D is the pre-exploitation equilibrium size (carrying capacity) at the start of year t of the component of the population to which density dependence is functionally related,

$\tilde{N}_a^s(F)$ is the number of animals of sex s and age a that are 'recruited' when the exploitation rate is fixed at F, expressed as a fraction of the number of calves of the same sex s (see Appendix 1), and

$\tilde{U}_a^s(F)$ is the number of animals of sex s and age a that are 'unrecruited' when the exploitation rate is fixed at F, expressed as a fraction of the number of calves of the same sex s.

Note that although these equations are written formally as if only the pregnancy rate component of 'fecundity' as defined here is density-dependent, exactly the same equations follow if some or all of this dependence occurs in the infant survival rate. Note that the dependence of K^D on t allows for the possibility that carrying capacity has varied over time. Butterworth *et al.* (1990) examine the implications of changes in carrying capacity for the assessment of the Eastern North Pacific gray whale.

Catches

BALEEN II allows for two series of sex-specific catches. One series of catches is taken uniformly from the 'recruited' component of the population while the other series is taken uniformly from the component of the population that is both 'recruited' and 'mature', which is termed 'mature-recruited' below. The equations which define $F_{r,t,a}^s$ and $F_{u,t}^s$ depend upon which of four cases applies. Of the four cases, Case 1 represents the normal situation; Cases 2 - 4 cover situations in which the catch in a given year exceeds the size of the component of the population from which it is assumed to be taken.

Case 1 - The total catch is less than the total number of 'recruited' animals and the 'mature-recruited' catch is less than the number of 'mature' animals (after the catch of 'recruited' animals is removed) (i.e. $C_t^{E,s} + C_t^{M,s} < P_t^{E,s}$ and $C_t^{M,s} < P_t^{M,s}\left(1 - C_t^{E,s}/P_t^{E,s}\right)$). For this case, the catch can be taken as desired:

$$F_{r,t,a}^s = C_t^{E,s} / P_t^{E,s} + \beta_a C_t^{M,s} / P_t^{M,s}$$
$$F_{u,t}^s = 0 \tag{7a}$$

where

$C_t^{E,s}$ is the total catch of animals of sex s during year t taken uniformly from the 'recruited' component of the population,

$C_t^{M,S}$ is the total catch of animals of sex s during year t taken uniformly from the 'mature-recruited' component of the population[6], and

$P_t^{E,s}$ is the total number of 'recruited' animals of sex s at the start of year t:

$$P_t^{E,s} = \sum_{a=0}^{x} N_{t,a}^s \tag{8}$$

To understand Equation (7a) further, consider the sum over all age-classes of the product of the number of recruited animals and the exploitation rate:

[3] The current Baleen II software actually prohibits age 0 animals from being 'recruited'.

[4] The pregnancy rate at the pre-exploitation equilibrium can be considered to be the equilibrium pregnancy rate when the exploitation rate, F, is fixed at zero.

[5] The contribution of 'recruited' animals of age 0 to Equation (6b) is ignored to avoid the need for solving a non-linear equation for the number of births.

[6] The calculation of the exploitation rate assumes that all 'mature' animals are 'recruited'.

$$\sum_{a=0}^{x} F^s_{r,t,a} N^s_{t,a} = \sum_{a=0}^{x} (C^{E,s}_t / P^{E,s}_t + \beta_a C^{M,s}_t / P^{M,s}_t) N^s_{t,a} =$$

$$\frac{C^{E,s}_t}{P^{E,s}_t} \sum_{a=0}^{x} N^s_{t,a} + \frac{C^{M,s}_t}{P^{M,s}_t} \sum_{a=0}^{x} \beta_a N^s_{t,a} = C^{E,s}_t + C^{M,s}_t$$

Case 2 - The total catch is less than the total number of 'recruited' animals but the 'mature-recruited' catch is greater than the number of 'mature' animals (after the catch of 'recruited' animals is removed) (i.e. $C^{E,s}_t + C^{M,s}_t < P^{E,s}_t$ and $C^{M,s}_t > P^{M,s}_t(1 - C^{E,s}_t/P^{E,s}_t)$). For this case, the total catch is assumed to be removed uniformly from the 'recruited' component of the population:

$$F^s_{r,t,a} = (C^{E,s}_t + C^{M,s}_t) / P^{E,s}_t$$

$$F^s_{u,t} = 0 \qquad (7b)$$

Case 3 - The total catch is greater than the total number of 'recruited' animals but is less than the total (0+) population size (i.e. $C^{E,s}_t + C^{M,s}_t > P^{E,s}_t$ and $C^{E,s}_t + C^{M,s}_t < P^{T,s}_t$). For this case, the 'recruited' component is extirpated and the difference between the total catch and the size of 'recruited' component of the population is removed with uniform selectivity from the 'unrecruited' component of the population:

$$F^s_{r,t,a} = 1$$

$$F^s_{u,t} = (C^{E,s}_t + C^{M,s}_t - P^{E,s}_t) / (P^{T,s}_t - P^{E,s}_t) \qquad (7c)$$

where $P^{T,s}_t$ is the size of the total (0+) component of the population for sex s:

$$P^{T,s}_t = \sum_{a=0}^{x} (N^s_{t,a} + U^s_{t,a}) \qquad (9)$$

Case 4 - The total catch is greater than the total (0+) population size (i.e. $C^{E,s}_t + C^{M,s}_t > P^{T,s}_t$). For this case, the entire population (both 'recruited' and 'unrecruited' components) is extirpated:

$$F^s_{r,t,a} = 1$$

$$F^s_{u,t} = 1 \qquad (7d)$$

These equations are based on the assumption that the harvest occurs in a pulse at the start of the year (before natural mortality). It would be straightforward to generalise Equation (7) to allow the harvest to occur at any time during the year.

Recruitment and maturity

The fraction of 'unrecruited' animals of sex s and age a which 'recruit' at age $a+1$, α^s_{a+1}, is given by:

$$\alpha^s_{a+1} = \begin{cases} (\alpha^s_{a+1} - \alpha^s_a) / (1 - \alpha^s_a) & \text{if } \alpha^s_a < 1 \\ 1 & \text{if } \alpha^s_a = 1 \end{cases} \qquad (10)$$

where α^s_a is the proportion of animals of sex s and age a which would be 'recruited' if the population were at pre-exploitation equilibrium:

$$\alpha^s_a = \begin{cases} 0 & \text{if } a < \text{rec}_{\min} \\ \left[1 + \exp\left\{-(a - r^s_{50}) / \sigma^s_r\right\}\right]^{-1} & \text{if } \text{rec}_{\min} \le a \le x-2 \\ 1 & \text{if } a \ge x-1 \end{cases} \qquad (11)$$

r^s_{50} is the age at 50% recruitment for animals of sex s,

σ^s_r is the parameter which determines the width of the recruitment ogive for animals of sex s[7], and

$\text{rec}_{\min}$ is the lowest age at which an animal may be 'recruited'.

The component of the population which may reproduce in a given year is the females that have reached the age at first parturition; this is the age at sexual maturity plus the gestation period (taken in BALEEN II to be one year). The proportion of females of age a which have reached the age at first parturition is given by:

$$\beta_a = \begin{cases} 0 & \text{if } a < \text{mat}_{\min} \\ \left[1 + \exp\left\{-(a - p_{50}) / \sigma_p\right\}\right]^{-1} & \text{if } \text{mat}_{\min} \le a \le x-2 \\ 1 & \text{if } a \ge x-1 \end{cases} \qquad (12)$$

where p_{50} is the age at 50% maturity plus one year, and σ_p is the parameter which determines the width of the maturation ogive.

Initial conditions

The population is assumed either to be at pre-exploitation equilibrium or to have a stable age-structure at the start of the projection period (year t_{INIT}). For the former case, a value for $K^E_{t_{INIT}}$, the pre-exploitation equilibrium size of the 'recruited' component of the population at the start of year t_{INIT}, is used to calculate the numbers at each age[8]:

$$U^s_{t_{INIT},a} = K^E_{t_{INIT}} \tilde{U}^s_a(0) / \sum_{s'} \sum_{a'=0}^{x} \tilde{N}^{s'}_{a'}(0)$$

$$N^s_{t_{INIT},a} = K^E_{t_{INIT}} \tilde{N}^s_a(0) / \sum_{s'} \sum_{a'=0}^{x} \tilde{N}^{s'}_{a'}(0) \qquad (13)$$

For the case in which the population is assumed to have a stable age structure (corresponding to uniform harvesting on the 0+ population[9]) at the start of year t_{INIT}, the numbers at each age are given by:

$$U^s_{t_{INIT},a} = N^E_{t_{INIT}} \tilde{U}^s_a(F_{INIT}) / \sum_{s'} \sum_{a'=0}^{x} \tilde{N}^{s'}_{a'}(F_{INIT})$$

$$N^s_{t_{INIT},a} = N^E_{t_{INIT}} \tilde{N}^s_a(F_{INIT}) / \sum_{s'} \sum_{a'=0}^{x} \tilde{N}^{s'}_{a'}(F_{INIT}) \qquad (14)$$

where $N^E_{t_{INIT}}$ is the size of the 'recruited' component of the population at the start of year t_{INIT}.

The value of F_{INIT} is selected numerically so that:

$$N^E_{t_{INIT}} = 0.5 N_0(F_{INIT}) \sum_{s} \sum_{a=0}^{x} \tilde{N}^s_a(F_{INIT}) \quad [10] \qquad (15)$$

where $N_0(F_{INIT})$ is the number of calves (of both sexes) at the start of the year when $F = F_{INIT}$ (Appendix 2 for a derivation):

$$N_0(F_{INIT}) = \left(1 - \frac{1}{A}\left[\frac{f(F_{INIT})}{f_{eq}} - 1\right]\right)^{1/z} \frac{K^D_{t_{INIT}}}{\tilde{P}^D(F_{INIT})} \qquad (16)$$

$\tilde{P}^D(F)$ is the size of the component of the population to which density dependence is functionally related as a function of F (either the total (1+) population size, the 'recruited'

[7] BALEEN II allows for the possibility that recruitment (and maturity) are knife-edged functions of age (i.e. $\sigma^s_r \to 0 (\sigma_p \to 0)$).

[8] Equation (13) is based on $K^E_{t_{INIT}}$ rather than, say, the pre-exploitation equilibrium size of the total population because $K^E_{t_{INIT}}$ is the parameter which for which a value is specified/estimated in the Hitter-Fitter package.

[9] The stable age-structure applies to the 0+ component of the population because F_{INIT} should be considered to be an increase rate rather than an exploitation rate.

[10] The 0.5 is needed to correct for the equations in Appendix 1 being defined in terms of one animal of each sex at birth.

population size, or the number of females that have reached the age at first parturition), expressed as a fraction of the number of calves (of both sexes).

The value for $K^D_{t_{INIT}}$ needed to apply Equation (16) is computed straightforwardly from $K^E_{t_{INIT}}$. This calculation does not involve the values for the parameters that determine the extent of density dependence (A and z).

Determination of the resilience and degree of compensation parameters

The values of the parameters A and z are obtained by assigning values to the quantities *MSYL* and *MSYR*, and then solving the set of equations relating these quantities to z and A. *MSYL* and *MSYR* may be chosen to refer either to the 'recruited' component of the population, that component which has reached the age at first parturition (the 'mature' component), or the 1+ population with uniform selectivity harvesting. Sex-structure is ignored when calculating the resilience and degree of compensation from *MSYR* and *MSYL*. The recruitment ogive and the age-specific natural mortality rates for females are thus assumed to apply to both sexes for the purposes of this calculation. In reality, male and female recruitment ogives will not always be identical which will lead to some error in evaluating A and z (and hence *MSY*).

The (normalised) sustainable yield as a function of the exploitation rate, $C(F)$, is given by:

$$C(F) = F\,P(F) = F\,B(F)\,\tilde{P}(F) \qquad (17)$$

where $P(F)$ is the equilibrium number of 'recruited' animals when the exploitation rate is fixed at F (either the number of animals defined by the female recruitment ogive, the number which have reached the age at first parturition, or the number of age 1+ animals),

$B(F)$ is the normalised number of births when the exploitation rate is fixed at F, and

$\tilde{P}(F)$ 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.

For *MSY*:

$$\left.\frac{dC}{dF}\right|_{F=F_{MSY}} = \left.\frac{d\{F\,B(F)\tilde{P}(F)\}}{dF}\right|_{F=F_{MSY}} = 0 \qquad (18)$$

i.e.:
$$P(F_{MSY}) + F_{MSY}\left\{ B(F_{MSY})\left.\frac{d\tilde{P}(F)}{dF}\right|_{F=F_{MSY}} + \tilde{P}(F_{MSY})\left.\frac{dB(F)}{dF}\right|_{F=F_{MSY}} \right\} = 0 \qquad (19)$$

The values for the resilience and degree of compensation parameters are obtained by solving Equation (19) given a value for *MSYR* ($= F_{MSY}$ - see Equation (17)) subject to the constraint that *MSYL* is equal to a pre-specified value.

Now, the population component (H) chosen for defining *MSYL* will not necessarily be the same as that to which density dependence is functionally related (D). For the calculations that follow, the value of $MSYL^D = P^D(F_{MSY})/K^D$ is required. This is obtained from the formula (Punt and Butterworth, 1991):

$$MSYL^D = \left[MSYL^H\,\tilde{K}^H\,\tilde{P}^D(F_{MSY})\right] / \left[\tilde{P}^H(F_{MSY})\,\tilde{K}^D\right] \qquad (20)$$

where $\tilde{K}$ is defined as $\tilde{P}(0)$ for the relevant component of the population.

The left-hand side of Equation (19) can be simplified to a form that does not involve the parameter (see Appendix 3):

$$1 + F_{MSY}\left(\frac{1}{\tilde{P}(F_{MSY})}\left.\frac{d\tilde{P}(F)}{dF}\right|_{F=F_{MSY}} - \frac{1}{\tilde{P}^D(F_{MSY})}\left.\frac{d\tilde{P}^D(F)}{dF}\right|_{F=F_{MSY}} - \frac{1}{z}\frac{(MSYL^D)^{-z}-1}{f(F_{MSY})-f_{eq}}\left.\frac{df(F)}{dF}\right|_{F=F_{MSY}} \right) \qquad (21)$$

where the required derivatives are determined by taking finite differences. The value of z is determined by solving Equation (21).

To calculate *MSYR* ($=F_{MSY}$) and *MSYL* for alternative harvesting patterns (e.g. uniform selectivity harvesting of the 1+ component of the population) than that used when calculating A and z, Equation (21) is solved for F_{MSY} where the alternative harvesting pattern is used to calculate the vectors $\tilde{U}^f$ and $\tilde{N}^f$ and hence the functions $\tilde{P}(F)$, $\tilde{P}^D(F)$ and $f(P)$. The value of *MSYL* is then calculated using an appropriate modification of Equation (20).

OUPUT STATISTICS

Population components

BALEEN II stores time-trajectories of the following population components:

(a) Total (1+) population size, P_t^{1+}.
(b) Total (0+) population size, P_t^T.
(c) Total 'mature' population size, $P_t^{M,f} + P_t^{M,m}$.
(d) 'Mature' female population size, $P_t^{M,f}$.
(e) Total 'recruited' population size, $P_t^{E,f} + P_t^{E,m}$.
(f) 'Recruited' male population size, $P_t^{E,m}$.
(g) 'Recruited' female population size, $P_t^{E,f}$.
(h) Calves, $P_t^{M,f} f_t$.

These model outputs can be used to calculate a variety of output statistics, e.g., the depletion in any year, trends in population size over various years, the maximum (realised) pregnancy rate over the projection period, and the fraction of the total (0+) population size in a given year consisting of, for example, calves.

Replacement yield

The replacement yield for year t is defined as the catch, at the start of year t, which will leave the size of the 'recruited' component of the population the same at the start of year t+1 as at the start of year t:

$$RY_t = \frac{P_t^E}{\sum_s \sum_{a=0}^{x} S_a^s N_{t,a}^s}\left[\sum_s \left(N_{t,0}^s + \sum_{a=0}^{x-2} S_a^s U_{t,a}^s \delta_{a+1}^s \right) + \sum_s \sum_{a=0}^{x} S_a^s N_{t,a}^s - P_t^E \right] \qquad (22)$$

The term in square parenthesis is almost[11] the difference between the size of the 'recruited' component at the start of year t and the size of this component at the end of year t in

[11] Almost, because the $N^s_{t,0}$ term should be replaced by $N^s_{t+1,0}$ - this is not needed here because the computation of *RY* assumes that population is in steady state and that the harvest will be equal to the replacement yield so that $N^s_{t+1,0} = N^s_{t,0}$. Note that for most applications, calves are not recruited so this complication does not arise.

the absence of harvesting (i.e. accounts for the impact of recruitment and natural mortality). The first term accounts for the fact that the catch is assumed to occur in a pulse at the start of the year, and is equal to $1/S$ if survival is assumed to be independent of age for all 'recruited' animals.

Productivity

The productivity of the resource can be assessed through *MSYR* and *MSYL* (defined in terms of harvesting of the 'recruited', total (1+) or 'mature' components of the population). The maximum sustainable yield, *MSY*, can be calculated as *MSYR.MSYL.K* where K is the pre-exploitation size of that component of the population in terms of which *MSYR* and *MSYL* are defined. Other measures of productivity are the maximum theoretical pregnancy rate, f_{max}, and the maximum steady rate of increase, λ_{max}. The latter is the positive real root of the equation:

$$1 = f_{max}\left[\sum_{a=mat_{min}}^{x-1}\frac{\beta_a}{\lambda_{max}^{a+1}}\prod_{a'=0}^{a-1}S_{a'}^{f} + \frac{\beta_x\prod_{a'=0}^{x-1}S_{a'}^{f}}{\lambda_{max}^{x}(\lambda_{max}-S_x^{f})}\right] \quad (23)$$

Equations (1) and (2) of Breiwick *et al.* (1984) can be shown to be special cases of Equation (23).

ALTERNATIVE PARAMETERISATIONS

The most common method for parameterising the BALEEN II model involves providing specifications for the following.

(a) The historical catches.
(b) Natural mortality for each combination of sex and age.
(c) The parameters of the recruitment ogive.
(d) The parameters of the maturity ogive.
(e) The pre-exploitation equilibrium size of the 'recruited' component of the population at the start of year, t_{INIT}, $K^E_{t_{INIT}}$.
(f) The size of the 'recruited' component of the population at the start of year, t_{INIT}, $N^E_{t_{INIT}}$, if it is assumed that the population was not at its pre-exploitation equilibrium size at the start of year t_{INIT}.
(g) *MSYR*, *MSYL* and the components to which these quantities apply.
(h) The component to which density dependence is functionally related.

However, alternative paramerisations are possible. The following three sections outline three alternatives that may be appropriate for an assessment of the B-C-B bowhead stock.

'Forwards' vs. 'Backwards'

The 'backwards' parameterisation of the BALEEN II model is based on the 'Hitting-with-fixed-MSYR' option of the Hitter-Fitter package. It involves specifying the size of some component of the population in some given year, N_{targ}, and selecting the value of $N^E_{t_{INIT}}$ (or $K^E_{t_{INIT}}$ if it is assumed that the population was at its pre-exploitation equilibrium level at the start of year t_{INIT}) so that if the population is projected from year t_{INIT} to the current year, the projected size of that component of the population in the specified year is equal to N_{targ}. Brent's method (Press *et al.*, 1988) is used to solve the non-linear equation relating N_{targ} to $N^E_{t_{INIT}}$. Note that for some choices of N_{targ} (e.g. $N_{targ} >> K$) there is no solution to this non-linear equation while for some choices for *MSYR*, there may be multiple solutions (Butterworth and Punt, 1995).

Using the maximum theoretical pregnancy rate

Equation (5) shows that the maximum theoretical pregnancy rate, f_{max}, is closely related to the resilience parameter A. Therefore, instead of specifying a value for *MSYR* it is possible to specify a value for f_{max} instead. Within BALEEN II, this involves solving the non-linear equation $f_{max} = f_{max}(MSYR, MSYL)$, i.e. *MSYR* is chosen so that the implied value for f_{max} is equal to the specified value.

Another possible use for introducing the parameter f_{max} is to eliminate the juvenile natural mortality rate, M_J. M_J may apply solely to calves (e.g. Wade, 1996). However, for the B-C-B bowhead case, M_J has been assumed to apply from age 0 to a transition age (Givens *et al.*, 1995; IWC, 1995). Given values for *MSYR*, *MSYL* and f_{max}, it is possible, using the following algorithm, to solve for A, z and M_J.

(a) Guess a value for M_J.
(b) Calculate $\tilde{U}(0)$, $\tilde{N}(0)$, $\tilde{U}(F_{MSY})$ and $\tilde{N}(F_{MSY})$.
(c) Calculate f_{eq} using Equation (4).
(d) Calculate A and z from *MSYL* and *MSYR* as described above.
(e) Calculate f_{max} using Equation (5).
(f) Compare this value of f_{max} with the input value and repeat steps (a) - (f) until convergence is achieved.

When solving for M_J, it is common to impose biologically sensible bounds such as that M_J is greater than the natural mortality rate for adults. Punt and Butterworth (1997) note that it is possible to use this approach to eliminate any of the other 'biological' parameters (age-at-maturity, adult natural mortality rate, etc.), but it seems most sensible to eliminate M_J because direct information about this parameter is seldom (if ever) available.

Using the maximum increase rate

The parameter λ_{max} can be used to replace *MSYR*[12]. For the case in which f_{max} is also used to specify M_J, the calculation procedure is as follows:

(a) Solve Equation (23) for M_J given f_{max}, λ_{max} and the remaining biological parameters.
(b) Calculate $\tilde{U}(0)$ and $\tilde{N}(0)$, and hence f_{eq} (see Equation (4)).
(c) Guess a value for F_{MSY}.
(d) Calculate $\tilde{U}(F_{MSY})$ and $\tilde{N}(F_{MSY})$.
(e) Calculate A and z from *MSYL* and *MSYR* ($=F_{MSY}$) as described above.
(f) Calculate f_{max} using Equation (5).
(g) Compare this value of f_{max} with the input value and repeat steps (c) - (g) until convergence is achieved.

IMPLICATIONS FOR DEFINING *MSYR* AND *MSYL* IN TERMS OF OTHER POPULATION COMPONENTS

There has been considerable debate in the Scientific Committee regarding the appropriate component to which the assumption *MSYL* = 0.6 should be assumed to apply (e.g. Butterworth and Punt, 1992b; Cooke and de la Mare, 1994; IWC, 1994; 1998). To examine this issue further, yield curves have been produced for representative choices for the biological parameters for the East Greenland-Iceland fin

[12] In principle, λ_{max} can replace f_{max} but this option is ignored here.

whales and the B-C-B bowhead whales (see Table 1)[13]. Fig. 1(a) show plots of sustainable yield against 'mature' female and total (1+) depletion for the B-C-B bowhead stock when harvesting is assumed to be uniform on the 'mature' component of the population, $MSYL_{mat}=0.6$ and $MSYR_{mat}=3/5/7\%$. Fig. 1(b) shows the same quantities except that harvesting is assumed to be uniform on the 1+ component of the population (the values for the parameters A and z for Fig. 1(b) are computed using the specifications for Fig. 1(a)). Fig. 2 shows the same quantities as Fig. 1 except that A and z are computed for the case $MSYL_{1+}=0.6$. Fig. 3 shows the same quantities as Fig. 1, except that the results pertain to the East Greenland-Iceland fin whales.

The most notable feature of Fig. 1(a) is that, for some choices for *MSYR*, if *MSYL* is defined in terms of the 'mature' component of the population, the size of the 1+ component at *MSYL* can be above *K*. This occurs because the stock-recruitment relationship exhibits strong super-compensation (i.e. the number of births drops as the population approaches carrying capacity – Holt, 1985; Butterworth and Best, 1990; Fig. 4) and so that the age-structure of the population at *MSY* is markedly skewed towards animals younger than the age at first parturition. The same qualitative result (quantitatively less marked) occurs if harvesting occurs on 1+ component of the population (Fig. 1b) or if the biological parameters for the East Greenland - Iceland fin whales are assumed instead (Fig. 3). The difference between the depletion of the 'mature' and 1+ components at *MSYL* is also reduced if density dependence is assumed to be functionally related to the 1+ rather than the 'mature' component of the population. As expected, defining *MSYL* in terms of the 1+ component of the population leads to *MSYL* for the 'mature' component of the population occurring at sizes well below 0.6 (Fig. 2). The

[13] For simplicity, density dependence is assumed to act on the mature female component of the population in all of the calculations of this section.

Table 1

Values for the biological and technological parameters for the East Greenland-Iceland stock of fin whales and the Bering-Chukchi-Beaufort Seas stock of bowhead whales used as inputs for the BALEEN II computations for Figures 1-4.

Parameter	East Greenland-Iceland fin whales[1]	Bering-Chukchi-Beaufort Seas bowhead whales[2]
Natural mortality (yr^{-1})	0.04 for all ages	0.04 (a=0,...,4); 0.02 (a=5+)
Age at 50% recruitment (males) (yr)	5	1
Age at 95% recruitment (males) (yr)	7	1
Age at 50% recruitment (females) (yr)	4	1
Age at 95% recruitment (females) (yr)	5	1
Age at 50% maturity[3] (yr)	8.5	20
Age at 95% maturity[3] (yr)	9.5	20

[1] Source: Butterworth and Punt (1992a).

[2] The adult natural mortality rate and the ages defining the parturition ('maturity') ogive are chosen to lie close to the medians of priors selected by IWC (1995).

[3] The corresponding age at first parturition is taken to be one year older than this.

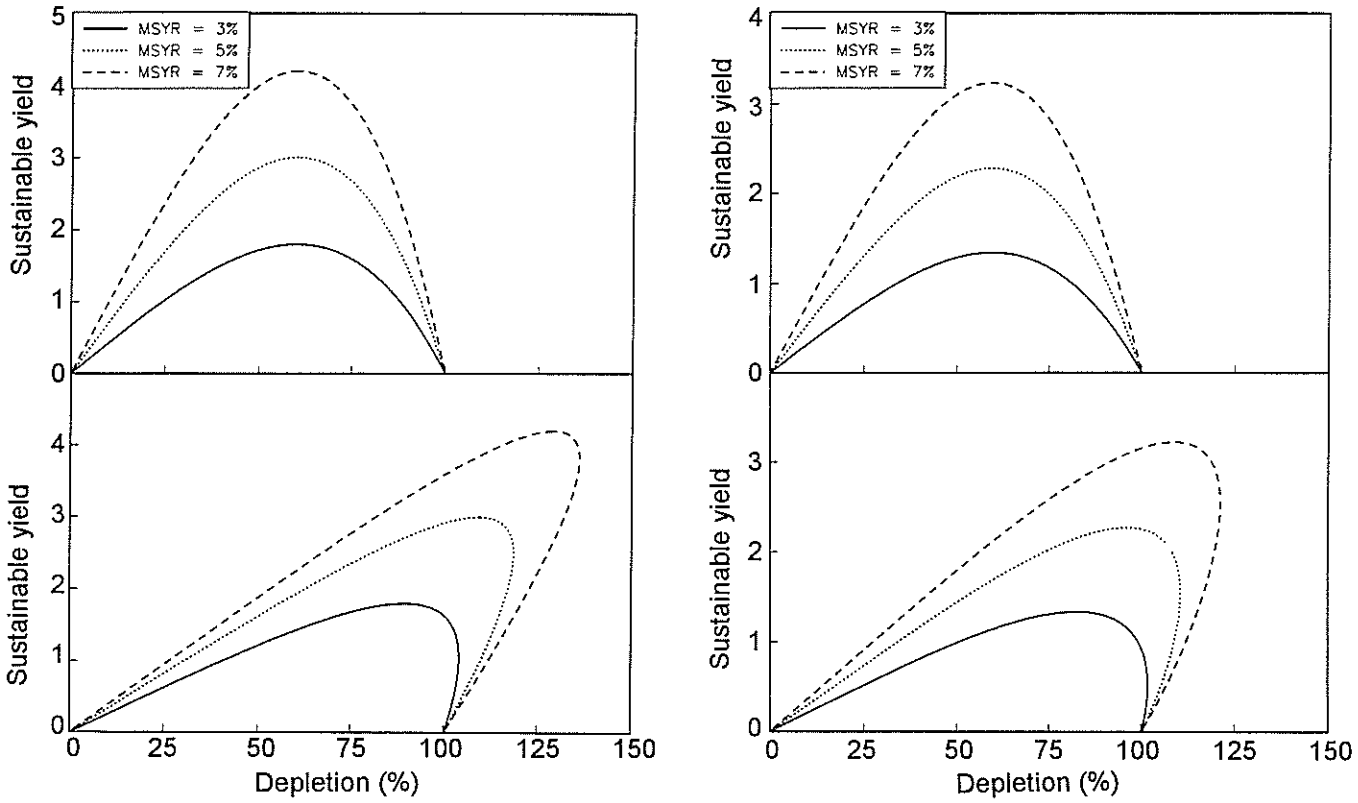


Fig. 1. Yield curves for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Each plot shows results for $MYSR_{mat}$ = 3%, 5%, and 7%. The upper panels show yield expressed as a function of the depletion of the 'mature' female component of the population, while the lower panels show yield expressed as a function of the depletion of the 1+ component of the population. Results are shown in (a) for harvesting of the 'mature' component of the population and in (b) for harvesting of the 1+ component of the population. The results in this figure pertain to $MSYL_{mat}=0.6$ and density dependence acting on the 'mature' female component of the population.

results in Figs 1-3 therefore show that the relationship between $MSYL_{1+}$ and $MSYL_{mat}$ does not depend strongly on the exploitation pattern assumed when calculating *MSY*.

The implications of Figs 1-3 need to be taken into consideration when output statistics are defined for assessments (e.g. if *MSYL* for the B-C-B bowhead stock is defined to be 0.6 in terms of the total (1+) component of the population, the 'target level' for the 'mature' component of the population may be 0.4 or less) and performance statistics for simulation trials.

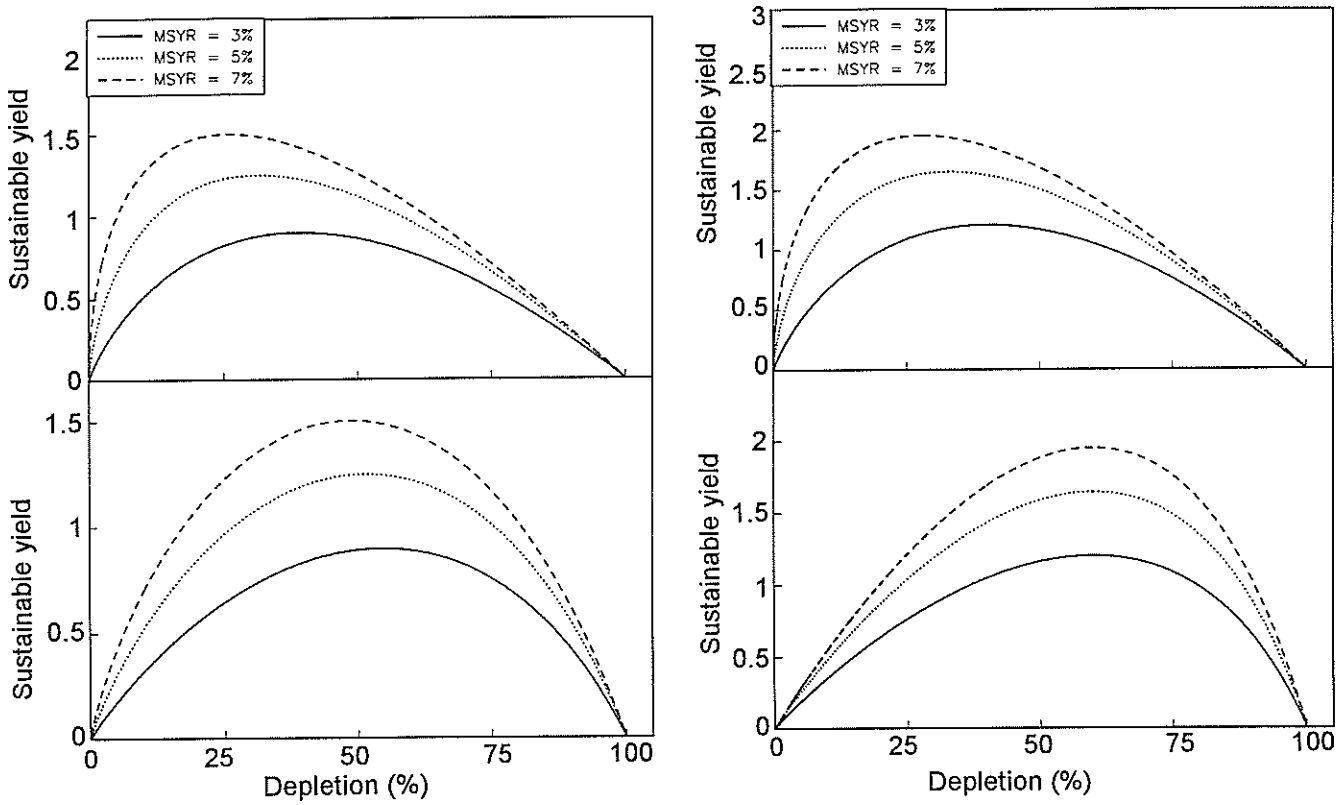


Fig. 2. As for Fig. 1 except that $MSYL_{1+}=0.6$.

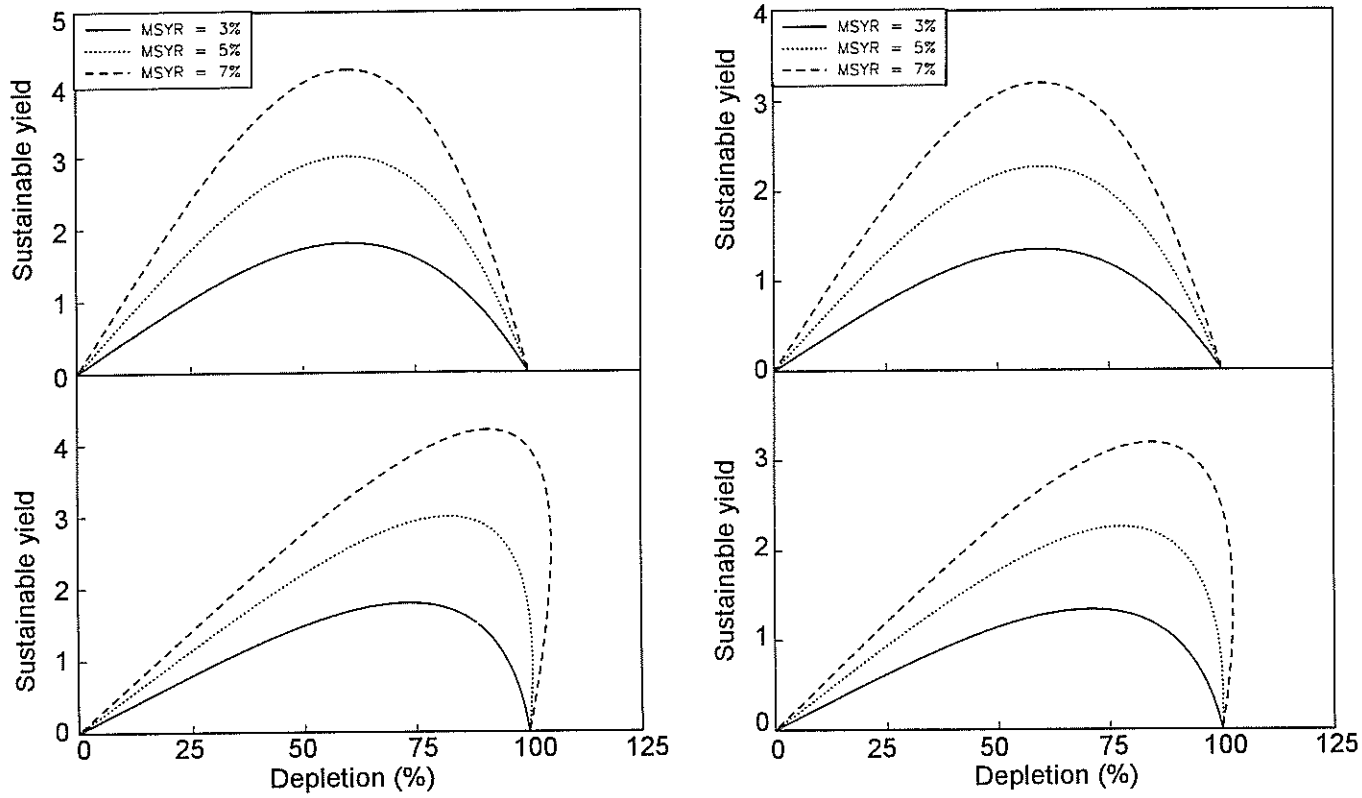


Fig. 3. As for Fig. 1 except that results are shown for the East Greenland-Iceland fin whale stock.

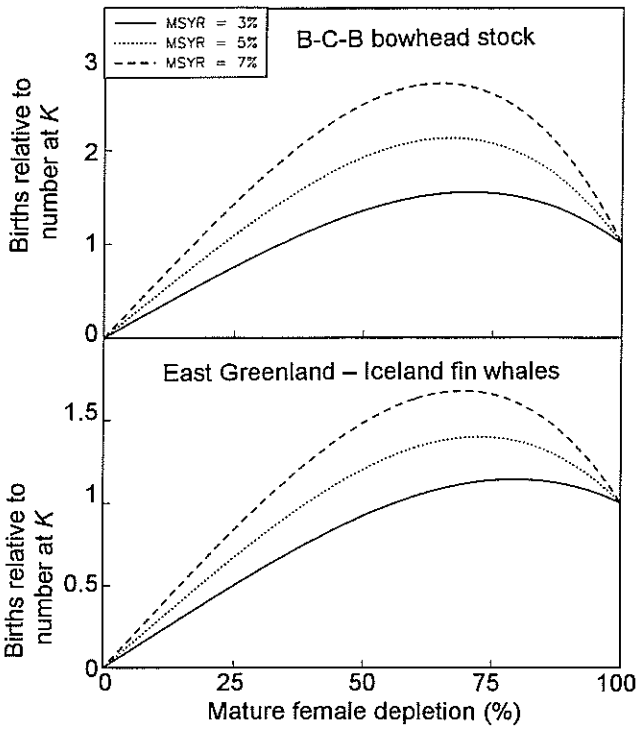


Fig. 4. Stock recruitment relationships for the Bering-Chukchi-Beaufort Seas stock of bowhead whales and the East Greenland-Iceland fin whale stock. Results in this figure pertain to $MSYL_{mat} = 0.6$ and density dependence acts on the 'mature' female component of the population. The number of births is shown relative to the number when the resource is at its pre-exploitation equilibrium level.

ACKNOWLEDGEMENTS

Cherry Allison (IWC Secretariat), Jeff Breiwick (NMML, NMFS), Doug Butterworth (Dept. of Mathematics and Applied Mathematics, University of Cape Town) and Geof Givens (Dept. of Statistics, Colorado State University) are thanked for their comments on an early draft of this paper.

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.

Butterworth, D.S. and Best, P.B. 1990. Implications of the recovery rate of the South African right whale population for baleen whale population dynamics. *Rep. int. Whal. Commn* 40:433-47.

Butterworth, D.S. and Punt, A.E. 1992a. Assessments of the East Greenland-Iceland fin whale stock. *Rep. int. Whal. Commn* 42:671-96.

Butterworth, D.S. and Punt, A.E. 1992b. The Scientific Committee ... 'agreed that the MSY rate would most likely lie between 1 and 4%' - but which MSY rate? *Rep. int. Whal. Commn* 42:583-91.

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.

Butterworth, D.S., Korrubel, J.L. and Punt, A.E. 1990. What is needed to make a simple density-dependent response population model consistent with data for the eastern North Pacific gray whales? *Rep. int. Whal. Commn* (special issue 18): In press.

Cooke, J.G. and de la Mare, W.K. 1994. Some aspects of the estimation and modelling of baleen whale sustainable yields. *Rep. int. Whal. Commn* 44:451-7.

de la Mare, W.K. 1989. Report of the Scientific Committee, Annex L. The model used in the HITTER and FITTER programs (Program:FITTER.SC40). *Rep. int. Whal. Commn* 39:150-1.

de la Mare, W.K. and Cooke, J.G. 1992. Baleen II: the model used in the HITTER/FITTER programs. International Whaling Commission, Cambridge, UK. 25pp.

Givens, G.H., Raftery, A.E. and Zeh, J.E. 1993. Benefits of a Bayesian approach for synthesizing multiple sources of evidence and uncertainty linked by a deterministic model. *Rep. int. Whal. Commn* 43:495-500.

Givens, G.H., Zeh, J.E. and Raftery, A.E. 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.

Holt, S. 1985. The classification of whale stocks and the determination of catch limits, under the current IWC management procedure, with limited information. *Rep. int. Whal. Commn* 35:487-94.

International Whaling Commission. 1991a. 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. 1991b. Report of the Scientific Committee, Annex F. Report of the sub-committee on North Atlantic minke whales. *Rep. int. Whal. Commn* 41:132-71.

International Whaling Commission. 1994. Report of the Scientific Committee, Annex M. Report of the Working Group on MSY rates. *Rep. int. Whal. Commn* 44:181-9.

International Whaling Commission. 1995. Report of the Scientific Committee, Annex F. Report of the sub-committee on aboriginal subsistence whaling. *Rep. int. Whal. Commn* 45:142-64.

International Whaling Commission. 1998. Report of the Scientific Committee. Annex I. Report of the Workshop on the Development of an Aboriginal Subsistence Whaling Management Procedure (AWMP). *Rep. int. Whal. Commn* 48:192-202.

Press, W.H., Flannery, B.P., Teukolsky, S.A. and Vetterling, W.T. 1988. *Numerical Recipes: The Art of Scientific Computing*. Cambridge University Press, Cambridge. i-xxii+818pp.

Punt, A.E. 1996. The effects of assuming that density dependence in the HITTER-FITTER model acts on natural mortality rather than fecundity. *Rep. int. Whal. Commn* 46:629-36.

Punt, A.E. and Butterworth, D.S. 1991. HITTER-FITTER-BOOTSTRAP User's Guide Version 2.0 (April 1991). Paper SC/43/O 9 presented to the IWC Scientific Committee, May 1991 (unpublished). 44pp.

Punt, A.E. and Butterworth, D.S. 1996. Further remarks on the Bayesian approach for assessing the Bering-Chukchi-Beaufort Seas stock of bowhead whales. *Rep. int. Whal. Commn* 46:481-91.

Punt, A.E. and Butterworth, D.S. 1997. Priors, likelihoods, Bayesian Synthesis and the assessment of of the Bering-Chuchki-Beaufort Seas stock of bowhead whales. Paper SC/49/AS2 presented to the IWC Scientific Committee, September 1997, Bournemouth (unpublished). 26pp.

Wade, P.R. 1996. A Bayesian stock assessment of the eastern Pacific gray whale using abundance and harvest data from 1967 to 1996. Paper SC/48/AS8 presented to IWC Scientific Committee, June 1996, Aberdeen (unpublished). 17pp [plus supplement].

Appendix 1

EQUILIBRIUM AGE-STRUCTURES

(A) Harvesting of the 'recruited' component of the population

$$\tilde{U}_a^s(F) = \begin{cases} 1-\alpha_0^s & \text{if } a = 0 \\ S_{a-1}^s \tilde{U}_{a-1}^s(F)(1-\delta_a^s) & \text{otherwise} \end{cases} \quad \text{(A1.1a)}$$

$$\tilde{N}_a^s(F) = \begin{cases} \alpha_0^s & \text{if } a = 0 \\ S_{a-1}^s(\tilde{N}_{a-1}^s(F)(1-F) + \tilde{U}_{a-1}^s(F)\delta_a^s) & \text{if } 1 \le a < x \\ S_{x-1}^s \tilde{N}_{x-1}^s(F)(1-F)/(1-S_x^s(1-F)) & \text{if } a = x \end{cases} \quad \text{(A1.1b)}$$

(B) Harvesting of the 1+ component of the population

$$\tilde{U}_a^s(F) = \begin{cases} 1-\alpha_0^s & \text{if } a = 0 \\ S_0^s(1-\alpha_0^s)(1-\delta_1^s) & \text{if } a = 1 \\ S_{a-1}^s(1-F)\tilde{U}_{a-1}^s(F)(1-\delta_a^s) & \text{otherwise} \end{cases} \quad \text{(A1.2a)}$$

$$\tilde{N}_a^s(F) = \begin{cases} \alpha_0^s & \text{if } a = 0 \\ S_0^s(\alpha_0^s + (1-\alpha_0^s)\delta_1^s) & \text{if } a = 1 \\ S_{a-1}^s(1-F)(\tilde{N}_{a-1}^s(F) + \tilde{U}_{a-1}^s(F)\delta_a^s) & \text{if } 2 \le a < x \\ S_{x-1}^s(1-F)\tilde{N}_{x-1}^s(F)/(1-S_x^s(1-F)) & \text{if } a = x \end{cases} \quad \text{(A1.2b)}$$

(C) Harvesting of the 'mature' component of the population

$$\tilde{U}_a^s(F) = \begin{cases} 1-\alpha_0^s & \text{if } a = 0 \\ S_{a-1}^s(1-F\beta_{a-1})\tilde{U}_{a-1}^s(F)(1-\delta_a^s) & \text{otherwise} \end{cases} \quad \text{(A1.3a)}$$

$$\tilde{N}_a^s(F) = \begin{cases} \alpha_0^s & \text{if } a = 0 \\ S_{a-1}^s(1-F\beta_{a-1})(\tilde{N}_{a-1}^s(F) + \tilde{U}_{a-1}^s(F)\delta_a^s) & \text{if } 1 \le a < x \\ S_{x-1}^s(1-F\beta_{a-1})\tilde{N}_{x-1}^s(F)/(1-S_x^s(1-F)) & \text{if } a = x \end{cases} \quad \text{(A1.3b)}$$

Appendix 2

THE DERIVATION OF EQUATION (16)

The equation defining fecundity as a function of density is given by:

$$f(F) = f_{eq}[1 + A\{1 - (P^D(F)/K^D)^z\}] \quad \text{(A2.1)}$$

Substituting $N_0(F)\tilde{P}^D(F)$ for $P^D(F)$ gives:

$$f(F) = f_{eq}[1 + A\{1 - (N_0(F)\tilde{P}^D(F)/K^D)^z\}] \quad \text{(A2.2)}$$

Solving Equation (A2.2) for leads to Equation (16)

Appendix 3

THE DERIVATION OF EQUATION (21)

The equation defining *MSY* is:

$$P(F_{MSY}) + F_{MSY}\left\{B(F_{MSY})\left.\frac{d\tilde{P}(F)}{dF}\right|_{F=F_{MSY}} + \tilde{P}(F_{MSY})\left.\frac{dB(F)}{dF}\right|_{F=F_{MSY}}\right\} = 0 \quad \text{(A3.1)}$$

Dividing Equation (A3.1) by gives:

$$1 + F_{MSY}\left\{\frac{1}{\tilde{P}(F_{MSY})}\left.\frac{d\tilde{P}(F)}{dF}\right|_{F=F_{MSY}} + \frac{1}{B(F_{MSY})}\left.\frac{dB(F)}{dF}\right|_{F=F_{MSY}}\right\} = 0 \quad \text{(A3.2)}$$

Now, differentiating $P^D(F) = B(F)\tilde{P}^D(F)$ with respect to F gives:

$$\frac{dP^D(F)}{dF} = B(F)\frac{d\tilde{P}^D(F)}{dF} + \tilde{P}^D(F)\frac{dB(F)}{dF}$$

Therefore:

$$\frac{dB(F)}{dF} = \frac{1}{\tilde{P}^D(F)}\frac{dP^D(F)}{dF} - \frac{B(F)}{\tilde{P}^D(F)}\frac{d\tilde{P}^D(F)}{dF} \quad \text{(A3.3)}$$

Now, $f(F) = f_{eq}[1 + A\{1-(P^D(F)/K^D)^z\}]$

i.e. $$\frac{df(F)}{dF} = \frac{-f_{eq}Az}{K^D}\left[P^D(F)/K^D\right]^{z-1}\frac{dP^D(F)}{dF} \quad \text{(A3.4)}$$

Solving Equation (A3.4) for $\frac{dP^D(F)}{dF}$ then gives:

$$\frac{dP^D(F)}{dF} = \frac{-K^D}{f_{eq}Az}\left[P^D(F)/K^D\right]^{1-z}\frac{df(F)}{dF} \quad \text{(A3.5)}$$

Substituting Equation (A3.5) into equation (A3.3) then gives:

$$\frac{dB(F)}{dF} = -\frac{B(F)}{\tilde{P}^D(F)}\frac{d\tilde{P}^D(F)}{dF} - \frac{1}{\tilde{P}^D(F)}\frac{K^D}{f_{eq}Az}\left[P^D(F)/K^D\right]^{1-z}\frac{df(F)}{dF} \quad \text{(A3.6)}$$

Now, $MSYL^D = P^D(F_{MSY})/K^D = B(F_{MSY})\tilde{P}^D(F_{MSY})/K^D$ (A3.7a)

or $K^D = B(F_{MSY})\tilde{P}^D(F_{MSY})/MSYL^D$ (A3.7b)

Evaluating Equation (A3.6) at $F = F_{MSY}$, substituting Equation (A3.7) into the resulting equation, dividing by $B(F_{MSY})$, and then simplifying gives:

$$\frac{1}{B(F_{MSY})}\frac{dB(F)}{dF}\bigg|_{F=F_{MSY}} = -\frac{1}{\tilde{P}^D(F_{MSY})}\frac{d\tilde{P}^D(F)}{dF}\bigg|_{F=F_{MSY}} - \frac{(MSYL^D)^{-z}}{f_{eq}Az}\frac{df(F)}{dF}\bigg|_{F=F_{MSY}} \quad \text{(A3.8)}$$

Now, from Equation (3), A is related to z and $MSYR^D$ according to the formula:

$$A = \frac{f(F_{MSY})/f_{eq} - 1}{1-(MSYL^D)^z} \quad \text{(A3.9)}$$

Thus, substituting Equation (A3.9) into Equation (A3.8) and simplifying gives:

$$\frac{1}{B(F_{MSY})}\frac{dB(F)}{dF}\bigg|_{F=F_{MSY}} = -\frac{1}{\tilde{P}^D(F_{MSY})}\frac{d\tilde{P}^D(F)}{dF}\bigg|_{F=F_{MSY}} - \frac{1}{z}\frac{(MSYL^D)^{-z}-1}{f(F_{MSY})-f_{eq}}\frac{df(F)}{dF}\bigg|_{F=F_{MSY}} \quad \text{(A3.10)}$$

Substituting Equation (A3.10) into Equation (A3.2) gives Equation (21) of the main text.

Annex S
Intersessional Review Group and *Ad hoc* Working Group Comments on Research Proposals (Agenda Item 17.2)

Members: Zeh (Convenor), Kato, Martin, Walløe.

Seven research proposals requesting funding were submitted, of which one was withdrawn and another was considered by the Other Great Whales sub-committee as part of its work (Annex E, item 6.2). The review group considered the remaining five proposals, along with comments from outside reviewers for each. A letter received in connection with SC/50/RP3 requested blue whale biopsy samples for analysis.

Evaluation of the proposals used the criteria and followed the recommendations given in IWC (1996). Scores were assigned to each research proposal on each of the seven criteria of IWC (1996). The group's summary comments on each proposal are given below.

SC/50/RP1: Development of a stock identification system for cetaceans based on trace element signatures in teeth or baleen. P. Outridge and D. Gregoire. $63,000 Canadian.

This is a proposal to develop a geographically-based stock identification system for cetacean species, based on the natural trace element or isotopic signature in their teeth or baleen. The outside reviewers considered the proposers qualified and the proposed approach sound. However, comments from one of the outside reviewers provide a good summary of the views of the intersessional review group. The authors of the proposal have no clear particular hypothesis to be tested and no idea concerning what cetacean they might consider. They did not demonstrate an awareness of problems for their technique that might be posed by migratory animals or an understanding of the need to understand the geographic distribution of the trace elements they might use in order to interpret results. The review group assigned an overall score of **Low** to the proposal.

SC/50/RP2: Abundance and stock identity of humpback whales (*Megaptera novaeangliae*) in New Caledonia, South Pacific. C. Garrigue, J. Greaves and C.S. Baker. $29,000 US 1998, $27,400 US 1999.

This proposal requested funding to collect photographs and biopsy samples of humpback whales in New Caledonia and use them to estimate population size, migratory patterns, and stock identity for this population. The outside reviews pointed out some weaknesses in study design and questioned the need for more samples in this location, given that a number are already available. The group assigned a **Low to Medium** overall score to the proposal.

SC/50/RP3: Delineation of breeding stocks of the blue whale (*Balaenoptera musculus*). B. May and C. Conway. $7,225 US Year 1, $8,670 US Year 2.

This is a request for funds to examine worldwide blue whale stock structure using introns of conserved nuclear genes. The outside reviewers were positive about the proposed approach and methods but questioned whether the proposers had or could obtain sufficient samples, and whether the approach would provide more answers than genetic approaches presently being used on blue whale samples. The group assigned an overall score of **Medium**.

SC/50/RP5: Retrospective analysis and method development for integrated analysis of the SOWER2000 survey. D. Borchers, S. Reilly and P. Hammond. £32,641.

This is a request for funds to develop methods for relating distribution, abundance and biomass of baleen whales to krill and apply these methods to existing data sets. Both the internal and outside reviewers had some questions about the clarity of objectives and proposed methods, but the proposers provided a thoughtful response to these questions. It was agreed that the relevance of the proposed research to current Scientific Committee priorities was high. The group assigned an overall score of **High**.

SC/50/RP6: Baseline photo-identification and genetic sampling of humpback whales off Moorea, French Polynesia. J. Darling and L. Gerber. $10,000 US, but only $5,000 US requested from IWC.

This is a request for funds to sample humpbacks in a breeding area in the South Pacific where existing data are limited. The biopsy samples might help to elucidate stock structure in the Southern Hemisphere, so the proposal does address a Scientific Committee need, and reviewers were generally positive about the competence of the proposers, the feasibility of the work and the chances of success. The group assigned an overall score of **Medium to High**.

The priority rankings of the review group are implicit in the overall scores assigned. The group strongly supported the funding of SC/50/RP5, discouraged funding of SC/50/RP1 and considered the remaining three proposals worthy of support if ample funds were available after accounting for other needs and priorities identified by the Scientific Committee.

REFERENCE

International Whaling Commission. 1996. Report of the Scientific Committee, Annex S. Review of IWC Scientific Committee Procedures for Assessing Research Proposals-Report of Intersessional Correspondence Group. *Rep. int. Whal. Commn* 46:227-8.

Annex T
Suggested Changes to IWC Publications[1]

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INTRODUCTION

The current IWC publications are: *Reports of the International Whaling Commission* (*Rep. int. Whal. Commn* – hereafter RIWC) and its *Special Issue* series. The RIWC volumes contain five sections: General Administration (List of Commission Members, Annual Report, Accounts, Commission participants and Agenda, Chairman's Report); Report of the Scientific Committee incl. Annexes and occasionally special meeting reports; Progress Reports on Scientific Research; Scientific Papers; Résumés. Table 1 summarises the various extents of each section for the last 10 volumes.

The Special Issue series only contains scientific material on specific subjects and is similar to the final sections of RIWC in style.

Some problems with RIWC

Scientific recognition

Over the years the scientific quality of RIWC has increased considerably. It has now become as rigorously reviewed as any quality journal. Amongst cetologists it has a high reputation. Unfortunately, and for no logical reason, the 'Scientific Establishment', particularly in some countries, refuses to recognise papers published in it as of the same quality as papers published in a journal. They are 'relegated' to the level of 'Proceedings' papers. However sympathetic ISI, the effective arbiters of this are in general, I have been told that unless it is published in a soft-bound volume, more than once a year, with the word 'Journal' in the title, it will only have the standing of a 'proceedings volume'. This has proved particularly problematic for some scientists as they receive little credit for papers published in RIWC when they are evaluated.

Variable size/Timing

One of the practical difficulties in the present system of RIWC is that the number of papers considered and accepted for publication varies considerably from year-to-year. For example the most recent volume is the largest ever, 1,032+pp. – in other years there can be half that. This, combined with the timing of meetings, and the need to produce *Special Issues*, makes the workload very difficult to manage (and of course, to budget). Given timing priorities in trying to ensure that RIWC is available for the next meeting, Special Issue timings suffer. A further problem is that the 'good' – in the sense of punctual – authors are penalised. The publication of the volume is effectively dictated by the speed of the slowest author. This is especially a problem if the later papers occur early in the volume – as Murphy's Law frequently dictates.

Advantages of RIWC

There is a lot to be said for having all the papers from the Annual Meeting, plus the Scientific Committee's Report and the Chairman's Report, in a single hard-bound volume. It also allows the papers to be organised by subject in a logical way, making it easier to find them.

The *Special Issue* series is extremely successful both from the point of view of its scientific recognition and sales (many are being reprinted).

A WAY FORWARD

The disadvantages noted above, unfortunately outweigh the advantages. I have therefore, tried to develop a strategy that provides an efficient way forward and makes the best use of the available scientific protocol!

A new journal

The only way to satisfy the rigid but not scientific criteria of scientific 'acceptability', is to establish a new journal. In practical terms, this essentially means changing the timing and cover, while maintaining the high standards of refereeing. In recognition of the quality and quantity of scientific work that is carried out at Scientific Committee meetings, and the interest of the wider scientific community in our work, I propose that the Committee's report is published as a *supplement* to the new journal. This will also enable it to be published in a more timely manner.

The *Special Issue* series would continue as a special issue to the journal.

However, even if there are questions to be asked about the ISI criteria, there are a number of positive aspects to the above approach, in addition to achieving full scientific 'respectability'. For example, it will also make managing the workload and the budget much easier. This format will enable peaks and troughs in size to be managed more efficiently and the budget to be more predictable. It will also reward punctual authors.

Working Title: ***[International] Journal of Cetacean Research and Management***
Abbreviation: ***[Int.] J. Cetacean Res. Manage.***

[1] This is a shortened version of SC/50/O10. It has been slightly revised to take into account discussion during the Scientific Committee meeting.

Annex U
Minority Statements

STATEMENT OF THE JAPANESE DELEGATION CONCERNING SMALL CETACEANS

The position of the Government of Japan, as stated at the last Annual Meeting of the Scientific Committee, has not changed on the matter of small cetaceans. That is, the activities of the Commission with the population management of whales should be limited to the matters concerning whales listed on the Nomenclature of the International Whaling Commission Final Act (1946).

However, we can support the Resolution adopted by the IWC at its 32nd Annual Meeting in 1980 that the Scientific Committee of the IWC is recommended to consider the status of small cetaceans and provide such scientific advice as may be warranted to Contracting Governments.

ITEM 2. ADOPTION OF AGENDA

With regard to the deletion of the sub-item 'Southern Hemisphere minke whales' from the Agenda Item 'CA/RMP – PREPARATION FOR IMPLEMENTATION', Yagi noted with regret that this was the first occasion where the Commission had explicitly intervened to preclude the Scientific Committee pursuing a request from a member government to further consideration of an issue relevant to scientific aspects of the management of whales. He stated that this action by the Commission was not in the interest of promoting cooperation among members of the Scientific Committee.

Annex V
E-mail Correspondence Groups (with Current Membership)

Other interested members of the Scientific Committee can join these groups by contacting the Chairman.

(1) Aboriginal Subsistence Whaling Management Procedure (SC Report Item 10.9.1)
Donovan (Chair), Allison, Born, Butterworth, Breiwick, DeMaster, George, Givens, Punt, Walløe, Witting, Zeh

(2) Environmental Concerns in the Arctic (SC Report Item 12.4)
DeMaster (Chair), Donovan, O'Hara, Perrin, Reijnders, Simmonds, Thiele, Von Bismarck, Walløe

(3) Greenland Fisheries Research Programme (SC Report Item 10.9.3)
Born (Chair), Breiwick, Butterworth, DeMaster, Donovan, Givens, Hammond, Hester, Øien, Smith, Walløe, Witting

(4) Harbour Porpoises in the North Sea and Adjacent Waters (SC Report Item 13.3)
Read (Chair), Berggren, Buckland, DeMaster, Donovan, Hammond, Martin, Palka, Reijnders, Rogan, Wade

(5) Increase Rates in Northern and Southern Hemisphere Humpback Whales (SC Report Item 9.3.4)
Clapham (Chair), Baker, Bannister, Best, Brown, Brownell, Butterworth, Friday, Findlay, Hester, Ohsumi

(6) Mathematically-based Techniques for Recognition Analysis (SC Report Item 9.9.3)
DeMaster (Chair), Carlson, Donovan, Friday, Hammond, Hiby, Slooten

(7) North Pacific Bryde's Implementation Simulation Trials (SC Report Item 8.4.1)
Punt (Chair), Allison, Butterworth, Fujise, Hammond, Hatanaka, Kato, Miyashita, Ohsumi, Palka, Pastene, Perrin, Polacheck, Skaug, Smith, Yagi

(8) North Pacific Minke Implementation Simulation Trials Steering Group (SC Report Item 8.2.4)
Butterworth (Chair), Allison, Hatanaka, Kawahara, Kim, Punt, Smith, Taylor

(9) North Pacific Sightings Survey Steering Group (SC Report Item 8.2.3)
Smith (Chair), Borchers, Butterworth, Hatanaka, Kato, Miyashita, Øien, Palka, Polacheck, Skaug

(10) Performance of Abundance Estimators Working Group (SC Report Item 7.3)
Palka (Chair), Allison, Borchers, Butterworth, Cooke, Hammond, Miyashita, Nishiwaki, Okamura, Polacheck, Skaug, Smith

(11) Sonogram Database (SC Report Item 9.9.2)
Fox (Chair), Clark, Kim, Leaper, Ljungblad, Swartz

(12) Southern Hemisphere Humpback Preliminary Assessment (SC Report Item 9.3)
Best (Chair), Brownell, Butterworth, Findlay

(13) SOWER 2000/1 (SC Report Item 12.3)
Reilly (Chair), Allison, Borchers, Butterworth, Donovan, Findlay, Hammond, Hedley, Hofmann, Ichii, Kato, Kock, Palka, Rogan, Slooten, Thiele

(a) IWC/CCAMLR – Allison, Butterworth, Findlay, Hammond, Hofmann, Ichii, Kato, Kock, Reilly, Slooten, Thiele
(b) IWC/GLOBEC – Allison, Butterworth, Hammond, Hofmann, Kato, Kock, Palka, Reilly, Rogan, Thiele
(c) Sightings Workshop – Borchers, Butterworth, Donovan, Hammond, Hedley, Hofmann, Kato, Kock, Palka, Reilly, Thiele

(14) Stock Definition (SC Report Item 7.5)
DeMaster (Chair), Best, Butterworth, Goto, Hatanaka, Kim, Pastene, Perrin, Polacheck, Punt, Rojas Bracho, Skaug, Slooten, Taylor, Walløe

(15) Whalewatching (SC Report Item 15.2)
Carlson (Chair), Best, Borge, Brownell, Clark, Donohue, Findlay, Lens, Ohsumi, Papastavrou, Pérez-Cortés, Simmonds, Swartz

(16) Gray Whale Current Status and Stock Monitoring
Brownell (Chair), DeMaster, Pérez-Cortés, Rojas Bracho, Walløe